City of Franklin, Tennessee

Integrated Water Resources Plan

DRAFT REPORT

July 2012

CDM Smith

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Executive Summary

The purpose of the IWRP project was to develop and recommend an implementable and broadly supported plan to meet Franklin's water resources needs for the next 30 years. It was essential that the plan be sustainable, cost-effective, permittable, defensible, and protect and enhance the Harpeth River.

The IWRP was developed in two phases:

- Phase I – Completed in winter of 2010, the purpose of Phase I was to convene a stakeholder advisory group and steering committee and formulate a set of objectives that the IWRP would address. A preliminary evaluation identified potential water, wastewater, stormwater, and reclaimed water projects to address objectives using an integrated systems simulation model and performance measures derived by the stakeholder group. Alternative groupings of project options were compared using decision support methodology described in this report. The outcome of Phase I was a greater understanding of Franklin's water resources systems, consensus amongst stakeholders on the objectives of the IWRP, and a refined list of project options which were inclusive of four specific hybrid alternatives which were recommended for further study in Phase II.

- Phase II – The purpose of Phase II was to perform a more in-depth analysis of the costs and benefits of the alternatives identified in Phase I. A dynamic watershed simulation model and detailed engineering studies provided refined estimates of the performance of project options over the 30-year planning period. The integrated systems model was subsequently updated with the revised data and cost estimates from the Phase II detailed analysis. The integrated systems model, in turn, was the basis for recommendations to the Steering Committee, Stakeholders, staff and elected officials for ultimate development of the final IWRP. Stakeholder involvement remained a key facet of the IWRP process throughout Phase II.

The Franklin IWRP considered multiple aspects of the City's water resources and their interactions with one another including, but not limited to, the following concepts:

- Harpeth River – flooding, low flow frequency, erosion of water quality, water quality and ecological health

- Drinking Water – Supply source, treatment, distribution, and conservation

- Wastewater – collection system, treatment plant facilities and capacities, and discharge permitting
- Reclaimed Water – Availability, distribution, and demand for this resource
- Stormwater – Conveyance, best management practices (BMPs), impacts on the Harpeth River, and potential harvesting and reuse

ES.1 IWRP Process

The IWRP was a stakeholder participation process that focused on identifying the best combination of project options into cumulative alternatives to meet a set of mutually agreed upon goals and objectives. The stakeholder group was comprised of diverse representatives with varying interests in Franklin, Williamson County and the Harpeth River. The group convened in Phase I and continued to meet during Phase II to discuss the project and give input on the selected projects and their interaction with each other and the Harpeth River. Throughout the project, public forums were held to present project progress and details of the plan; this also provided the opportunity for public input. In addition, numerous BOMA update meetings were held for updates and feedback.

Results of Phase I of the IWRP included development of four hybridized plan alternatives which were developed to meet the project objectives developed during Phase I. Phase II of the IWRP included detailed evaluations of the following subsystems: stormwater, water treatment, water distribution, water conservation, existing wastewater treatment, new wastewater treatment, wastewater collection, ecological restoration, reclaimed water, biosolids, and the creation of a water quality model of the Harpeth River. The detailed evaluations for these subsystems are compiled in the Appendices of this report. The four hybridized alternatives were evaluated along with an alternative which represented maintaining the systems current condition for baseline comparison using an integrated systems simulation model which was used to identify the preferred plan as a result of its ability to satisfy multiple project goals.

ES.2 Harpeth River Modeling Results

One of the most important products of the IWRP process is the dynamic model of the Harpeth River through the City. The model was developed in coordination with the Tennessee Department of Conservation (TDEC) and utilized data from both USGS and the Harpeth River Watershed Association. Results of the model show that the Harpeth River is impaired as it enters the City limits. The model was also used to evaluate each alternative with respect to its impact on the water quality and flow within the Harpeth River. Although none of the alternatives were able to restore low dissolved oxygen concentrations as a result of the upstream impairments, the preferred alternative was demonstrated to improve water quality through the 7-mile portion of the river in the City due to the inclusion of the discharge of highly treated effluent upstream of the City from a new wastewater plant located at the Goose Creek site and the removal of the existing low-head dam.

ES.3 Summary of the Preferred Alternative

This IWRP provides the framework for improvements to the City's water resources over the next 30 years that, once adopted, should be reviewed and updated approximately every five years. This approach will allow the City to adapt the plan to meet water resources demands as needed, accounting for population growth and demographic changes. The primary components of this IWRP include:

- Harpeth River low-head dam removal
- Increase in water treatment plant (WTP) capacity to 4.0 mgd and addition of ultraviolet (UV) disinfection and an advanced oxidation process (AOP) to address disinfection requirements, as well as aesthetic issues such as taste and odor
- Upgrade of the existing WWTP to 16 mgd
- Design and construction of an initial 16 mgd biosolids treatment capacity comprised of thickening, anaerobic digestion, dewatering and solar drying, at the existing WWTP site with further expansion to 24 mgd during the planning period
- Installation of the defined water quality improvements to the potable water distribution system
- Connection of probable reclaimed water customers to the existing system
- Installation and upgrades to the City-wide SCADA system for the water and sewer systems
- Upgrade the City's Automated Metering Infrastructure (AMI)
- Create accurate computerized models of both the sanitary sewer and drinking water delivery systems
- Initiate a toilet replacement program
- Build the new south WWTP initially at 4.0 mgd capacity (2026) with provisions for build-out at 8.0 mgd (2040)
- Tie in Berry's Chapel Utility and Cartwright Creek Utility District facilities when the opportunity and capacity is available

The following components of this alternative are recommended annually or other scheduled basis based on availability of funding and/or project need:

- Annual rehabilitation of the sanitary sewer collection system (recommended 5 percent – this would provide for a complete rehabilitation of the entire system every 20 years)
- Annual rehabilitation of the drinking water distribution system (recommended 5 percent)

- The stormwater basin projects should be completed on average once every three years based on the project size and the availability of the stormwater utility funding. Projects include improvements to: Sharps Branch, Quarry Branch, North Ewingville Creek, Liberty Creek, Sam Mill Creek, Donelson Creek, and Goose Creek
- A stream restoration project should be scheduled to follow the stormwater basin projects such that the section of restored stream will be downstream of the basin to take advantage of the newly created storage. Projects would include improvements to the Harpeth River, Five Mile Creek and Sharp's Branch
- Where existing infrastructure makes it practical, sewer customers should be added from those currently served by septic tanks

ES.4 Immediate Priority Projects

The projects that comprised the preferred alternative discussed above are described further within the report; the detailed technical analyses conducted for each project option are provided as Appendices to this report. The projects that are needed to meet the City's water resources demands over the next 30 years were prioritized such that those that are required to meet an immediate regulatory or capacity requirement could be identified and implemented early. The six immediate priority projects are summarized in **Table ES-1** and were presented to the Board of Mayor and Alderman in February of 2012.

Table ES-1 Immediate Priority Projects

Number	Description	Start	Finish	Cost, Millions	Eligible for Access Fee Funding	Projected Access Fee Funded Portion	Projected Rate and/ or SDF Funded Portion
1	WTP Improvements (LT2ESWTR)	11/2012	4/2015	$9.8	yes	$5.2	$4.6
2	Distribution System Water Quality Improvements (D/DBP)	11/2013	1/2014	$2.0	no	$0	$2.0
3	Biosolids Facility for 16 mgd	7/2012	1/2015	$66.0	yes	$16.5	$49.5
4	Expand Existing WWTP to 16 mgd	7/2012	1/2015	$18.6	yes	$4.7	$13.9
5	SCADA Water and Wastewater	12/2013	12/2014	$5.6	no	$0	$5.6
6	Automated Metering Infrastructure	12/2012	5/30/2014	$3.5	no	$0	$3.5

ES.5 Financing

The IWRP explored several methods of financing the immediate priority projects. Through discussions with City staff, the analysis focused on the use of impact fees to offset improvements that were growth related and financing the remainder of the project costs through debt. The resulting impact on the monthly water and sewer bill of the recommended improvements to an average customer (7,000 gallons of water consumed per month) were calculated as shown in **Figures ES-1 and ES-2,** over the next 10 years.

Figure ES -1
Water - Impact of Debt Service on Residential Inside Rates

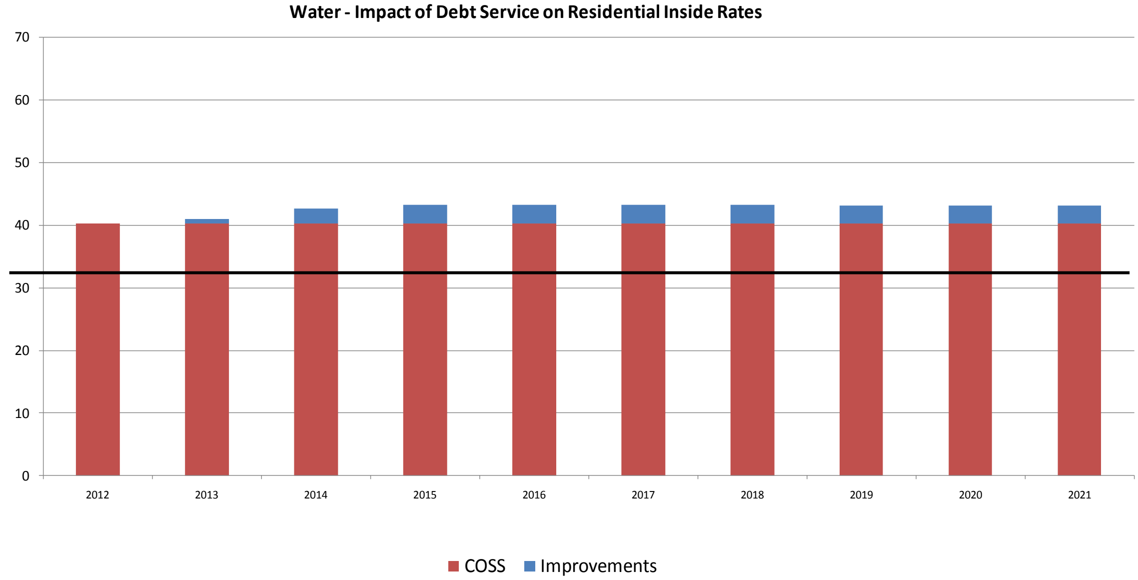
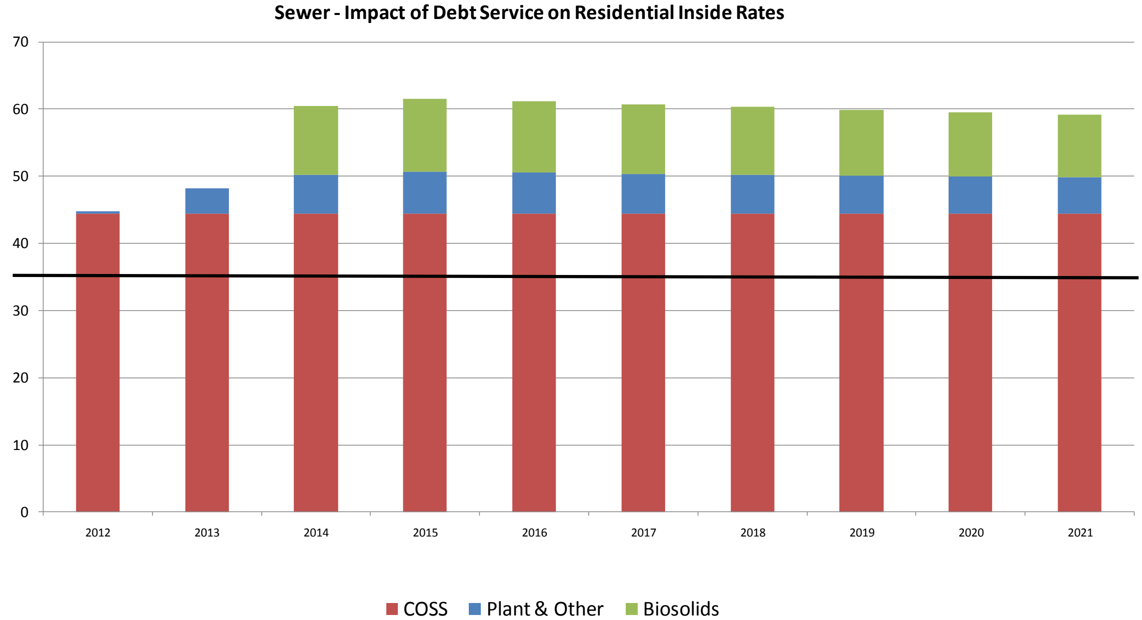


Figure ES-2
Sewer - Impact of Debt Service on Residential Inside Rates



Alternative funding programs such as the State Revolving Fund (SRF) Program were also evaluated and may present a more attractive alternative to funding the improvements than through traditional bonds due to the reduced interest rates and small principal forgiveness for these loans. Additionally, several projects in the IWRP may be eligible for the TDEC Energy Grant Program which provides grants for projects which can demonstrate a reduction in greenhouse gas emissions over their current practices. These potential alternative funding sources are discussed further in Section 6.

Section 1
Introduction

The City of Franklin (City) is located in one of the fastest growing regions of the country; from 1997 through 2008, the population of the City nearly doubled and continues to grow rapidly compared to the national average. With this rapid growth, the City continues to experience increasing pressure on utility services and infrastructure. All areas of the City's water, wastewater, and stormwater infrastructure have experienced pressures due to this growth.

These increasing demands have led City officials, administration and staff to evaluate the water resources from a long-term, holistic perspective that encompasses water supply and treatment, wastewater collection and treatment, biosolids treatment and disposal, reclaimed water distribution, stormwater management, ecological preservation, and restoration along the Harpeth River and its tributaries. In order to allow the City to address these needs, an Integrated Water Resources Plan (IWRP) was developed using a facilitated process involving stakeholders to assist with the definition of the goals, objectives, performance measures and alternatives, and ultimately the recommended plan as the final product of the two-year planning process. CDM Smith supported the City in the stakeholder participation process as well as conduct technical evaluations based on stakeholder derived objectives. The final IWRP, includes identification of projects that would be adaptively implemented in phases over the next 30-year planning period. In addition to presentation of the phased schedule of projects, a regulatory plan and funding plan have been developed so that the IWRP can be implemented in a manner that allows the City to meet the needs of its growing community.

1.1 Background

The City of Franklin relies on the Harpeth River for water supply, treated effluent disposal, recreation, and other water resource needs. As the City continues to grow, the stresses placed on this key water resource continue to compound, and are exacerbated by weather extremes (droughts and floods). Protecting the Harpeth River's water resources, ecology and value as a recreational resource is a goal shared by all stakeholders. Balanced with this goal, the City needs a reliable long-term source for drinking water and sustainable solutions for wastewater effluent disposal and stormwater management.

To achieve this balance, the City looked to develop a long-range plan that considers governing science and engineering principles, evaluates and debates alternatives, and builds broad consensus around a comprehensive set of sustainable, affordable actions that will provide for effective management for the future of the City's water resources.

1.2 Project Scope and Approach

The purpose of the IWRP project is to develop an implementable and broadly supported plan to meet Franklin's water resources needs for the next 30 years. The plan must be sustainable, cost-effective, permitable, technically defensible, and protect and enhance the Harpeth River.

The IWRP was developed in two phases:

- **Phase I** – Completed in winter of 2010, the purpose of Phase I was to convene a stakeholder advisory group and steering committee and formulate a set of objectives that the IWRP would address. A preliminary evaluation to identify potential water, wastewater, stormwater, and reclaimed water projects to address these objectives was performed using an integrated systems simulation model with performance measures derived by the stakeholder groups. Alternative groupings of project options were compared using decision support methodology described in this report. The outcome of Phase I was a greater understanding of Franklin's water resources systems and needs, consensus amongst stakeholders on the objectives of the IWRP, and a refined list of project options which were inclusive of four specific alternatives, recommended for further study in Phase II.

- **Phase II** – The purpose of Phase II was to perform a more in-depth analysis of the costs and benefits of the alternatives identified in Phase I. A dynamic watershed simulation model and detailed engineering studies provided refined estimates of the performance of project options over the 30-year planning period. The integrated systems model was subsequently updated with the revised data and cost estimates from the Phase II detailed analysis. The integrated systems model in turn, was the basis for recommendations to the Steering Committee, Stakeholders, staff and elected officials for ultimate development of the final IWRP. Stakeholder involvement remained a key facet of the IWRP process throughout Phase II. The preferred alternative identified in Phase II was presented as a recommendation from the stakeholders to the City of Franklin Board of Mayor and Alderman (BOMA) for future implementation.

The Franklin IWRP considered multiple aspects of the City of Franklin's water resources and their interactions with one another including, but not limited to, the following:

- Harpeth River – flooding, low-flow frequency, erosion of water quality and ecological health

- Drinking Water – Supply source, treatment, distribution, and conservation

- Wastewater – collection system, treatment plant facilities and capacities, discharge permitting, and biosolids processing and disposal
- Reclaimed Water – Availability, distribution, and demand for this resource
- Stormwater – Conveyance, best management practices (BMPs), impacts on the Harpeth River, and potential harvesting and reuse

1.3 Project Area and Planning Period

Two key conditions were defined and characterized at the onset of the project in order to establish project boundaries and constraints: the geographic limits of the project and the planning period to be utilized for the project. In considering geographic boundaries for the IWRP, stakeholders expressed interest for opportunities and project options to incorporate regional water resource concerns. To incorporate these preferences, the steering committee reached a consensus on a 3-circle concept, shown in **Figure 1-1**, which outlines the preferences for the geographic boundaries for the project and includes the following distinctions for the project planning area:

1. The City of Franklin's existing service area and its specific needs is the top priority
2. The City of Franklin's urban growth boundary (UGB) was considered in the planning and project development and was the secondary priority
3. The regional area and Harpeth River watershed was considered, providing opportunities for mutual cooperation amongst stakeholder groups. This was the third priority of the geographic concept.

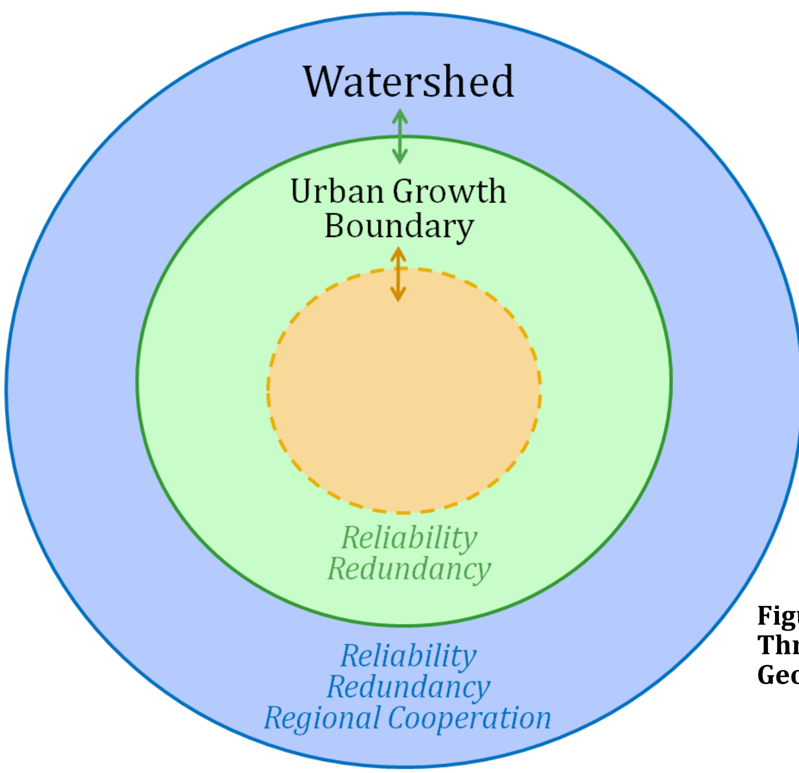


Figure 1-1
Three-circle Concept for Geographic Boundaries

Defining these geographic boundaries provided focus on the existing service area, without being exclusionary of regional issues. In addition to this project planning area, the steering committee defined the Harpeth River as the central point of project integration, providing a guideline for measuring success of each project alternative evaluated. The project area is shown in **Figure 1-2**.

In addition to defining the geographic boundaries of the project, the steering committee discussed and defined a planning period for the IWRP. There was strong consensus that a planning period of 30 years would be most appropriate for the IWRP, indicating 20 years was too short for project implementation and 50 years would include too much uncertainty for developing alternatives. A time period of 30 years was utilized for final project scheduling and implementation for final reporting.

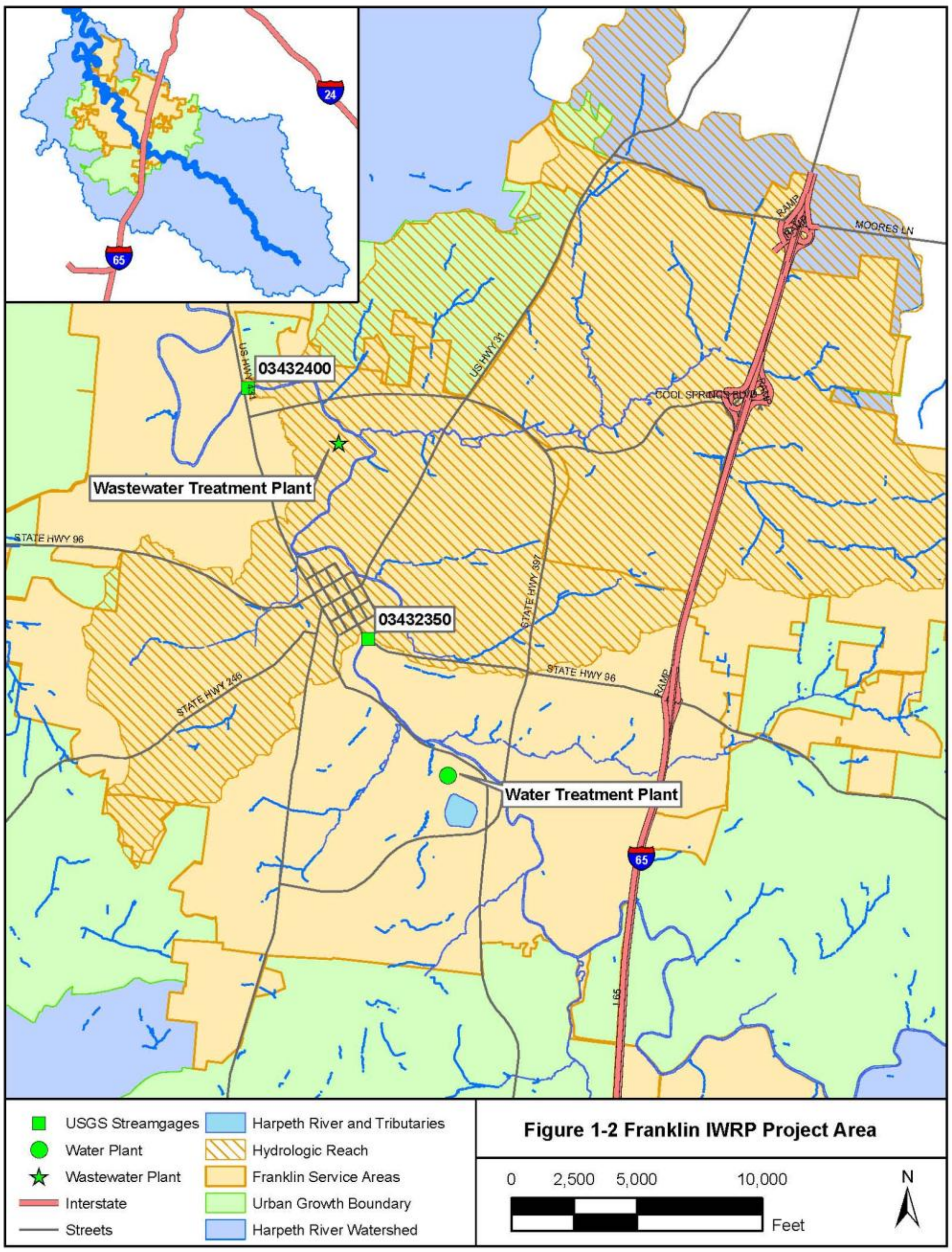


Figure 1-2 Franklin IWRP Project Area

Section 2
Stakeholder Participation and the Integrated Planning Process

The goal of the IWRP process was to provide a long-range plan that garnered broad consensus and support from the City's elected officials, administration, staff, citizens, civic organizations and other interested parties that would be affected by the recommendations and long-term implementation of the integrated plan. Thus, the IWRP process focused on consensus building—specifically on reaching agreements between participating stakeholders regarding selection of options and a final alternative which would be the most broadly accepted and beneficial to the public. Consensus was achieved during the process through extensive transfer and sharing of knowledge, discussions amongst the stakeholders and eventual agreement on plan goals, rather than on the project preferences of individuals or their organizations. Historically, plans that are focused on consensus goals, such as the IWRP, are much more likely to receive broad support than plans formulated on individual preferences for specific projects.

2.1 Stakeholder Groups

The first step in the IWRP process was to identify representatives for those who would be affected by and have jurisdictional authority over implementation of the integrated plan. Stakeholders were selected to represent citizens of Franklin, the City's utility staff, other local and regional utilities, watershed organizations, technical advisors, and regulatory officials. The four levels of stakeholders that were defined and their roles in the IWRP process are described below.

1. **Decision Makers** – Board of Mayor and Aldermen (BOMA)
2. **Steering Committee** – City Staff, Technical Advisors, BOMA Representative
   - Participate with stakeholder advisory group in interactive stakeholder workshops
   - Arrange presentations and discussions with the public and BOMA
   - Make recommendations to BOMA
   - Work with facilitators to direct the process

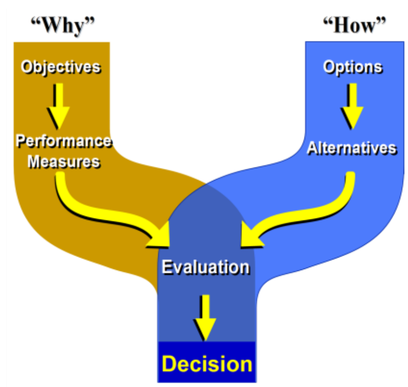
3. **Stakeholder Advisory Group** – Citizen representatives, watershed organizations, utility directors, state regulatory representatives, technical experts

   - Participate in collaborative workshops; defining goals, projects, alternatives and the ultimate plan for recommendation
   - Make recommendations to the steering committee, and ultimately BOMA

4. **Citizens and the Public**

   - Receive output and reports on project progress through public meetings
   - Offered opportunity to share ideas and information with stakeholder advisory group and steering committee through public input

2.2 Consensus Building



Blending the two tracks of water resource planning enables us to move from technical needs to "interest-based" solutions.

The most fundamental aspect of building consensus among stakeholders was distinguishing between the reasons for making decisions and the means of implementing them. This is often described as separating the "Why" from the "How". In other words, beginning to solve problems by discussing how to solve them can often lead to disagreements, because the roots of the issues have not been agreed upon. By defining the challenges to be addressed, participants in the IWRP process can agree on why any given decision must be made. By first defining the objectives and their associated performance measures, stakeholders can engage in cooperative discussions on how to address problems. By defining the project objectives, stakeholders were able to concentrate on the options, and ultimately the grouping of options (alternatives), that allowed those defined objectives to be met with the greatest overall effectiveness. The IWRP process was divided into two distinct tracks to define the "Why" and "How"; first to identify goals and objectives for the plan and then identify the projects or management measures that could best address these defined and ranked goals.

2.3 Integrated Planning Framework

To help make a clear distinction between the "Why" and "How", a commonly employed IWRP framework was used for this project. At the core of the framework are four key terms that were used to focus stakeholders attention. These terms were used in development of a common statement of objectives, and then, on consensus-building around the best way to achieve the goals. The terms defined here will be used throughout this report:

Objectives (Why)	Defined major goals of the IWRP, in broad and understandable terms
Performance Measures (Why)	Specific metrics that indicate whether or not, and how well, an objective is achieved
Options (How)	Individual projects or policies that will be assembled into comprehensive alternatives
Alternatives (How)	Packages of individual projects and policies designed to meet objectives

During the process, stakeholders defined objectives through interactive "brainstorming" resulting in nine objectives from hundreds of suggested and recommended goals. After defining objectives, options were identified by the project team, steering committee and stakeholders, and were grouped, by stakeholders, into alternatives, each with a specific metric. With agreeable objectives ranked individually by the group, the project options were compared using common performance measures which clearly indicated how well each alternative satisfied the group's collective objectives. Using this common basis of measurement, decisions could be based on technical knowledge instead of personal preference.

2.4 Collaborative Workshops and Meetings

Stakeholders were engaged from the beginning and throughout the entire planning process, allowing definition of objectives of the plan, identification of potential solutions, collaboration on formulation of analysis tools, and development of recommendations for BOMA. Steering committee meetings were held monthly during the planning process to discuss and facilitate project progress. Stakeholder advisory group workshops were held at key points throughout the development of the IWRP. A summary of the stakeholder meetings and their objectives is provided in **Table 2-1**. Associated information for all meetings have been provided for the public on the City's IWRP website at http://www.franklin-gov.com/index.aspx?page=623.

Stakeholder Workshops

The definitions above (objectives, performance measures, options, and alternatives) served as the primary framework for a series of collaborative workshops with the IWRP stakeholder advisory group and steering committee. During Phase I, four workshops were held to facilitate consensus on the major components of the IWRP process and to formulate recommendations on preferred alternatives that warranted more detailed technical and economic analysis during Phase II. At the conclusion of Phase I, there were four recommended alternatives that were recommended to BOMA, who approved these alternatives for further analysis and study during Phase II.

During Phase II, three workshops were held to discuss the detailed technical analysis of the selected alternatives, Harpeth River water quality model, the integrated systems model; and ultimately, the recommended alternative for the steering committee to present to BOMA.

Public Forums

The project team coordinated two public forums during Phase I and two public forums during Phase II to provide information to the general public regarding project objectives and alternatives arising from the selection process. The focus of these meetings was to educate the community about the purpose and scope of the project and provide an opportunity for feedback to the steering committee and the stakeholder advisory group. The presentations from the public forums have been provided on the City's IWRP website.

Table 2-1 Franklin IWRP Key Meetings

Meeting	Date	Goals
Introductory Stakeholder Meeting	December 17, 2009	1. Outline the approach and timeline for Phase I 2. Define the roles of the stakeholders 3. Explain the first need for information from stakeholders
Workshop 1: Objectives	January 20, 2010	1. Identify project objectives and discuss objective weighting 2. Identify performance measures 3. Identify constraints that bound plan scope
Public Forum 1	February 22, 2010	1. Explain IWRP process and why it is needed 2. Define scope and process 3. Present draft objectives from Workshop #1 4. Solicit feedback from attendees
Workshop 2: Performance Measures	March 24, 2010	1. Review objectives and results of objective weighting 2. Discuss performance measures 3. Discuss specific project options for meeting objectives 4. Discuss grouping options into themed alternatives 5. Conduct brief demonstration of integrated system model
Workshop 3: Alternatives	June 2, 2010	1. Review of alternatives formulation process 2. Review list of specific project options 3. Initial grouping of options into themed alternatives
Public Forum 2	July 12, 2010	1. Review IWRP process and objectives 2. Discuss development of options and performance measures 3. Explain alternatives formulation 4. Present integrated system model
Workshop 4: Comparing and Modifying Alternatives	August 18, 2010	1. Explain the analysis process and score card methodology 2. Review the results and scores of the alternatives 3. Select and refine alternatives for Phase II
Workshop 5: Technical Analysis Review	June 1, 2011	1. Detailed review of initial technical analysis including discussions of stormwater, ecological restoration, water conservation, wastewater collection and treatment, water distribution and treatment, and water reclamation system

Public Forum 3	June 21, 2011	1. Review of initial technical analysis including discussions of stormwater, ecological restoration, water conservation, wastewater collection and treatment, water distribution and treatment, and water reclamation system
Workshop 6: Water Quality, Alternatives and Sensitivity Analysis	October 26, 2011	1. Review and discussion of the detailed water quality model of the Harpeth River 2. Review of four alternatives, their project options and costs 3. Review and discussion of alternative ranking and sensitivity analysis
Workshop 7: Final Analysis and Discussion	January 25, 2012	1. Update Stakeholders on discussions from Workshop 6 2. Discuss and define final stakeholder recommendations 3. Discuss steps for completing IWRP process and presentation to the Board of Mayor and Alderman (BOMA)
BOMA Update/ Public Forum 4	February 28, 2012	1. Present and discuss the final IWRP recommendation and receive feedback for IWRP adjustment

Technical Workshops

In addition to the workshops and public forums throughout the project, the team hosted two technical meetings during Phase I for interested parties to review the formulation and functionality of the integrated systems model used for analyzing alternatives. During these meetings, technical specialists were available to provide explanations of detailed information regarding the decision model assumptions, construction, and integrations of model relationships and the overall process of running and utilizing the model.

BOMA Presentations

During Phase II, four technical presentations were conducted to update BOMA and citizens of Franklin on the detailed analysis being performed on each of the key facets of the IWRP. The meetings conducted were broken into the primary topics for the detailed analysis as follows:

July 12, 2011	Stormwater, Ecological Restoration, and Water Conservation
August 9, 2011	Water Treatment and Distribution System
August 23, 2011	Wastewater Treatment and Biosolids Management and Collection System
September 13, 2011	Harpeth River Water Quality Model and Integrated Systems Model

These sessions provided BOMA and the public interim updates on detailed technical analyses conducted for alternatives comparison, and ultimately, the recommended IWRP alternative.

2.5 Integrated System Modeling and Analysis

Stakeholders were provided technical information on performance of the alternatives with the help of an integrated system simulation model (discussed in detail in Section 4). This computer tool simulated connectivity between Franklin's water supply, wastewater, stormwater, and reclaimed water systems both directly and through their interactions with the region's common natural water resource, the Harpeth River. Fundamentally, the tool was developed to support two primary functions:

- **Understanding of System Dynamics** – An important part of the consensus-building process is developing a common understanding of the dynamics (cause-and-effect relationships), tradeoffs, and vulnerabilities of interconnected water resource systems. Before examining specific alternatives, the model was used in two technical forums to illustrate potential effects and tradeoffs of several key decisions that might be made. For example, the group explored the effects of increased water supply withdrawals on the Harpeth River over its entire flow regime, and also, the effects of increased reclaimed water use on water quality in the river. The model was used in these venues to help answer important "what if" questions about prospective options in a technical, objective way.

- **Providing Performance Measures for Alternatives** – The model was also used to provide most analyses for scoring quantitative performance measures for the alternatives (life-cycle costs were calculated externally). Examples of model output included frequency of low river flows, concentration of pollutant loads into the river, energy consumption, amount of wastewater and stormwater reclaimed for beneficial uses, and other defined performance measures. These values were used directly to help the stakeholders and steering committee compare initial alternatives during Phase I and the final four alternatives during Phase II.

The model was developed with STELLA software (Systems Thinking Experimental Learning Laboratory with Animation). STELLA is a dynamic and graphical tool used to simulate interactions between and within subsystems that are part of a larger interconnected system. It is frequently used in environmental engineering venues to better understand the implications of decisions across a broad array of social and environmental sectors. Fundamentally, STELLA helps screen options and alternatives, providing numeric scores for performance measures identified as quantitative. In this context, STELLA does not make decisions, but it can be used to generate information and promote more informed and balanced decisions via rapid comparison of the performance of alternatives using physical, environmental, and economic metrics. Its ability to include multi-sector interests in an analytical framework is what distinguishes it from more traditional hydraulic or hydrologic models, which evaluate systems in a purely physical setting. The tradeoff is in resolution. STELLA models do not simulate small, discrete river basins, channels, or pipes but include key system elements and their interdependencies in a lower-resolution network framework in which physical, environmental, and economic response patterns can be effectively examined.

2.6 Identification of Preferred Plans

Once the alternatives were formulated and each had been analyzed with the integrated systems simulation model, a composite score for each alternative was developed. Part of this process included interactive work with the steering committee to assign qualitative scores to alternatives where numerical scores would be inappropriate or infeasible (in these instances, a scale such as poor/good/better/best was used). The score for each performance measure was then multiplied by the weight of the associated objective (modified in some cases to emphasize performance measures that best distinguished alternatives over those that showed little distinction). These weighted values were added to provide a composite score for each alternative. Composite scores could easily be compared to identify the most preferred alternatives, tradeoffs between alternatives, and the component parts of each alternative that seemed to contribute most broadly to its effectiveness. This information was used by the stakeholders to regroup certain options and form hybrid alternatives aimed at addressing as many objectives as possible.

At the conclusion of Phase I, the process yielded four preferred hybrid alternatives which, by consensus of the stakeholders and approval of BOMA, were carried forward into Phase II for more detailed technical and economic analysis.

During Phase II, the same alternatives analysis was utilized; however, the inputs for the integrated systems simulation model were revised to match the results of the detailed technical analysis performed and documented in this report and its associated appendices. The composite scores of each of the recommended alternatives were compared utilizing these revised analyses to determine the preferred final alternative. As part of Phase II, which included a revised systems model analysis, sensitivity analyses and rankings were conducted to evaluate the final composite scores; this process is described further and in more detail in Section 5.

Section 3
Summary of IWRP Phase I

The purpose of Phase I was to convene a stakeholder advisory group and steering committee, formulate a list of objectives that the IWRP would address, conduct a preliminary evaluation of potential projects and options to be included in the IWRP, and develop recommended groupings of projects, referred to as alternatives, based on a framework of weights and performance measures agreed upon by the stakeholders. An integrated system model and decision support methodology were used to assist the stakeholders in understanding how decisions made concerning one aspect of the water resources system would affect other measures and the system as a whole. Phase I concluded with a greater understanding of the City of Franklin's water resources systems, consensus amongst stakeholders on the objectives of the IWRP, and a refined list of alternatives to be studied further in Phase II.

During Phase I of the IWRP process, various project options were grouped into alternatives and then refined into four hybrid alternatives that performed best with respect to meeting the specific objectives defined by the stakeholders. These hybrid alternatives were carried forward into Phase II for more detailed technical and economic analysis. This section provides a summary of the process used to develop the four hybrid alternative plans that were proposed during Phase 1 and further evaluated during Phase II of the IWRP process. A more detailed definition of the work completed as part of Phase I of the process is included in Appendix A.

3.1 Defining and Weighting Objective

The IWRP project objectives were developed by the Steering Committee and Stakeholder Advisory Group during the initial stakeholder workshop. As part of a brainstorming process, the group defined numerous potential objectives for the plan which were consolidated and ultimately trimmed to a group of nine collective objectives that were used to evaluate the effectiveness and purpose of the final IWRP. The objectives for the IWRP, as defined by the stakeholders, are as follows:

1. Meet current and future demands for water and wastewater reliably
2. Maximize efficiency of water use and value of water resources
3. Improve water quality and ecological health of the Harpeth River
4. Provide excellent level of water/wastewater utility services at a reasonable cost.

5. Provide safety and security of water resources systems

6. Achieve regional acceptance

7. Achieve sustainable biosolids management

8. Provide improved access and aesthetics of the Harpeth River

9. Minimize carbon footprint of water resources facilities and operations

Once the objectives were defined, each stakeholder was asked to assign a weight to each objective by distributing 100 total points among the nine objectives. The resulting average of the stakeholder's weights for each objective was utilized as the weighting factors for the CDP decision tool alternatives analysis. **Table 3-1** lists each objective and the associated minimum, maximum and average score given by the stakeholders that were utilized for all project analysis of the alternatives.

3.2 Options and Alternatives

A list of potential project options for each water resources system, including drinking water (water treatment and distribution system; water conservation), wastewater (wastewater treatment and collection system and biosolids management), stormwater management and ecological restoration, reclaimed water, and the Harpeth River, were provided to the stakeholders. These options were compiled from existing studies, utility master plans, Franklin staff input, and other sources and did not exclude any feasible project option from consideration. Stakeholders were asked to review these project options and given an opportunity to provide additional feedback and ideas for project options for consideration.

From this comprehensive list of project options, stakeholders designed alternatives around the five most heavily stakeholder weighted objectives. This process consisted of selecting options that were determined to best meet each of the objectives individually, and grouping these options into an alternative named to meet that objective as described below.

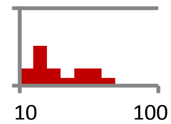
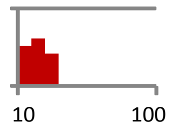
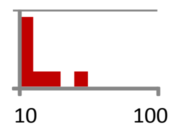
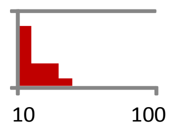
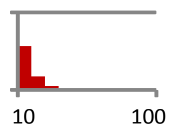
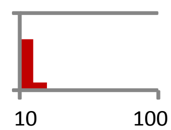
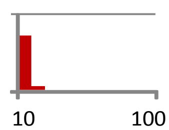
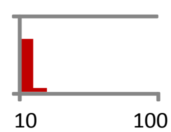
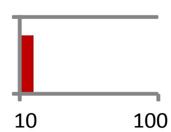
- **Water Quality and Ecological Health** – The focus of this alternative is improving the water quality and ecological health of the Harpeth River and includes project options specifically aimed at that objective; this alternative was titled "Water Quality."

- **Cost** – This alternative is designed to provide services for water resources at a reasonable cost and includes project options that were anticipated to meet the water demands of the City at the lowest estimated lifecycle cost; this alternative was titled "Low Cost."

- **Efficiency** – The options selected for this alternative are intended to maximize the efficiency of water use and emphasize the value of water resources; this alterative was titled "System Efficiency."

- **Reliability** – This alternative includes options designed to reliably meet current and future demands for water and wastewater; this alternative was titled "Reliability."

Table 3-1
City of Franklin IWRP Objectives and Weights

Objectives		Weights			
Name	Description	Min	Max	Average	Histogram
Reliability	Meet current and future demands for water and wastewater reliably	0	70	31.1	
Efficiency	Maximize efficiency of water use and value of water resources	5	25	15.5	
Water Quality & Ecological Health	Improve water quality and ecological health of Harpeth River and watershed	0	50	13.5	
Service at a Reasonable Cost	Provide excellent level of water/wastewater utility services at reasonable cost	0	40	13.2	
Safety & Security	Provide safety and security of water resources systems	0	25	8.3	
Regional Acceptance	Achieve regional acceptance	0	15	5.7	
Sustainable Biosolids Management	Achieve sustainable biosolids management	0	15	4.7	
Improved River Access	Provide improved access and aesthetics of Harpeth River	0	15	4.5	
Carbon Footprint	Minimize carbon footprint of water resources operations	0	10	3.5	

Histograms (graphs in the last column) represent the number of respondents at each weight and are intended to illustrate whether the group's values were generally unified or dispersed. In all the graphs, the horizontal axis is the weight of the objective (in 10 point intervals from 0-10 to 90-100), and the vertical axis is the number of respondents at each weight.

- **Safety and Security** – Options included in this alternative were selected with the intent to provide safety and security of water resources systems; this alternative was titled "Safety & Security."

Following development of plan alternatives, an integrated system simulation model was used to provide information on the broad impacts of various options. Specifically, the model was used to evaluate the five original alternatives by determining the composite value of performance measures, weighted by the importance of the objective linked to each performance measure (see Section 3.3 for a detailed explanation of this process). Using this information, stakeholders were then able to identify tradeoffs among the themed alternatives, as well as options that appeared to perform well by addressing more than one objective. The alternatives were regrouped into hybrid alternatives, which effectively rearranged the best project options to yield balanced alternatives aimed not at one objective, but at meeting as many objectives as possible. Phase I concluded with a consensus that four remaining hybrid alternatives should be carried forward to Phase II for more detailed technical and economic analysis.

3.3 Performance Measures

Performance measures are quantitative and qualitative metrics that allow evaluation of an alternative with respect to meeting the specific objectives. Each performance measure was developed to support one of the nine objectives and provides a means for quantifying the effectiveness of an alternative with respect to meeting that objective. The performance measures originated as ideas directly from the stakeholders. The project team refined the performance measures such that they would have qualitative or quantitative results that could be outputs of the integrated model. The performance measures were also refined such that they could address multiple facets of an objective and provide results that would distinguish amongst alternatives. Finally, the number of performance measures was limited so that each would have significance in the final alternative scoring. Too many performance measures would ultimately dilute the performance measure scoring and could potentially affect the ability to differentiate between the specific alternatives.

Each objective had one or more performance measures that reflected the components of the objective that were identified as important by the stakeholders. For example, there are many ways to maximize the efficiency of water use and the value of water resources, including maximizing reclaimed water use, reducing water demand, and reducing inflow and infiltration within the wastewater collection system. The level to which an alternative addresses each of these components cannot be represented by a single value; therefore, complex objectives have multiple performance measures.

Performance measures were also chosen to create distinguishable results and differences amongst the alternatives, meaning that they should be defined such that different combinations of projects yield different performance measure values. If the value of a performance measure for all alternatives is approximately equal, that measure is not indicative of how well each alternative meets the objective when compared to the other alternatives. Similarly, too many performance measures for one objective could result in dilution of their importance to the overall score; and therefore, the number of sub-weighted performance measures was limited.

Because the integrated model was used to help stakeholders understand system trade-offs, in addition to providing quantitative values (e.g. percent of time demands met, life cycle cost of projects, etc.), qualitative performance measures were also needed to aid in integrated model computations. Certain aspects of the system were not directly modeled and performance measures could not be quantitative metrics related to those systems. For example, the extent of regional focus is not a measure that could be quantified numerically; as a result, qualitative performance measures were used when there was no available method of quantifying a particular metric.

Qualitative scores were defined by the steering committee and the technical team for each alternative, and were assigned based on a relative scale of 0 to 5; the scale generally corresponded to a range of worse than current conditions, no change, and better than current conditions, based on the collection of options within each alternative. For example, an alternative with stream bank restoration would receive a higher score for ecological indicators than an alternative with no ecological restoration option.

3.4 Scorecard Tool and Analysis of Results

The performance measures, as developed in conjunction with the stakeholders and listed in **Table 3-2** were scored for each alternative by using either direct output from the integrated model described in Section 2.5 for quantifiable performance measures or from qualitative scores developed by the steering committee. The software program, Criterion Decision Plus (CDP), was used to perform the scorecard analysis which included standardization of raw performance measure scores, application of objective weights as determined by the stakeholder advisory group, and ranking alternatives based on the aggregate scores across all objectives and associated performance measures.

Goals, objectives, performance measures, and stakeholder weights were input into the CDP for analysis. In order to rank alternatives (groups of options), raw scores for each performance measure were input into CDP; scores for each of the performance measures were standardized on a linear scale from 0 to 1, with the best possible score translating to 1 and the lowest possible score translating to 0. In this way, the various units in which performance measures were quantified were eliminated, making it possible to compare all scores. **Figure 3-1** illustrates an example of how a value (in this example – cost) of an alternative is translated into a unitless score.

For each alternative, a composite score for each stakeholder derived objective was determined based on the sum of scores for each performance measures; this score was multiplied by the weight of the associated objective (**Table 3-2**). The weighted values were then summed for comparison across all alternatives.

Table 3-2 Franklin IWRP Performance Measures

Objectives	Weight	Performance Measures	Units
Reliability	31.1	Percent of time all demands met	% time (all days)
		Average magnitude of deficits (all uses)	volume, MG
		Volume of WW capacity surplus or shortfall	MGD
		Supply redundancy	% volume
Efficiency	15.5	Volume of stormwater put to beneficial use	MGD (all days)
		Percent of total reuse demand satisfied	% volume
		Percent of demand reduction	% volume
		Reduction in inflow and infiltration	qualitative
		Percent reduction in unaccounted for water	% volume
Water Quality & Ecological Restoration	13.5	Frequency of low flow < September median	% time (all days)
		Average summer BOD load (lb/day)	LB/day (summer only)
		Average summer nitrogen load (lb/day)	LB/day (summer only)
		Ecological indicators	Qualitative
		Negative impacts of stormwater reduced	Qualitative
Service at a Reasonable Cost	13.2	Life-cycle cost of projects and policies	Dollars
Safety & Security	8.3	Combined change in water and sewer rates	Qualitative
		Meet secondary drinking water standards	Qualitative
		Percent of total wastewater on septic	% volume
Achieve Regional Acceptance	5.7	Change in 100-year flood elevation	Qualitative
		Vulnerability of infrastructure & facilities	Qualitative
		Emerging water quality concerns	Qualitative
		Extent of regional focus	Qualitative
Sustainable Biosolids Management	4.7	Likelihood of public acceptance	Qualitative
		Biosolids handled sustainably	Qualitative
Improved Access & Aesthetics	4.5	Percent of stream flow that is treated effluent	% volume (Sept. only)
Carbon Footprint	3.5	Extent of bank stabilization	Qualitative
		Erosion potential	Qualitative
		Public accessibility	Qualitative
		Average energy requirements (kWh/day)	average kWh/day

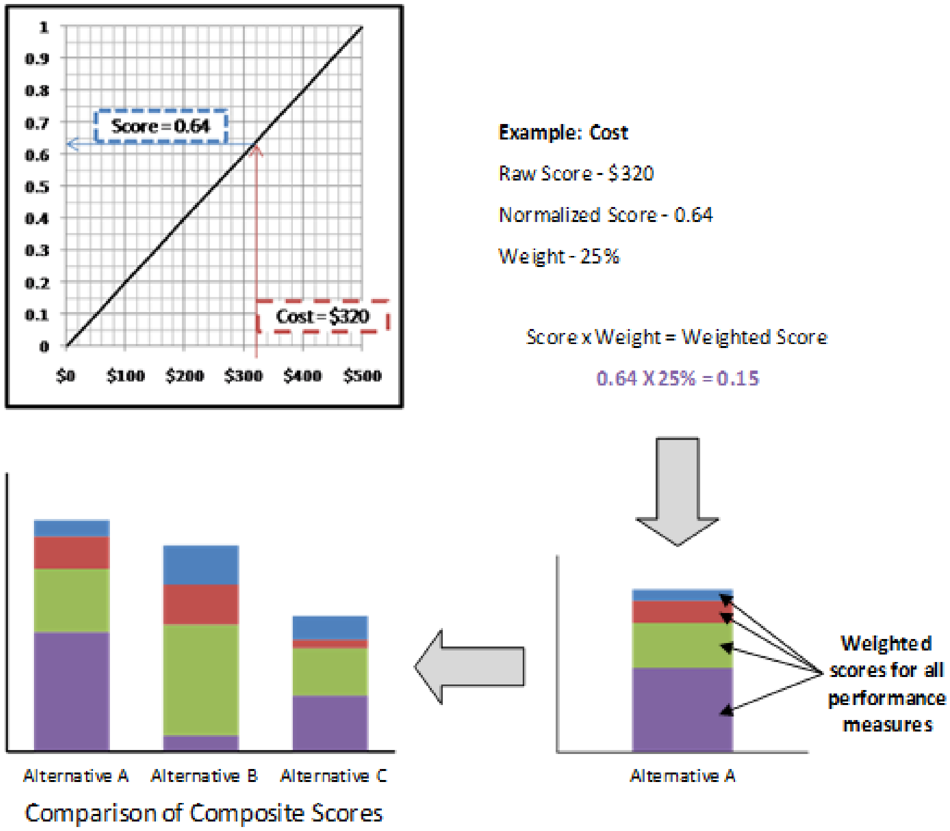


Figure 3-1
Sample Process of Normalizing and Weighting Performance Measures Scores

Performance measure scores for each of the initial alternatives are provided in **Table 3-3**; results are also shown graphically in **Figure 3-2** which provides the raw scores for each of the nine objectives. The comprehensive, summed score for each alternative is also presented as a stacked bar chart, with each color representing an objective in **Figure 3-3**, along with the existing plan of action which was referenced as the "Non-Integrated" alternative as a comparative baseline for the new alternative plans.

Table 3-3 Performance Measure Scores for Initial Alternatives

	Objectives	Weight	Performance Measures	Units	Water Quality	Low Cost	Efficiency	Reliability	Safety & Security	Non-Integrated
1	Reliability	31.1	% time all demands met	% time (all days)	27.7	33.2	56.1	57.9	24.7	24.7
			Avg magnitude of deficits (all uses)	MG	8.06	6.87	8.82	9.36	7.84	7.84
			Vol of WW capacity surplus or shortfall	mgd	4.19	5.83	3.56	2	3.56	0.29
			Supply redundancy	% volume	0	19.9	36.1	44	19.9	19.3
2	Efficiency	15.5	Volume of stormwater put to beneficial use	MGD (all days)	0.1	0	0.50	0.50	0	0.00
			% total reuse demand satisfied	% volume	38.2	52.4	60.7	60.1	37.2	37.3
			% demand reduction	% volume	0	5	5	0	5	0
			Reduction in inflow and infiltration	qualitative	5	4	5	2	5	2
			% reduction in unaccounted for water	% volume	0	50	50	0	50	0
3	Water Quality & Ecological Restoration	13.5	Frequency of low flow < September median	% time (all days)	7.37	9.11	0.81	0.92	0.81	9.11
			Average summer BOD load	LB/day (summer only)	960	1,030	1,020	1,030	1,100	1,130
			Average summer nitrogen load	LB/day (summer only)	240	250	280	280	390	380
			Ecological indicators	qualitative	4.5	3	4.5	3.5	3	3
			Negative impacts of stormwater reduced	qualitative	3.5	3	3	3	3.5	3
4	Service at a Reasonable Cost	13.2	Life-cycle cost of projects and policies	million $	566	405	605	759	677	360
			Combined change in water and sewer rates	qualitative	2.5	2.3	2	1.8	1.5	3
			Meet secondary drinking water standards	qualitative	2.5	3.5	5	4	3	3.5
5	Safety & Security	8.3	% of total wastewater on septic	% volume	0	4	0	0	0	4
			Change in 100 year flood elevation	qualitative	4	3	3	3	5	3
			Vulnerability of infrastructure & facilities	qualitative	1.5	4	4.5	4	4	1.5
			Emerging water quality concerns	qualitative	4	3.5	5	4	3.5	4
6	Achieve Regional Acceptance	5.7	Extent of regional focus	qualitative	4.5	3	4	3	3	3
			Likelihood of public acceptance	qualitative	3	4	3.5	2.5	3	1
7	Sustainable Biosolids Mgmt	4.7	Biosolids handled sustainably	qualitative	1	4	4.5	2	5	1
8	Improved Access & Aesthetics	4.5	% of streamflow that is WWTP effluent	% volume (Sept. only)	36	5	22	22	36	35
			Extent of bank stabilization	qualitative	5	1	5	1	5	1
			Erosion potential	qualitative	4.5	3	3.5	3	4	3
			Public accessibility	qualitative	3	3	3	3	2	3
9	Carbon Footprint	3.5	Average energy requirements	average kWh/day	95,800	35,200	30,500	134,900	57,600	72,600

Raw scores are planning-level estimates based on existing information and used only for initial comparison – they are subject to revision with more detailed evaluation in Phase II.

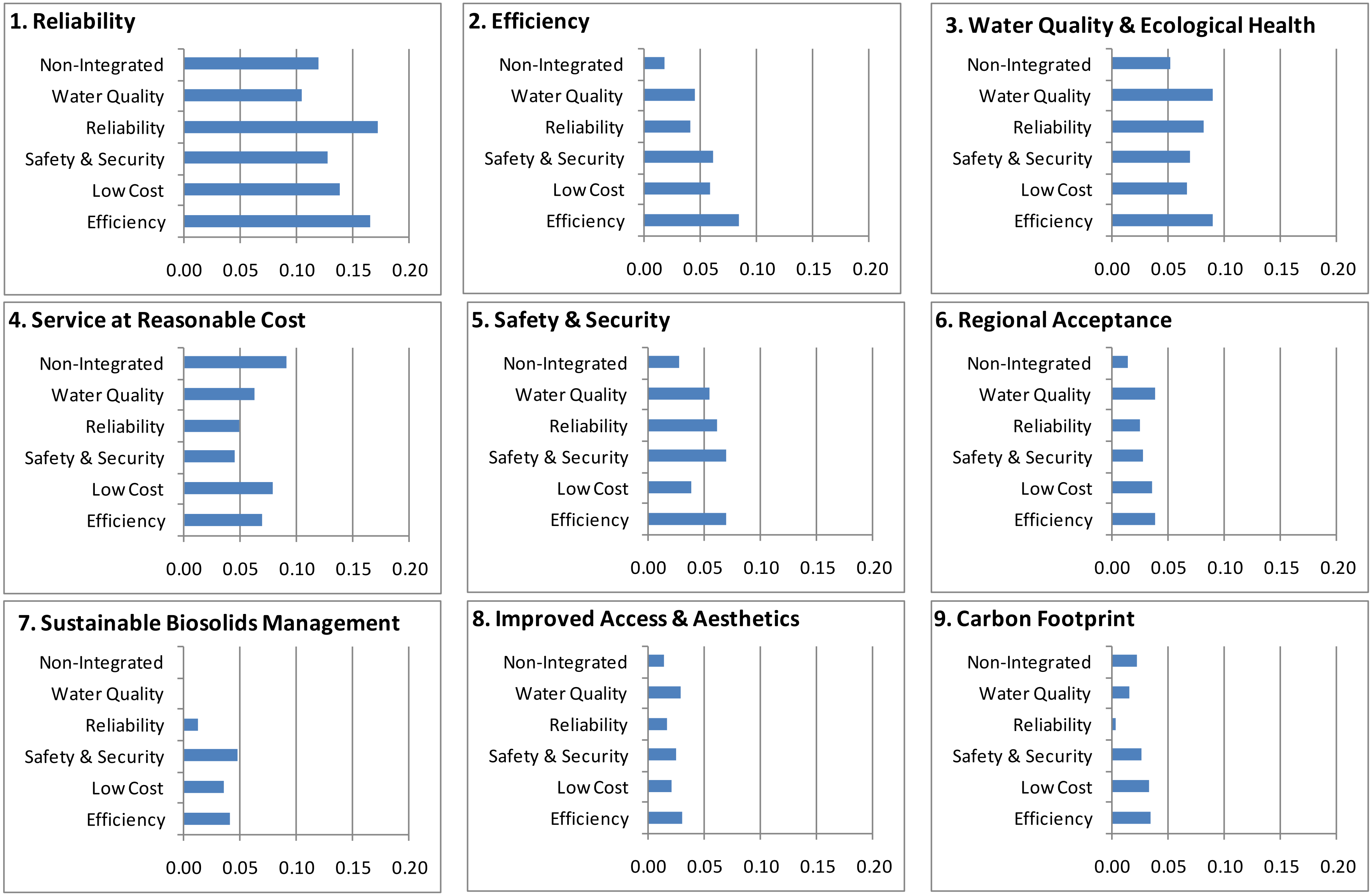


Figure 3-2
Weighted Objective Scores for the Initial Alternatives

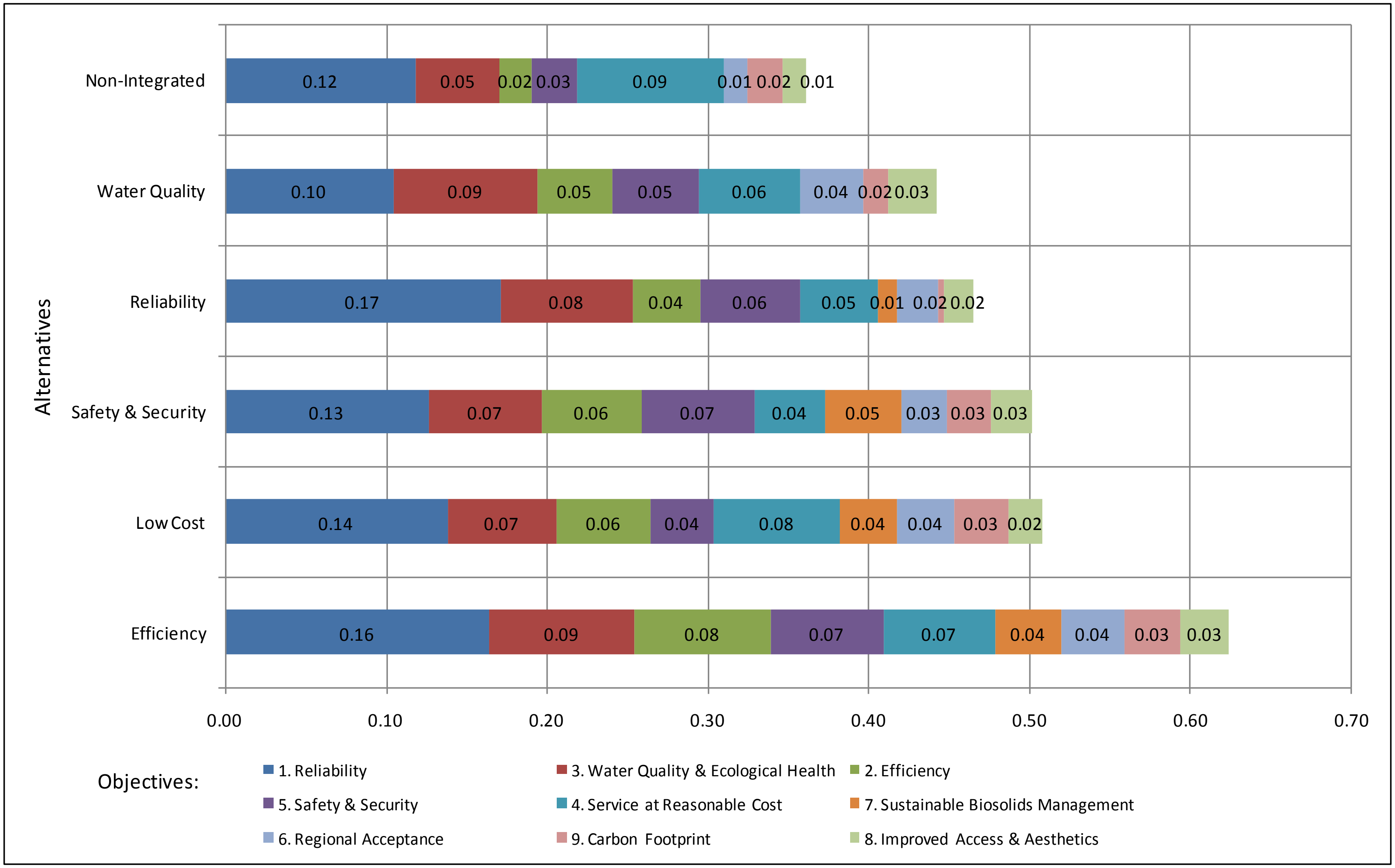


Figure 3-3

Composite Scores for the Initial Alternatives

Based on the initial analysis, "Efficiency" was the overall best scoring alternative, significantly outperforming the remaining alternatives based on the performance measures; however, generally, all five alternatives scored well with respect to the objectives they developed to target (i.e., "Reliability" scored the best in the reliability performance measures). A closer analysis of results reveals that while safety and security and low cost had similar scores overall, the composite scores differed in their components. The "Low Cost" alternative does not score well for the performance measures under the safety and security (5) and sustainable biosolids handling (7) objectives; and "Safety & Security" does not score as well for the cost (4) objective.

The composite scores shown in Figure 3-3 are not intended to rank the initial alternatives for inclusion in the final IWRP; rather, they served to help the stakeholders understand the potential trade-offs involved with selecting different sets of options. Each and every alternative scored well overall, but for different reasons and for scoring well in regards to different objectives. A potential hybrid alternative would be to combine the projects that resulted in high scores in each of the alternatives. Examples include merging the "Safety and Security" and "Efficiency" alternatives to take advantage of the higher scoring options for each or modifying the "Water Quality" alternative, aimed at improving water quality, to improve scoring on the performance measures for the efficiency objective. This is likely due to the selections of project options included in the alternative, which do not include building reclaimed water distribution infrastructure, addressing inflow and infiltration, or conservation. Augmenting the "Water Quality" alternative with these types of projects would likely result in a hybrid alternative that would score better than the original alternatives. This analysis of project options and trade-offs allowed the technical team, steering committee and stakeholders to ultimately define new hybrid alternatives.

3.5 Hybrid Alternative Development

During Workshop 4, the stakeholders reviewed the results from the initial alternatives analysis and discussed possibilities for improving the alternatives by creating hybrids aimed at meeting multiple objectives. The stakeholders developed four hybrid alternatives and agreed to recommend that each of them be studied further in Phase II of the IWRP process. Each of these hybrid alternatives scored better than their original base alternatives. The revised results from these hybrid alternatives are included in **Figure 3-4**. The recommended hybrid alternatives from Phase 1 were:

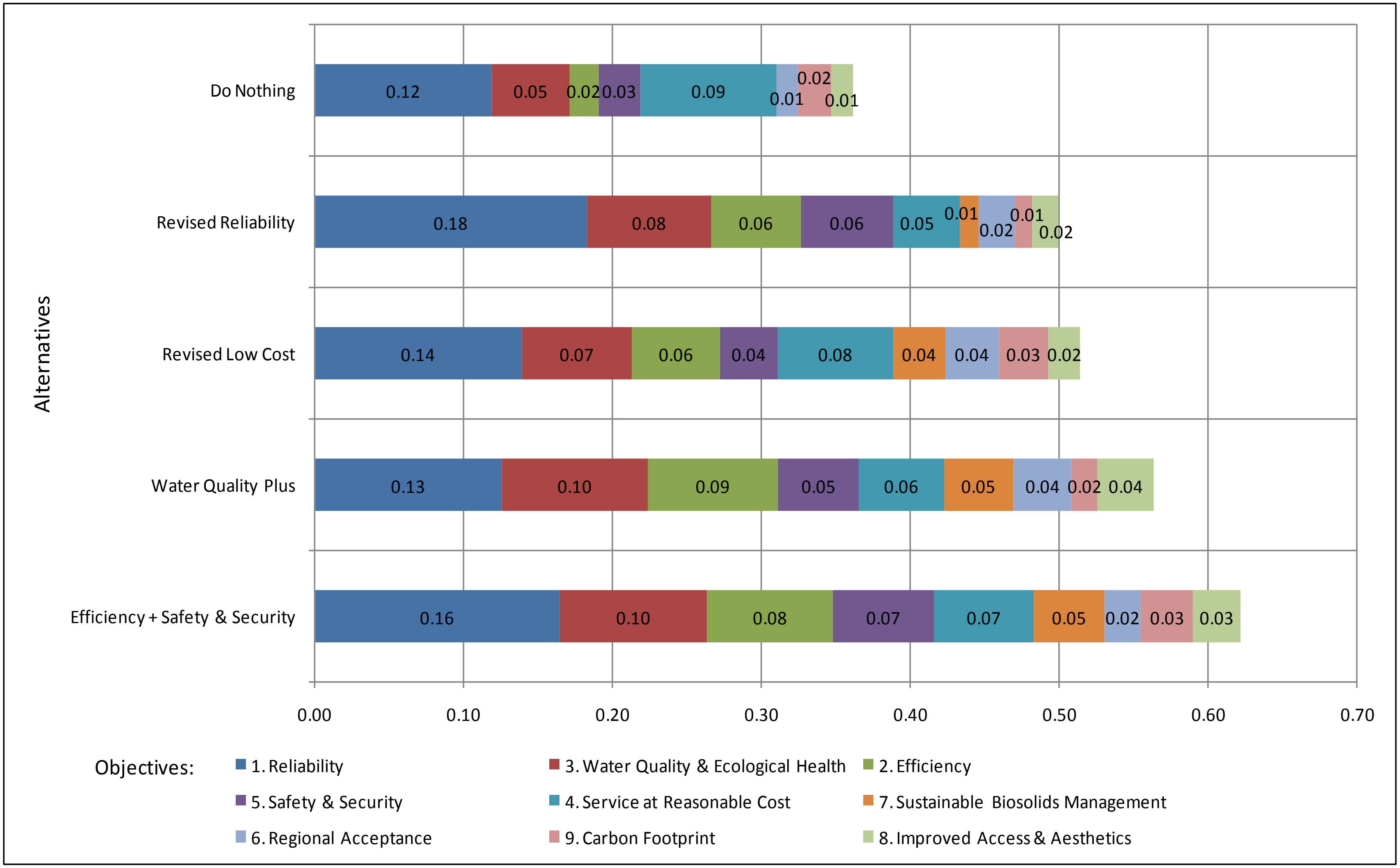


Figure 3-4
Composite Scores for Recommended Hybrid Alternatives

"**Efficiency + Safety & Security**" – Through the analysis and discussion of the separate alternatives ("Efficiency" and "Safety & Security"), a combination of the options in these two alternatives were selected with the intent of maximizing the performance of the resulting hybrid alternative. This includes all stormwater, distribution system, collection system, conservation, reclaimed water, and ecological restoration options (except addressing the dump site, which is not included in any alternative due to lack of information defining the project, namely cost, at this time). Water supply options include repair of the raw water reservoir, upgrading the existing drinking water treatment plant (WTP) to a 4 mgd facility, and purchasing all remaining water from Harpeth Valley Utility District (HVUD). Wastewater will be accepted from other small communities and a new WWTP will be constructed at the proposed Goose Creek site. Biosolids handling will be improved by upgrading the facility for biogas- to-energy and processing biosolids for potential land application.

"**Water Quality Plus**" – The initial "Water Quality" alternative was improved by selecting projects in the distribution system, water conservation, and reclaimed water sectors, due to the fact it had the second lowest efficiency score of the five initial alternatives. This hybrid alternative includes all stormwater, distribution system, collection system, conservation, reclaimed water, and ecological restoration options. All of the water supply for the City will be purchased from HVUD; no water will be withdrawn from the Harpeth River. The existing WWTP will be upgraded to sufficient capacity to treat Franklin's and neighboring small communities' wastewater and to treat effluent in the summer months to a higher standard. Biosolids handling included upgrading to produce Class A solids and biogas-to-energy.

"**Revised Low Cost**" – The initial "Low Cost" alternative was modified in its wastewater treatment plant (WWTP) option, switching from building a new WWTP at Goose Creek to upgrading and rerating the existing plant to treat wastewater flow through the planning period. This alternative includes all conservation options and no stormwater options. Select, low cost options for the distribution and collection systems are included. Only the removal of the low-head dam (which is not considered to be entirely funded by the City) is included as an ecological restoration option. Reclaimed water options that do not involve building new lines or converting tanks are included. The water supply option is to update the existing 2.1 mgd plant, repair the reservoir, and purchase the remaining water needed from HVUD. The wastewater option is to upgrade and rerate the existing plant only. Biosolids handling will include upgrading to biogas-to- energy (to recover energy costs) and transport the solids to a landfill for disposal and processing.

"**Revised Reliability**" – The initial "Reliability" alternative was modified to include water conservation projects, because the initial score for efficiency was the lowest of the five alternatives. This alternative included all conservation options, stormwater options that focus on reuse, collection and distribution system options that aim to provide customers with a more reliable service, and no ecological restoration options. The water supply option includes a new transmission line from the Cumberland River and upgrades the Franklin WTP to treat all of the City's water based on this improved supply. The existing WWTP will be upgraded and rerated and a new plant will be constructed at the proposed Goose Creek site. Several, though not all, reclaimed water options are included. Biosolids handling will be improved by upgrading both to

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produce the smallest volume of solids as reusable products or ash which would be disposed in a landfill.

Table 3-4 summarizes the four recommended hybrid alternatives and their associated project options. In addition to the four hybrid alternatives, the current management practices were carried forward as a "Non-Integrated" alternative. This alternative was created because it was evident from the initial evaluation process that the City could not simply maintain the status quo with expansion or improvements to facilities occurring as needed in a reactionary rather than proactive approach and it was helpful to stakeholders to demonstrate the improvements from the current practices to any of the integrated solutions in a comparative process.

3.6 Summary and Phase II Objectives

At the culmination of Phase I activities a report was prepared that documented the stakeholder process, as well as development of the integrated system model, technical data and assumptions, and other information used to screen alternatives that were carried into Phase II of the IWRP. The report is provided in Appendix A. As a result of the recommendations from Phase I of the IWRP, the Phase II process was commenced to conduct the following:

- Detailed technical analysis of the recommended hybrid alternatives
- Detailed cost analysis of key project options
- Continued modeling and screening of the plans to compare and rank them
- Continued interaction with stakeholders, steering committee, and public
- Conceptual analysis, as necessary, to support cost and performance estimation (siting, sizing, performance, needs, etc.)
- Identification of a single preferred plan (the IWRP) from among the alternatives
- Development of a permitting plan for the identified projects
- Financing plan for the implementation of the IWRP to be utilized for future cost of service and budgeting analysis
- Phasing plan for project implementation

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Table 3-4 Hybrid Alternative Option

		Non Integrated	Efficiency + Safety & Security	Water Quality +	Revised Low Cost	Revised Reliability
Overall System	SCADA System		X	X	X	X
Wastewater Treatment	*WW Explanation*	*Existing plan capacity not sufficient to meet demands; assumed that capacity is added, as needed basis*	*Maximize existing plant, and build additional capacity at new site*	*Maximize existing plant, and build additional capacity at existing site*	*Maximize existing plant, and build additional capacity at existing site*	*Distribute capacity between existing plant, new capacity at existing location, and new capacity at new location*
	Existing Plant 12mgd	X	X	X	X	X
	Existing Plant 16mgd		X	X	X	
	Parallel 4 mgd Train at Existing Plant					
	Parallel 6 mgd Train at Existing Plant					X
	Parallel 8 mgd Train at Existing Plant			X	X	
	South Plant 4 mgd					
	South Plant 6 mgd					X
	South Plant 8 mgd		X			
	Accept WW from Lynnwood/Cartwright		X	X		
	Higher Standard Effluent in Summer			X		
Water Treatment	Update 2 mgd plant + HVUD Purchase	X			X	
	Upgrade to 4 mgd + HVUD Purchase		X			
	Shut down WTP + HVUD Purchase			X		
	Cumberland River Line (no HVUD or Harpeth supply)					X
Reclaimed Water	Upgrade Pump to 12 mgd		X	X		X
	Add Probable Customers		X	X		X
	Add Uncertain Customers					
Collection System	Collection System Model		X	X	X	X
	Convert Septic Users		X	X		X
	Rehab System for II Reductions		X	X	X	
Distribution System	Distribution System Model		X	X	X	X
	Short Term Water Quality Improvement Projects		X	X		X
	Long Term Supply Projects		X	X		X
	Address Non-Revenue Water		X	X	X	
Stormwater	Stormwater BMPs		X	X		
	LID Practices in New Development		X	X		X
Conservation	Irrigation Controls		X	X		X
	Toilet Replacement Program		X	X		X
	Additional Conservation		X			
Ecological Restoration	Low Head Dam Removal		X	X	X	
	Restore Harpeth Streambanks		X	X		
	Restore Five Mile Streambanks		X	X		
	Restore Sharpe's Branch Streambanks		X	X		
	Restore Additional Tributaries			X		
Biosolids	Anaerobic Digestion & Solar Drying		X	X	X	X
	Hauling to Landfill	X				

Section 4
Phase II System Analysis

This section provides a summary of results of the detailed technical analysis completed during Phase II related to the modeling overview, Harpeth River analyses and technical aspects of the water resources analysis including drinking water, wastewater, reclaimed water, stormwater, ecological restoration and water conservation. The technical memoranda developed to document the detailed technical analyses of each phase during this planning process are referenced as supporting materials and are provided in Appendices B through H.

4.1 Integrated Modeling Overview

The integrated systems model is not a high resolution parametric model aimed at reproducing hydraulic or biochemical processes in a given system. It is a platform to integrate general response patterns and the interdependence of subsystems to compare the alternatives to one another. This is accomplished by defining and developing empirical relationships between the water, wastewater, stormwater, and reclaimed water subsystems. For this project, the integrated model was developed specifically to help stakeholders and decision-makers understand the interconnectivity between the various water resources and utilities within the project area.

The integrated systems model analyzes a variety of system responses by simulating different plans and their impacts on flows, demands, pollutant loads, costs, and quality of the water resources in the study area. The objectives of the model were to provide the following functions in support of stakeholder decisions:

Provide technical information including:

- Results for the quantitative performance measures,
- Impacts of decisions aimed at one water resource on all others, and
- Sufficient detail to distinguish the broad benefits and impacts of alternatives across the resources and utilities that are under evaluation (e.g., water, wastewater, stormwater, reclaimed water, Harpeth River).

Provide screening and aid in plan formulation by answering questions, such as

- What project options work well together?

- Are there combinations of project options that counteract each other?
- What projects offer little or no benefit?
- How well does an alternative satisfy the broad, collective interests of the stakeholders?

4.1.1 Model Approach

Franklin's water resources are a network of natural and man-made systems that satisfy demands on water (e.g., irrigation, industrial use, human consumption, habitat, and recreation). Water moves between these network segments through completely natural, altered natural, and man-made pathways. The simulation model of the City's water resources system was developed to represent the system's segments and their interconnectivity and the model can simulate movement of water and, in some cases, pollutant loads through the system.

Figure 4-1 is a schematic representation of the City's water resources system model that was developed for the project. Colored boxes represent the model segments and colored arrows with link segments represent the flow of water throughout the system. Each colored arrow has an indicator for representation of flow or flow and load. Gray boxes and black arrows indicate data input and calculations involved in determining how the system operates. There are four different types of calculations or values used in the integrated system model, described below and indicated on the schematic using the corresponding number:

- Data – information input directly into the model from historical records or known values (e.g., plant capacity, rainfall records, streamflow and water quality).
- Residual Calculations – values resulting from mass balance calculations (e.g., wastewater effluent flowing to the river is the total effluent created less the effluent needed for reuse as irrigation water).
- Scientific Calculations – calculations using engineering equations or theoretical values (e.g., Manning's equation for open-channel flow).
- Relational Calculations – values resulting from dependencies on other variables (e.g., phosphorus loading to the river depends on volume of wastewater effluent flowing to the river).

The simulation model operates on a daily time scale in order to examine the effects of all system operations on flows in the river. While a monthly time scale would be most appropriate for the resolution of this model, monthly averaging of flow data tends to suppress recognition of low-flow periods that are important to consider in the analysis. A single major storm event can cause an otherwise dry month to appear normal when flows are averaged over the time period. In addition, flow data is readily available from USGS measurements at two stream gages within the City limits; and therefore, it is not necessary to consolidate data as is sometimes practiced to minimize uncertainty in hydrologic estimates.

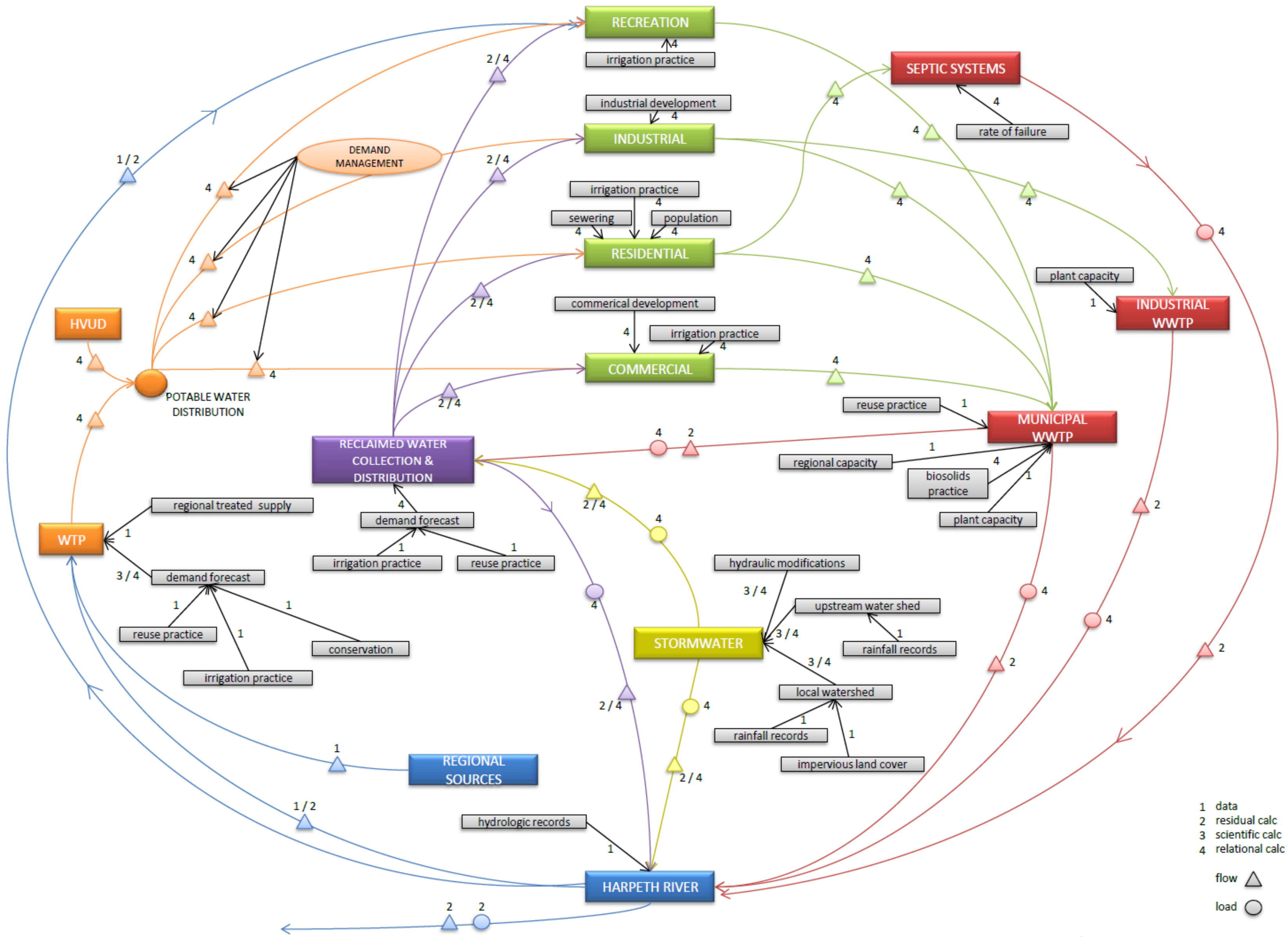


Figure 4-1
Franklin Integrated Systems Model Schematic

In order to organize development of the integrated model, the model is divided into segments which represent the categories of the City's water resources: the Harpeth River, water supply, wastewater, reclaimed water and stormwater. These sectors of the water resources system are interconnected so decisions or policies aimed at managing water within one sector often has direct effects and interacts with the other systems. For example, increasing the volume of reclaimed water usage would effectively decrease demand on the potable water supply and treatment associated with irrigation demand; however, it would also decrease the volume of effluent discharged to the river limiting the supplemental flow during potential low-flow periods. The model sectors, interrelations and their connections are discussed further in this section. In addition, the detailed explanation of the development of the model was provided in the Franklin IWRP Phase I Report, Appendix A.

4.1.1.1 Harpeth River

The inflows and withdrawals from the Harpeth River system are modeled as defined in **Figure 4-2.** Inputs are labeled with letters corresponding to how they are added across the system and are summed to calculate the downstream flow equation. Input A is the upstream boundary condition for the model. Inputs B and C are dependent upon the options selected under the scenario being modeled for the associated wastewater and stormwater options. The WTP withdrawal (D) is a function of the demand for potable water, limits on river withdrawals, the intake pump capacity, the raw water reservoir level and capacity, and the WTP treatment capacity. Input E, stormwater volume into the river, is represented by a single addition to the river flow, rather than a continuous input along the length of the river. This input represents the total volume of stormwater flowing into the river within the modeled city area. Though much smaller by comparison, base flow return to the river (G) is also quantified at a single point and includes irrigation and septic system recharge only as precipitation infiltration changes are indirectly quantified within the stormwater calculations. Input F is the discharge from the existing and potentially expanded WWTP and is the result of various factors including; but not limited to, potable water use, sewer flows, WWTP capacity, and reclaimed water use.

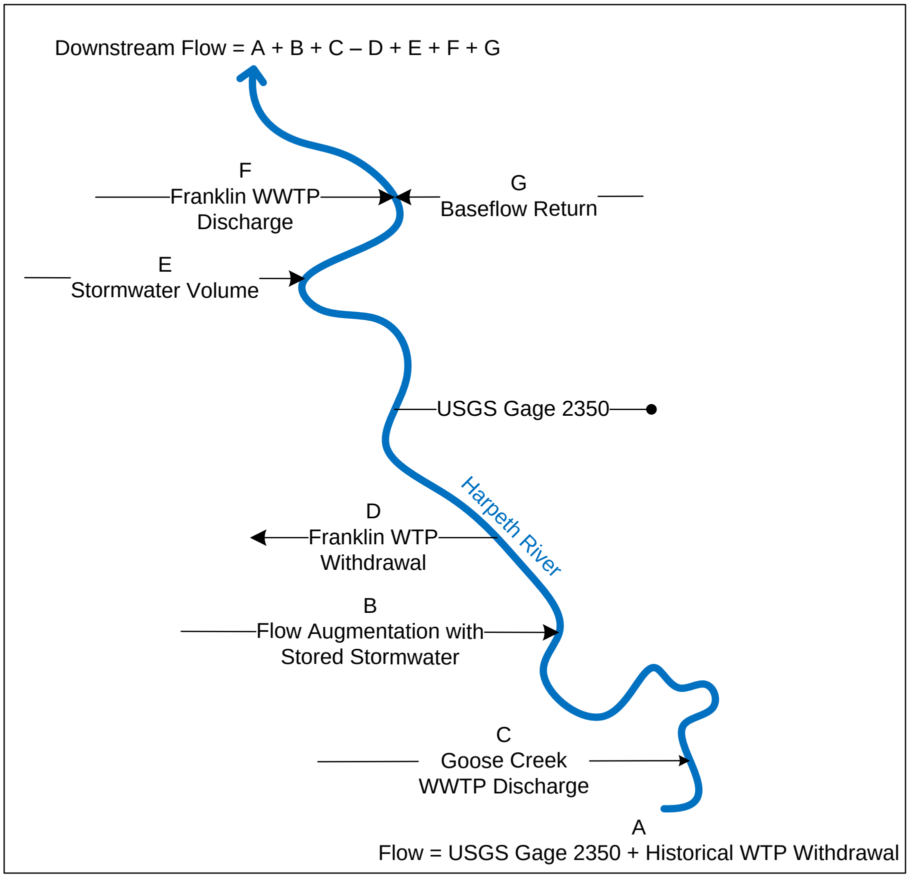


Figure 4-2
Spatial Orientation of Modeled Harpeth River Inflows and Outflows

4.1.1.2 Potable Water Demand and Supply

Franklin's water demand projections are documented in the Water Resources Demand Projections Technical Memorandum (Appendix A). The model utilizes the estimated future demand associated with the City's water service area, which is less than the City's total demand due to the fact many areas of the City are served by one of the other utility districts. The model generates total water demand for the City, and then partitions demand into that which is met by the City system and that which is met by the other utilities as presented in **Table 4-1**.

Table 4-1 Annual Total Water Demand Projections

Projected Demand Year	Total City Water Demand (MG)	Percent of Total City Demand Served by Franklin
2015	4,190	65.0%
2020	4,840	62.5%
2025	5,440	60.0%
2030	6,300	57.5%
2035	7,340	55.0%
2040	8,330	52.5%

The Franklin IWRP explored multiple pathways for producing the supply and treatment of the potable water necessary to meet the City's demands:

- **Harpeth River raw water supply and treatment at existing WTP**: Under multiple modeled IWRP alternatives and under existing conditions and operations, water is drawn from the Harpeth River at maximum allowable rates, as governed by pump capacity and low flow withdrawal constraints. The water available for withdrawal in the Harpeth River is specified by the 2007 Aquatic Resource Alteration Permit (ARAP). The City can withdraw up to 20% of the total flow within the river; however, this withdrawal is limited by pump capacity into the raw water reservoir. Per the ARAP, all river withdrawals must cease when the Harpeth River flow drops below 10 cfs.

- **Regional wholesale purchase:** Regional potable water wholesale sources, primarily Harpeth Valley Utility District (HVUD), are included in the model to supply all remaining City demand that cannot be met with water from the Harpeth River. It is also a possible option to configure the model to supply all of the City's demand by purchasing treated water from HVUD. The agreement between the City and HVUD stipulates a minimum purchase requirement. Based on the current agreement with HVUD, the capacity of the HVUD infrastructure is expected to be adequate to meet their committed portion of the City's demand through 2040.

- **Cumberland River raw water supply and treatment at existing WTP:** The integrated model includes an option for the City to meet all of its potable water demand by constructing a pipeline to transport raw water from the Cumberland River to the existing Franklin WTP. As part of this option, the WTP would be upgraded to a capacity possible to treat all of the City's water demand.

The water supply sector of the model uses user-specified input, along with natural and imposed constraints on the system, to draw water from one or a combination of the sources listed above. Raw water, either from the Harpeth River or other regional sources (i.e. Cumberland River), enters the system through the raw water reservoir. Basic reservoir inflows and outflows are included in the model, including direct rainfall, evaporation, leakage, and backwash. Water from the reservoir flows, as demanded, into the Franklin WTP and is then combined with regional treated sources to meet total potable water demands. Different scenarios modeled for the Franklin IWRP use different combinations of water sources to evaluate the cost and performance of the City's various water supply options.

The treatment capacity of the City's WTP presents a constraint for raw water coming into the water supply system. The existing capacity is 2.1 mgd, and three options are included in the model for future capacities: maintain the existing 2.1 mgd, upgrade the plant to a capacity of 4.0 mgd, and/or upgrade the WTP to a capacity that would treat all of the City's demand for the planning period.

4.1.1.3 Wastewater Treatment

The integrated model includes several options for meeting the City's long-term wastewater treatment capacity needs. Franklin's wastewater demand projections are documented in the Water Resources Demand Projections Technical Memorandum (Appendix A). The WWTP effluent can be treated and utilized as the reclaimed water source and sent to the reclaimed water distribution system for use or storage. The flow not utilized by the reclaimed water system is discharged to the Harpeth River as part of the City's NPDES permit. Pollutant loading to the river is calculated based on the discharge volume and the permitted effluent concentrations.

The City's WWTP treats most of the wastewater generated within the municipal boundaries of the city. The model generates wastewater demand projections based on the total city water demand projections. Analysis of City records of water use and wastewater flows, as well as data from collection system monitoring, estimate that an annual average of 76.5 percent of water metered for household use returns to the WWTP. Water metered for household use also includes many outdoor uses, as most of the City's residents do not have separate irrigation meters. This wastewater return fraction varies throughout the year. Estimates of rainfall-dependent inflow and infiltration (5 – 31% of total wastewater flow under baseline conditions) and groundwater infiltration (1 – 27% of total wastewater flow under baseline conditions) are added to the household-generated wastewater flows to calculate the total WWTP demand. **Table 4-2** shows the projected total wastewater flows for the City through 2040. The total flow generated could be reduced by implementing water conservation measures or inflow and infiltration control practices.

Table 4-2 Annual Total Wastewater Generation Projections

Projected Demand Year	Total City Wastewater Generation (MG)
2015	3,490
2020	4,040
2025	4,540
2030	5,260
2035	6,120
2040	6,960

The Franklin IWRP includes multiple options for wastewater treatment capacity analysis and comparison:

- **Existing WWTP:** Based on additional IWRP Phase II analysis, the existing WWTP could be upgraded to a capacity of 16 mgd through hydraulic and biological treatment improvements. This would be a potential interim solution to the City's wastewater capacity, but could not fulfill the demand for wastewater treatment for the entire planning period.

- **Parallel treatment train to add capacity to the existing WWTP location:** Additional capacity can be added to the existing WWTP location by building a parallel treatment train, adding up to 12 mgd of additional capacity to meet the planning period demand (total capacity of 24 mgd).
- **New Goose Creek WWTP discharging upstream of the City:** The construction of a proposed WWTP in the Goose Creek area would allow for the additional capacity, in phases, of up to 12 mgd of additional capacity to meet the planning period projected demand.

The IWRP alternatives specify a combination of the WWTP treatment options listed above to meet the City's 24 mgd demand requirement for the planning period. If a new treatment plant is built in the Goose Creek area, the increased discharge could potentially assist with flow within the Harpeth River including increasing the frequency and volume of water withdrawal for drinking water treatment under the ARAP. For this reason, a rule has been added to the model to force up to 4 mgd of effluent to the river from the new, upstream WWTP before the remainder of the effluent is available for reuse. The variability of the availability for reuse allows the various project options and scenarios to be analyzed to help establish the best balance between effluent flow augmentation and reclaimed water demand.

4.1.1.4 Wastewater Reuse

The City has infrastructure in place to reuse wastewater effluent (reclaimed water) for irrigation at sites throughout the City. The current capacity of the reuse system is limited by the reclaimed water pump station to 6.0 mgd. The integrated systems model uses estimates of probable users projected irrigation needs as the basis for reuse demands. This sector of the model was revised during Phase II to reflect a more modest projection for total reuse demand. Probable customers include those who can reasonably be expected to tie-in to the reclaimed water system or those that are in close proximity to existing reclaimed water infrastructure and have future probable potential for hook-up. The existing and probable reclaimed water demands are estimated at 520 and 670 million gallons per year, respectively, totaling 1,190 million gallons of estimated demand per year, or an average of 3.3 mgd. Using these modest reclaimed water projections, the City should be able to meet reclaimed water demand through 2040 with the projected wastewater effluent flows; however, the largest issue is the potential to store reclaimed water during low demands and supplement flows during high demand. The potential upgrades for the reclaimed water system include upgrade of the reclaimed water pump station from 6 mgd to 12 mgd and associated distribution improvements to add additional probable customers.

4.1.1.5 Stormwater

The model uses a representative volume of stormwater generated by three broad land use types within the City based on streamflow data and river withdrawals and discharges over the hydrologic period of record (1975 through 2009). There are two USGS streamflow gages on the Harpeth River in Franklin: gage 2350 is upstream of most of the City, located just downstream of the WTP intake; gage 2400 is downstream of most of the City, located just downstream of the

WWTP discharge. The difference in drainage area of these two gauges (19 square miles) is used as a representative subset of the Harpeth River watershed within the City for the purposes of the integrated systems modeling. Pollutant loading to the river from stormwater runoff is estimated based on the model's calculated stormwater volumes and pollutant concentrations for the different land uses. The typical pollutant concentrations have been revised based on Phase II investigations, and are shown in **Table 4-3**.

Table 4-3 Typical Pollutant Concentrations in Stormwater Runoff

Land Use Type	Biological Oxygen Demand	Total Suspended Solids	Total Nitrogen	Total Phosphorus
Residential	10.9	50	0.58	0.31
Commercial	11.4	48	0.62	0.23
Undeveloped	8.25	72	0.85	0.33

The Franklin IWRP explores multiple stormwater management practices to reduce the impacts of stormwater on the Harpeth River and its tributaries. The model calculates the reduction in stormwater pollutant loading from baseline conditions by using estimated pollutant removal rates for various best management practices and low impact development technologies, and applying those reductions to the appropriate land use-generated stormwater flows.

4.1.2 Model Software

The integrated model was developed utilizing the STELLA software tool (Systems Thinking Experimental Learning Laboratory with Animation). STELLA is a dynamic and graphical tool used to simulate interactions between, and within, subsystems that are part of a larger interconnected system. It is frequently used in environmental engineering analyses to better understand the implications of decisions across a broad array of social and environmental sectors.

STELLA is a graphical system simulation package that allows users to model physical flow systems with operational or planning level resolution. The software allows users to develop on-screen control interfaces that facilitates rapid adjustments of system variables for alternatives and sensitivity analyses. When dozens of alternatives are feasible (be they alternate water sources, use and reuse guidelines, operational triggers, etc.), STELLA can rapidly help planners and decision makers screen information, identify key drivers, and understand the causal relationships throughout the big picture of a complex system.

Fundamentally, STELLA helps screen options and alternatives, providing numeric scores for performance measures identified as quantitative. In this context, STELLA does not make decisions, but it can be used to generate information and promote more informed and balanced decisions via rapid comparison of the performance of alternatives using physical, environmental, and economic metrics. Its ability to include multi-sector evaluations in an analytical framework is what distinguishes it from more traditional hydraulic or hydrologic models which evaluate systems in a purely physical setting. The tradeoff with this model approach is in the level of resolution. STELLA models do not simulate small, discrete river basins, channels, or pipes but include key system elements and their interdependence in a lower-resolution network framework in which physical, environmental, and economic response patterns can be effectively examined.

4.1.3 Model Validations

The relationships in the model are based largely on empirical data (stormwater loads, for example) and straightforward combinations of mathematical terms (such as the linear addition or subtraction of flows and loads). The purpose of the model is not to reproduce the watershed and utility processes, but to better understand the interdependence of the processes and their sensitivity to future decisions through relative analysis and comparisons. Therefore, the model has been tested so that the input can be shown to reproduce current and/or historic patterns or trends and respond appropriately to changes. There are no parameters to calibrate, and the testing of the model relies on expert judgment to determine if the system responses are representative of actual and expected conditions.

4.2 Harpeth River

To appropriately understand the interaction of the water resource systems and their interdependance and effects on the Harpeth River, a hydraulic and water qulaity model of the Harpeth River was devloped as an important factor in the IWRP analysis. The input data to the Harpeth River hydraulic and water quality model were developed from USGS stream gage records and historic plant monthly operating reports (MORs) for the water and wastewater treatment plants on the river. Flow time series for the upstream boundary, tributary lateral boundaries, and direct runoff were developed using a mass-balance approach with the four main stem gages: Harpeth River gage 3432350 at the City, Harpeth River gage 3432400 below the City, Harpeth River gage 3433500 at Bellevue, and Harpeth River gage 3434500 at Kingston Springs. Tributary gage data was used where available, and basin transposition was used to calculate flows from ungaged tributaries. Daily discharge volumes and concentrations were input directly for the Franklin WWTP. The smaller Cartwright Creek and Berry's Chapel WWTPs had only monthly data available, so monthly average daily discharge and concentrations were used as input to the model. The WTP withdrawal records were used with the gage data to estimate flows upstream of the city. The modeled water treatment withdrawal was developed based on the City's practice of withdrawal of the approximate treatment plant capacity, or that which is allowed according to the ARAP.

4.2.1 Water Quality Model

During Phase I of the Franklin IWRP, water quality in the Harpeth River was addressed only through estimation of changes to pollutant loads into the river, and not with estimates of instream fate and transport of pollutants. To evaluate and compare alternatives, specific questions about instream water quality were addressed:

- Which IWRP alternative is likely to yield the best water quality in the Harpeth River in Franklin and downstream?
- What are the water quality benefits and impacts of the selected alternative?

- Are IWRP recommendations likely to change if upstream water quality (above the Franklin Urban Growth Boundary) is improved?

A dynamic water quality model of the Harpeth River was required to address these key questions, in addition to the generalized integrated system model developed in STELLA. At the time of this study, two water quality models of the Harpeth River had already been developed for other original purposes. A suite of models of the watershed loading, river hydraulics, and water quality processes was developed by EPA Region 4 as part of a TMDL for the river in 2004. Another model of the hydraulics and water quality processes has been developed and maintained by TVA with assistance from TDEC (River Management System, or RMS). Both models have strengths and limitations, and were compared in a memorandum, *Harpeth River Water Quality Model Comparison,* dated February 2011. A copy of this memorandum is included as part of Appendix A.

Ultimately, with collaboration and consensus of Tennessee Department of Environment and Conservation (TDEC), the RMS model was selected to support the IWRP study. It simulates the open channel flow in the river and instream water quality dynamics such as the nutrient cycle and dissolved oxygen levels. The model does not simulate rainfall-runoff relationships; therefore, stream gages on the Harpeth River were used to represent flows. A technical description of the model development and calibration processes is included in Appendix A.

4.2.1.1 Water Quality Study Area

The model focuses on the City of Franklin and the downstream reaches of the Harpeth River for approximately 13 miles downstream of the existing WWTP. The City of Franklin has no jurisdiction upstream of its Urban Growth Boundary, nor would any of the IWRP alternatives affect either flows or pollutant loads entering the City from upstream. Therefore, the upstream boundary for the analysis is just above the site of the proposed new wastewater treatment facility on the south side of the City, River Mile 92.4.

The downstream boundary was identified as River Mile 73, downstream of the confluence with the West Harpeth River. Because no field data on tributary flows or pollutant loads were available, this limit avoids the impact of uncertainty in tributaries affecting the model results, but it allows us to examine the impacts of IWRP alternatives for a reasonable stretch of the Harpeth River as it flows northward out of the City. **Figure 4-3** illustrates the model boundaries with respect to the City of Franklin and the Harpeth River Watershed.

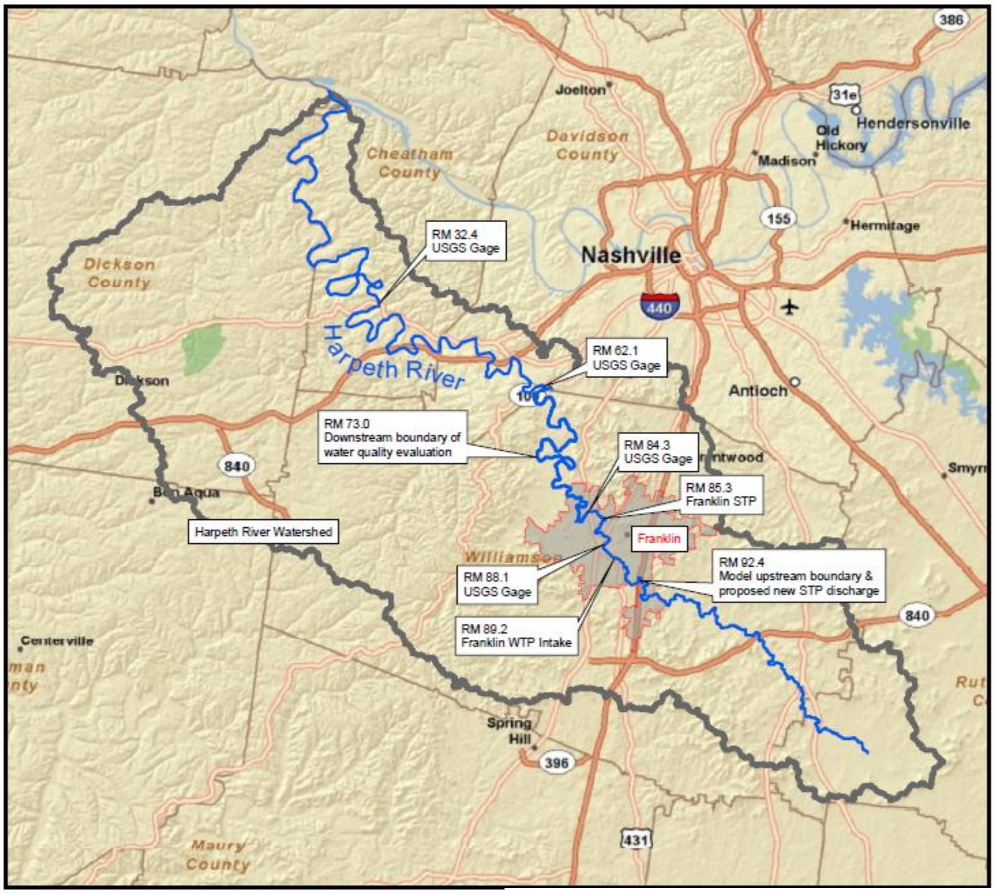


Figure 4-3
Water Quality Study Area

4.2.1.2 Simulated Processes

Fundamentally, the water quality model is comparable to tools such as HEC-RAS for river hydraulics and WASP for water quality analysis and is comprised of two different modules:

ADYN: This module accepts flow hydrographs at boundary conditions (upstream or at midstream loading points such as treatment plant discharges or tributary confluences) and routes flow hydraulically based on channel geometry and calibrated roughness coefficients (Manning's "n" values). The river is divided into segments approximately one half mile long, and the hydraulic characteristics of depth and velocity are averaged within each segment such that the hydraulic model produces flow, depth, and velocity for each river segment as input to the water quality module RQUAL (below). The module also simulates flow over weirs, which is applied at the low head dam currently used to impound water at the City's WTP intake. This module indirectly simulates residence time in impoundments and travel time through the study area, both of which can affect water quality. For the Harpeth River, only the main stem is modeled – tributary flows are entered as inputs into the main stem.

RQUAL: The module accepts output from the hydraulic model, as well as pollutant concentrations at the same boundary locations as flow. Inputs also include dissolved oxygen, sediment oxygen demand, and periphyton (fixed algae growing on the river bed) respiration and photosynthetic rates for each reach. The model computes concentration outputs at 30-minute time steps for the following parameters: particulate and dissolved nutrient (phosphorus and nitrogen), floating algae, and dissolved oxygen (including diurnal oscillations).

4.2.1.3 Alternatives and Scenarios

The Harpeth River model was used to simulate the potential impacts of the IWRP alternatives on water quality. Major features of the alternatives that were simulated included:

- Future changes in flow at the existing (north) WWTP
- Potential discharge from the proposed (south) WWTP
- Changes in withdrawal patterns from the river at the drinking water plant
- Removal of the low-head dam at the drinking water plant
- Estimated changes in stormwater flows and pollutant loads
- The effects of reusing water in the future (less pollutant discharge and less flow into river)

The hybrid alternatives developed by stakeholders in Phase I were compared for an entire calendar year that included very dry summer conditions, because dry conditions in the river are more sensitive to IWRP decisions than normal or wet conditions. Additionally, alternatives were analyzed with existing upstream water quality, which currently does not meet Tennessee water quality standards for dissolved oxygen, and with hypothetically improved upstream water quality conditions for comparison. Because the City does not have authority to affect upstream water management practices, and none of the IWRP alternatives included options that would affect upstream water quality, it was important to determine if hypothetical improvements upstream would change the relative performance of the simulated alternatives.

4.2.1.4 Model Testing and Calibration

There was an intensive process by which the Harpeth River model was developed, calibrated, tested, and reviewed by both an internal technical review committee and external specialists. The extents of the process to develop and utilize the Harpeth River model are described in the *"Harpeth River Water Quality Model for IWRP Analysis"* technical memorandum in Appendix A. The memorandum discusses data use, calibration techniques, resulting parameterization of the model, and the results of technical reviews.

4.2.2 Results of Water Quality Modeling

The primary measure used to compare alternatives with respect to water quality was dissolved oxygen, because concentrations must be above 5.0 mg/l to meet the designated uses of the

Harpeth River. While the model produced diurnal results for dissolved oxygen by simulating variations in the ratio of photosynthesis to respiration of biomass in the river, the daily average values were deemed sufficient to compare the alternatives. Unless otherwise noted, the graphs in this section depict daily average results for dissolved oxygen.

4.2.2.1 Existing Condition of the Harpeth River

Currently, the Harpeth River does not meet Tennessee standards for dissolved oxygen, upstream of the City, within the City, and downstream of the City. Records from 2007-2009 show excursions below 5.0 mg/l as illustrated in **Figure 4-4** (field data obtained by the City of Franklin). Also, as demonstrated by field data, water quality does not change significantly in response to the City's influence. In some cases, just downstream of the low-head dam (River Mile 86.5, for example), dissolved oxygen increases above upstream values because of reaeration. In addition, water quality in the river 6 miles downstream of the WWTP shows almost no variation from the water quality upstream of the City. This data suggests that the influences of the water management activities in Franklin, while they have an effect on the river, are not the dominant source of dissolved oxygen depletion. Through modeling, review of USEPA measured data, and discussions with TDEC, it was determined that sediment oxygen demand (SOD) and the pervasive presence of fixed algae (periphyton) is the leading cause of oxygen depletion, and the majority of the detrimental pollutant loads likely originate upstream of Franklin.

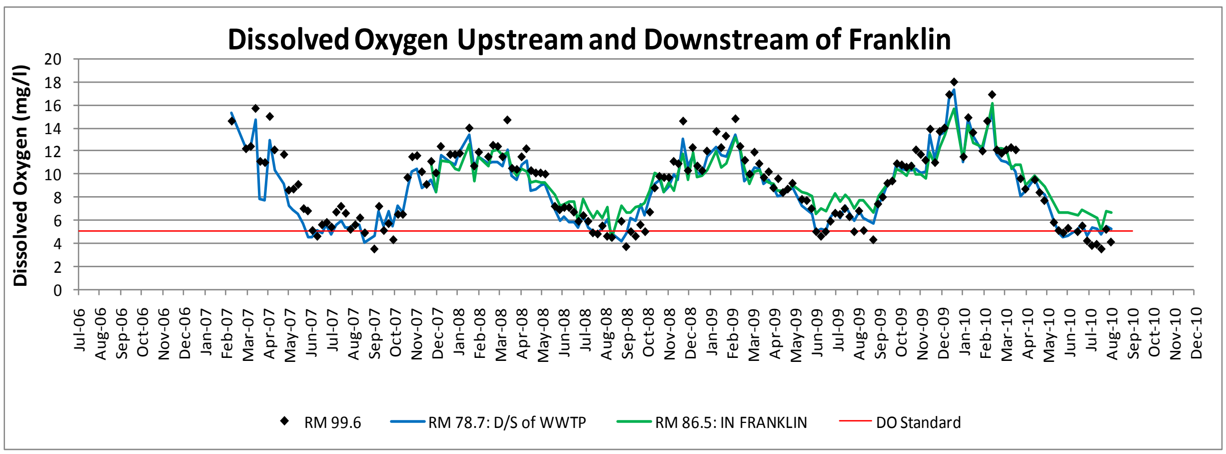


Figure 4-4
Existing Water Quality Upstream, Within, and Downstream of Franklin

4.2.2.2 Comparison of Alternatives

The purpose of this analysis is to provide a comparative basis for the alternatives by evaluating the alternatives as each impact the water quality of the Harpeth River. In order to demonstrate the key results, model output has been presented as follows:

- River data in profile from upstream to downstream
- Time series through the summer at key river miles
- Annual diurnal patterns of the preferred plan compared with the non-integrated plan
- Water quality with improved upstream conditions

- Comparison of IWRP loads to TMDL requirements

The model results for the hybrid alternatives are shown along the profile of the river at a specific time (July 15th of 2007, at midnight and at noon) in **Figures 4-5** and **4-6.** Alternative 1 showed the best improvement upstream of the dam because it includes the most effluent discharge from the proposed south WWTP which would be expected to boost DO levels as the effluent enters the river well oxygenated. Because this alternative also includes the removal of the dam, it reduces both the depth and residence time in the impoundment and avoids low sags in dissolved oxygen. Downstream of the dam, the alternatives are nearly indistinguishable. At the site of the existing WWTP, alternatives that include more discharge from the existing plant help elevate dissolved oxygen levels locally because of the oxygenation and increased flow; however, within five miles, the DO differences between alternatives is minimal. Results further downstream are not differentiable due to the uncertainty in loads from the tributaries, and for purposes of alternatives comparison, results essentially converge.

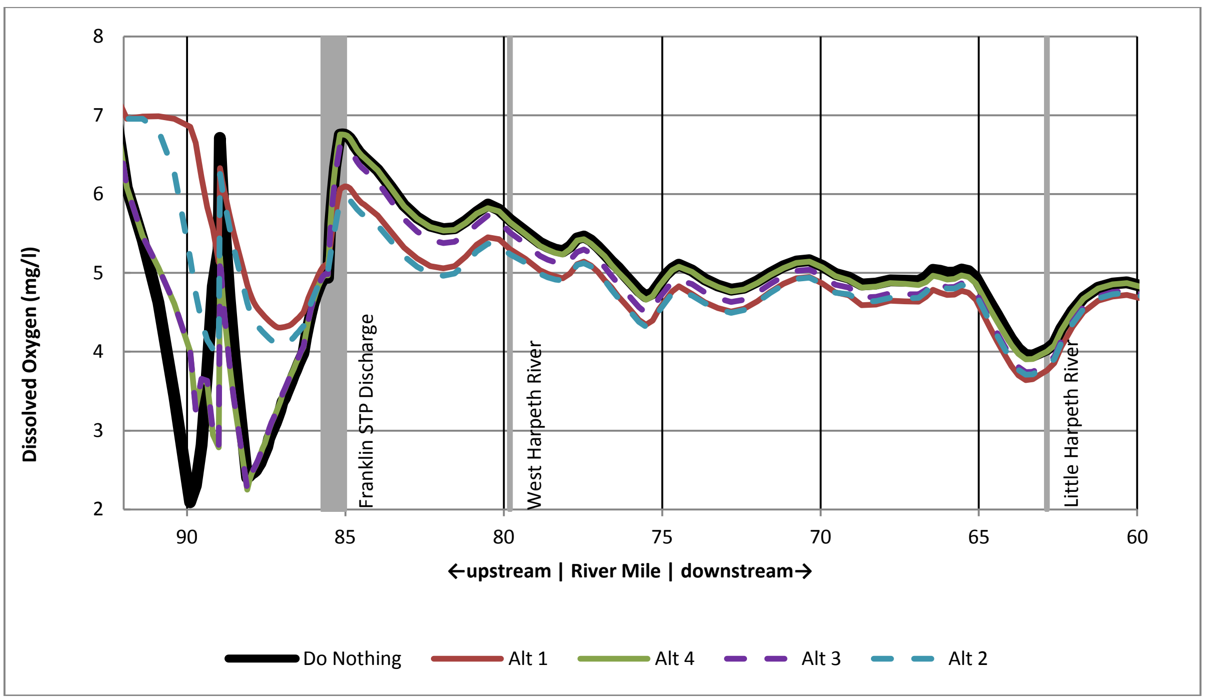


Figure 4-5
Dissolved Oxygen Pattern with Hydrology from July 15th 2007 at Midnight

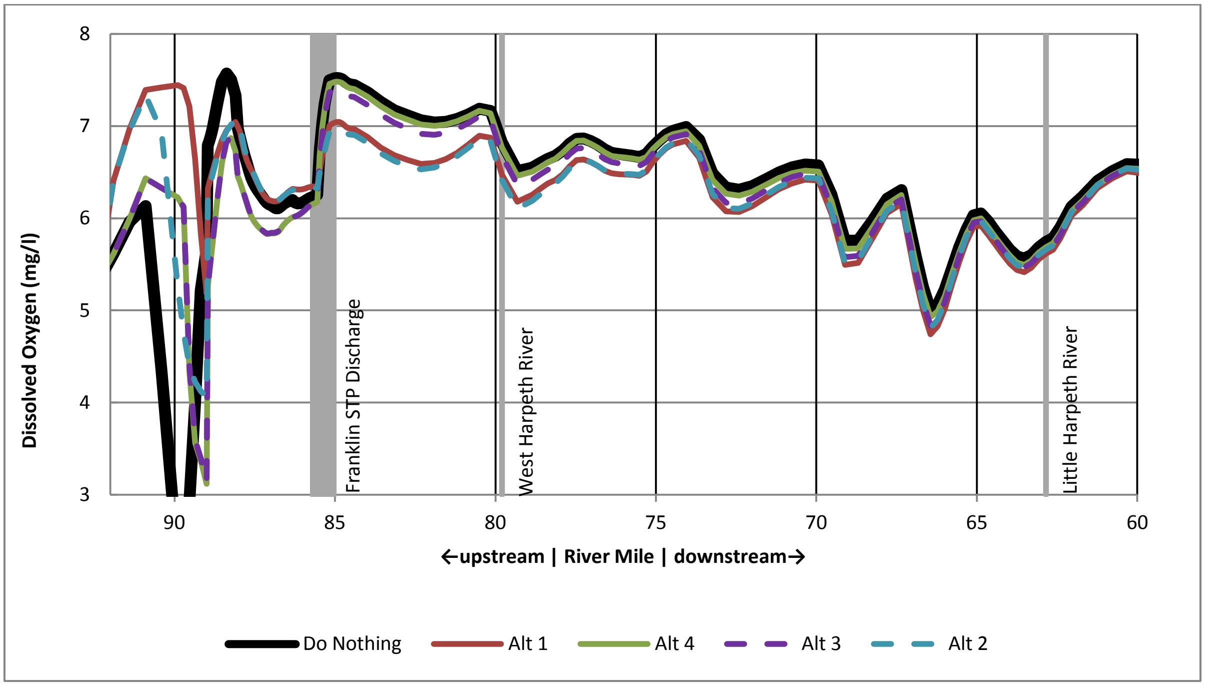


Figure 4-6
Dissolved Oxygen Pattern with Hydrology from July 15th 2007 at Noon

Time series plots of dissolved oxygen at 10:00AM are shown at key river miles in **Figures 4-7**, **4-8**, and **4-9**. Between the water intake and the existing north WWTP (River Mile 87.4), the alternatives that discharge effluent from the proposed south WWTP show an increase in dissolved oxygen during the lowest flow period. This applies further upstream as well, beginning at approximately River Mile 92 where the proposed WWTP would be located. This is the reach that has been the most heavily impaired prior to the IWRP because of the impoundment and degraded upstream water quality conditions. Just downstream of the existing WWTP (River Mile 83), alternatives that rely more heavily on the expansion of this facility without the proposed WWTP show higher dissolved oxygen. Again, these local effects are due to the high oxygenation of the effluent, which can help an oxygen-starved river during periods of critical low flow. Downstream at River Mile 77, alternatives trend toward convergence and the model cannot track downstream dynamics of the oxygen sags due to a lack of data for the tributaries.

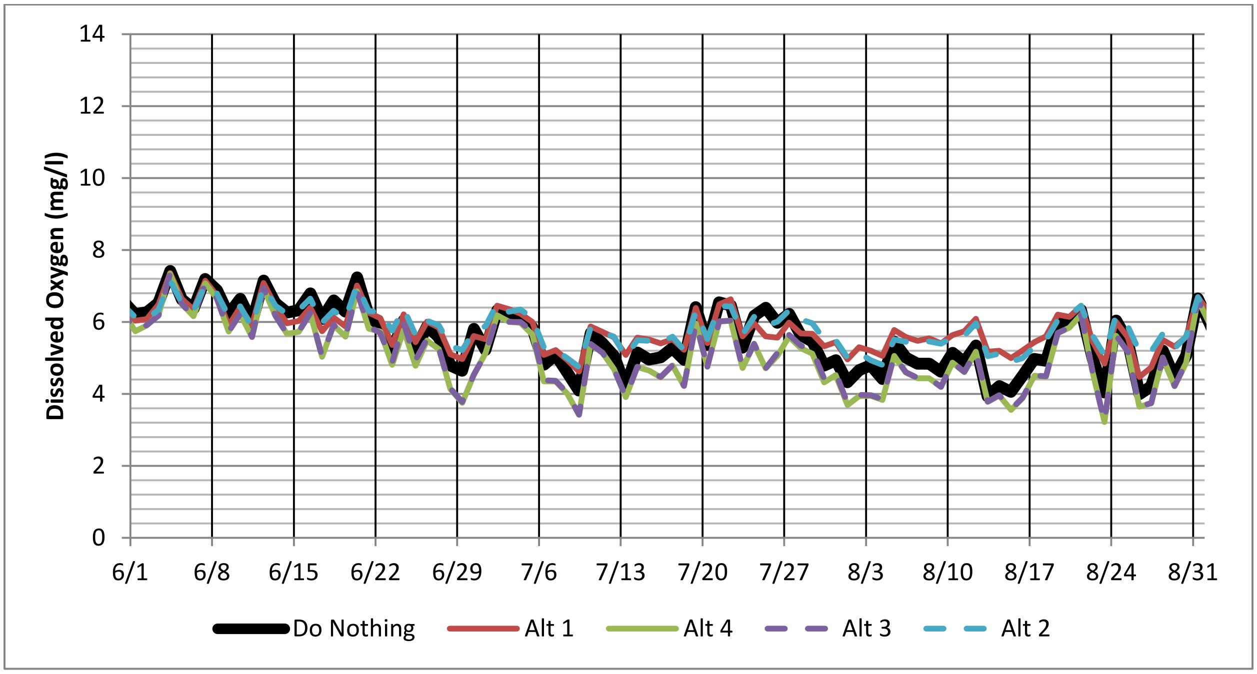


Figure 4-7
Simulated Dissolved Oxygen at 10:00 am, River Mile 87.4 (downstream of dam, WTP, and South WWTP)

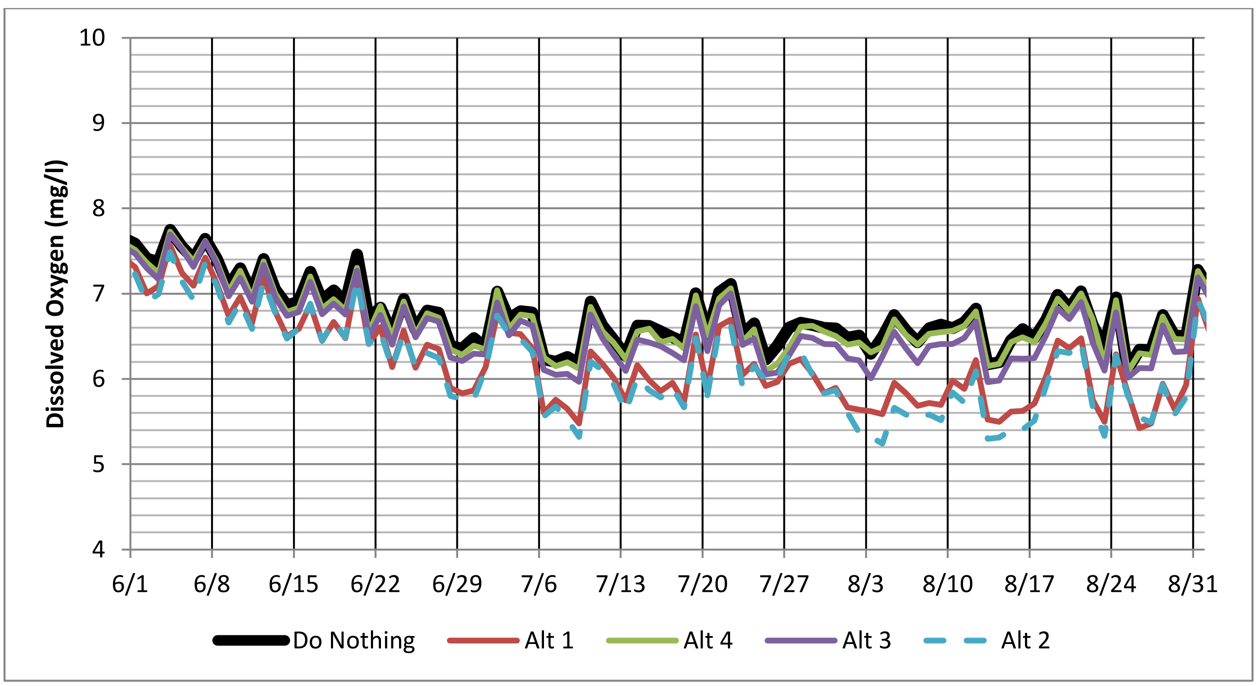


Figure 4-8
Simulated Dissolved Oxygen at 10:00 am, River Mile 83.0 (Downstream of north WWTP)

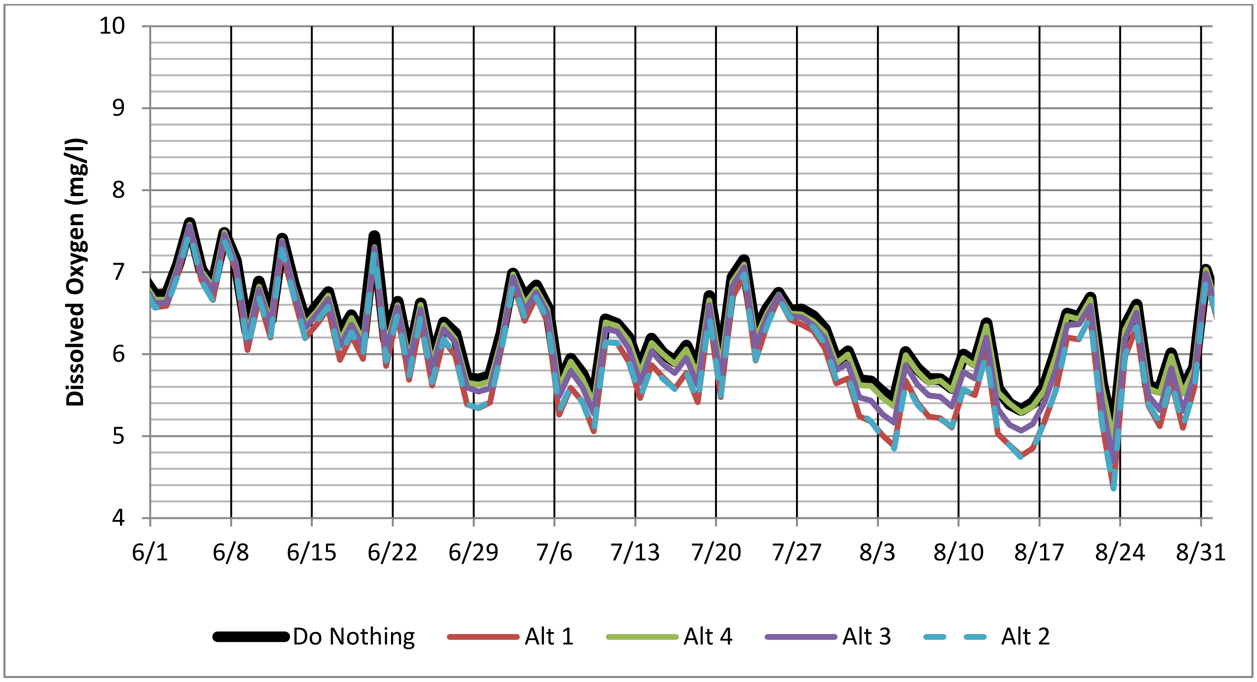


Figure 4-9
Simulated Dissolved Oxygen at 10:00 am, River Mile 77.0 (8 Miles Downstream of North WWTP)

4.2.2.3 Comparison of the Preferred Alternative with the Non-Integrated Plan

The preferred alternative was also compared to the non-integrated plan over the full diurnal range of dissolved oxygen oscillation to demonstrate the magnitude of improvement that the plan is anticipated to have on the Harpeth River. **Figure 4-13** illustrates that the preferred plan would offer significant improvement upstream of the existing north WWTP with respect to minimum daily dissolved oxygen concentrations. **Figure 4-14** illustrates that even downstream of the existing north WWTP, the difference in minimum dissolved oxygen levels between the preferred plan and the non-integrated plan are very small. **Figure 4-15** shows that further downstream, 8 miles north of the existing WWTP, the preferred plan is indistinguishable from the existing conditions demonstrating that the benefits of the preferred plan upstream of the existing WWTP outweighs potential disadvantages downstream.

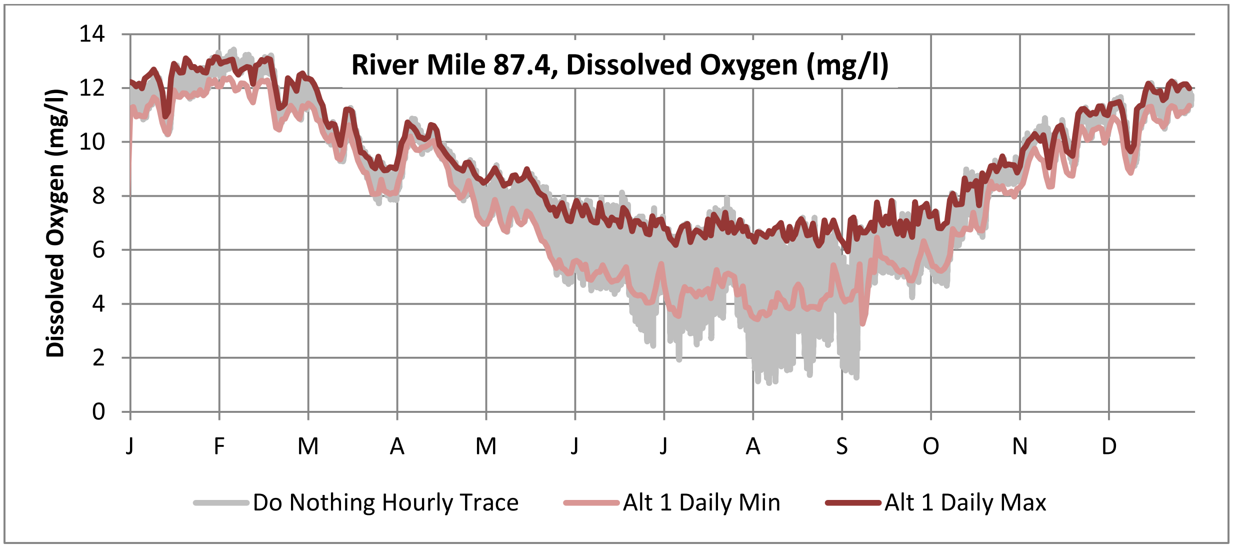


Figure 4-10
Minimum and Maximum Dissolve Oxygen for Preferred Plan and Non-Integrated Plan (In Between North and South WWTPs)

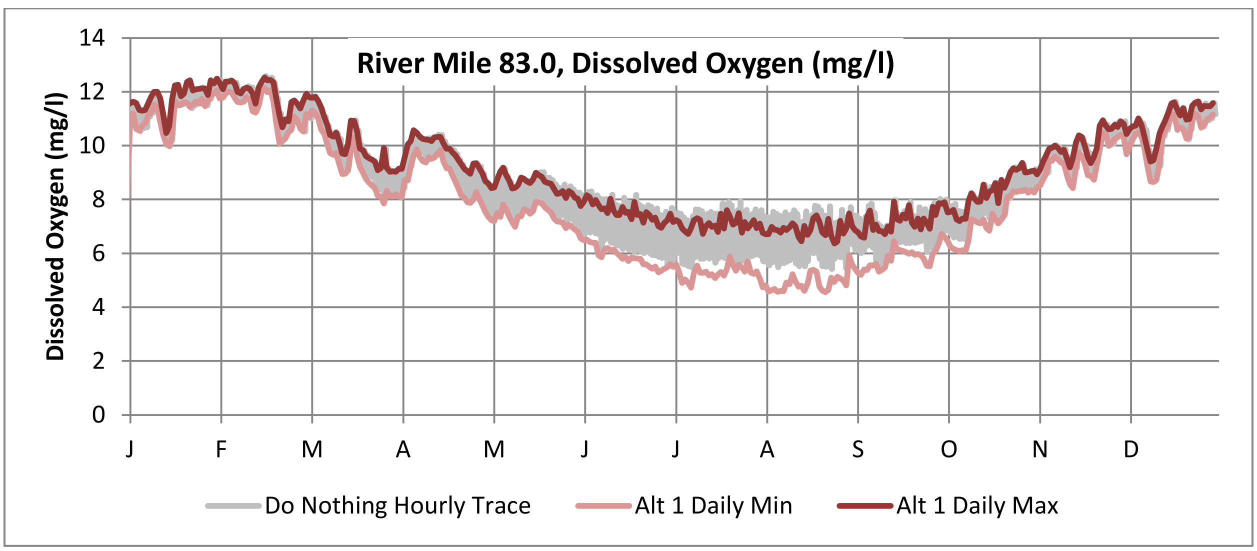


Figure 4-11
Minimum and Maximum Dissolved Oxygen for Preferred Plan and Non-Integrated Plan (2 Miles Downstream of the North WWTP)

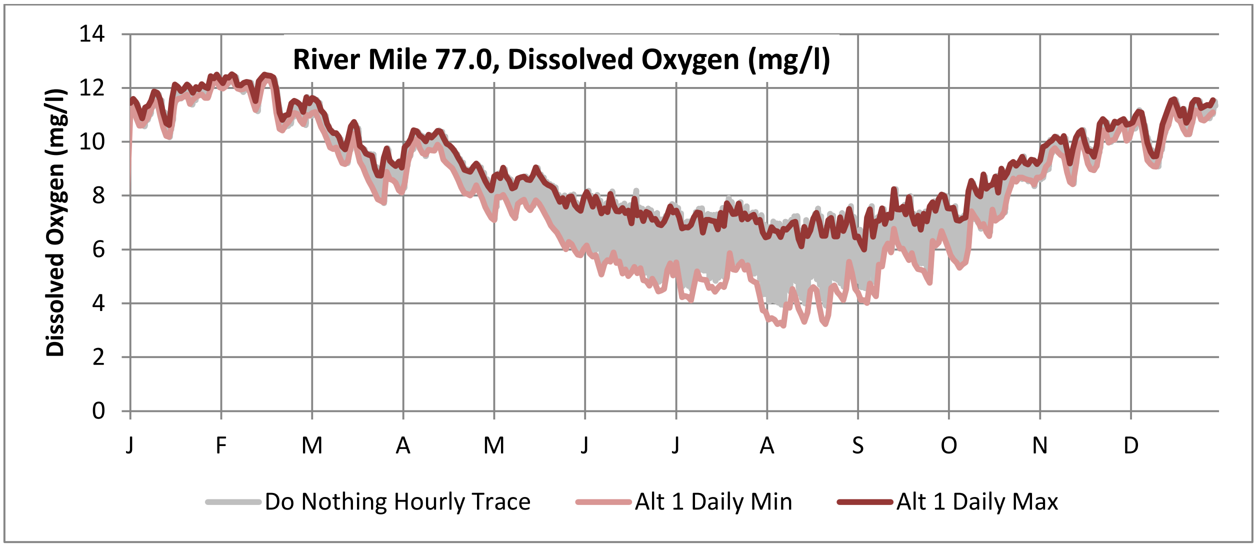


Figure 4-12
Minimum and Maximum Dissolved Oxygen for Preferred Plan and Non-Integrated Plan (8 Miles Downstream of the North WWTP)

4.2.2.4 Effect of Improved Upstream Water Quality on Preferred Alternative

Figure 4-13 presents results for conditions in which the upstream water quality was hypothetically improved to meet Tennessee water quality standards. This activity was conducted to demonstrate the long-term impacts of the plan if changes in the headwater reaches of the Harpeth River were implemented to improve upstream water quality. Results of this analysis show that the preferred plan has little to no impact on dissolved oxygen as water flows from upstream, through the City, and then downstream as far as 8 miles north of the Urban Growth Boundary. More data is needed with respect to pollutant loads and flows from the key tributaries to further verify these findings, but these results clearly indicate the following:

- The seasonal decrease in dissolved oxygen concentrations is caused by effects upstream of the City
- The influence of the City's discharges and withdrawals with the preferred plan would not make this seasonal dip appreciably worse during critical low-flow periods

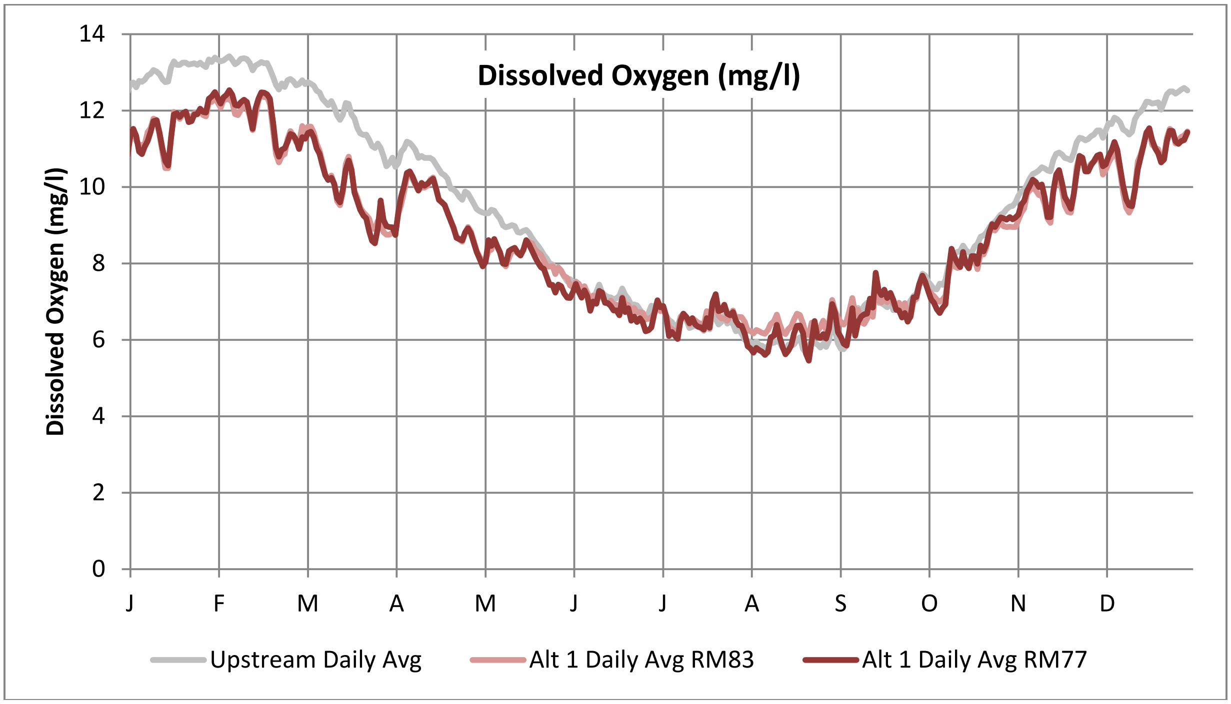


Figure 4-13
Preferred Plan Evaluated with Improved Upstream Water Quality

4.2.2.5 Evaluation of the Preferred Alternative with Respect to the Harpeth River TMDL

The projected pollutant loading by the wastewater plants operating at the end of the planning period (2040) was compared to waste load allocations defined in the EPA 2004 TMDL for dissolved oxygen. **Figures 4-14**, **4-15**, and **4-16** shown that all alternatives evaluated satisfy the TMDL requirements for summer and winter biochemical oxygen demand (BOD) loading. Likewise, all alternatives satisfy the summer and winter limits for ammonia, with a few marginal exceptions that could be managed. Nitrogen, which does not have seasonal threshold, is regulated using a year-round limit, and while the preferred plan and most other alternatives satisfy the limit in the summer when it is most critical, the annual average would be exceeded. This may require clarification and discussion during the permitting process, because higher nitrogen loads in winter would not lead to increased organic productivity when the temperature is at its lowest.

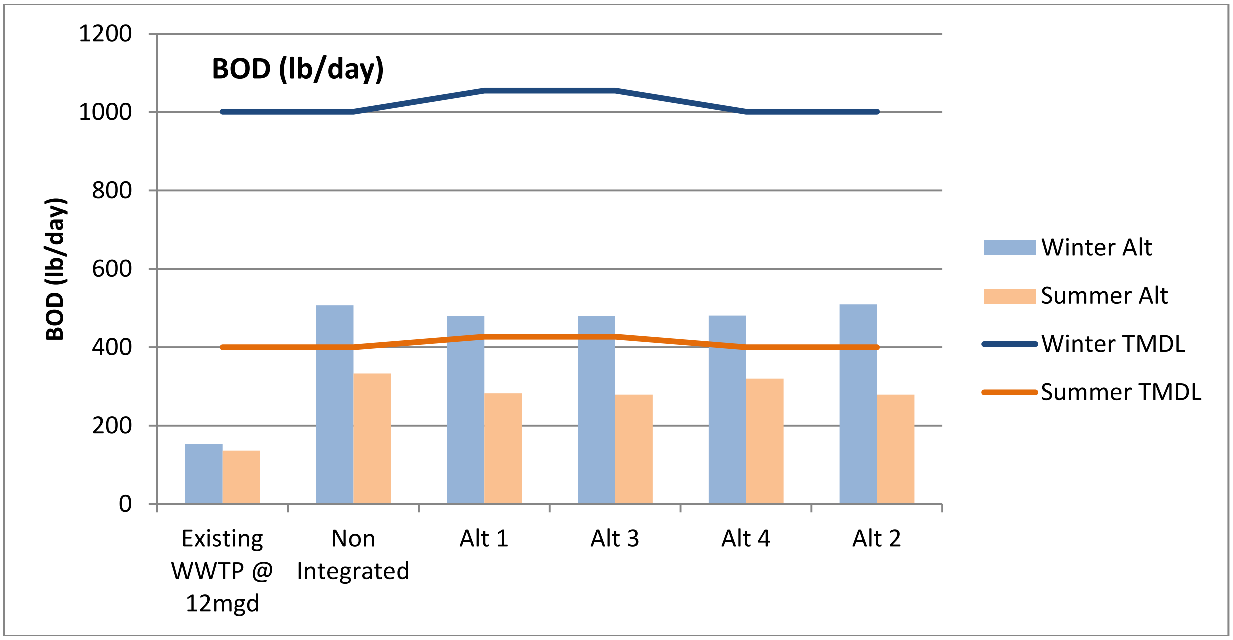


Figure 4-14
IWRP Loads Compared Against TMDL Limits for BOD

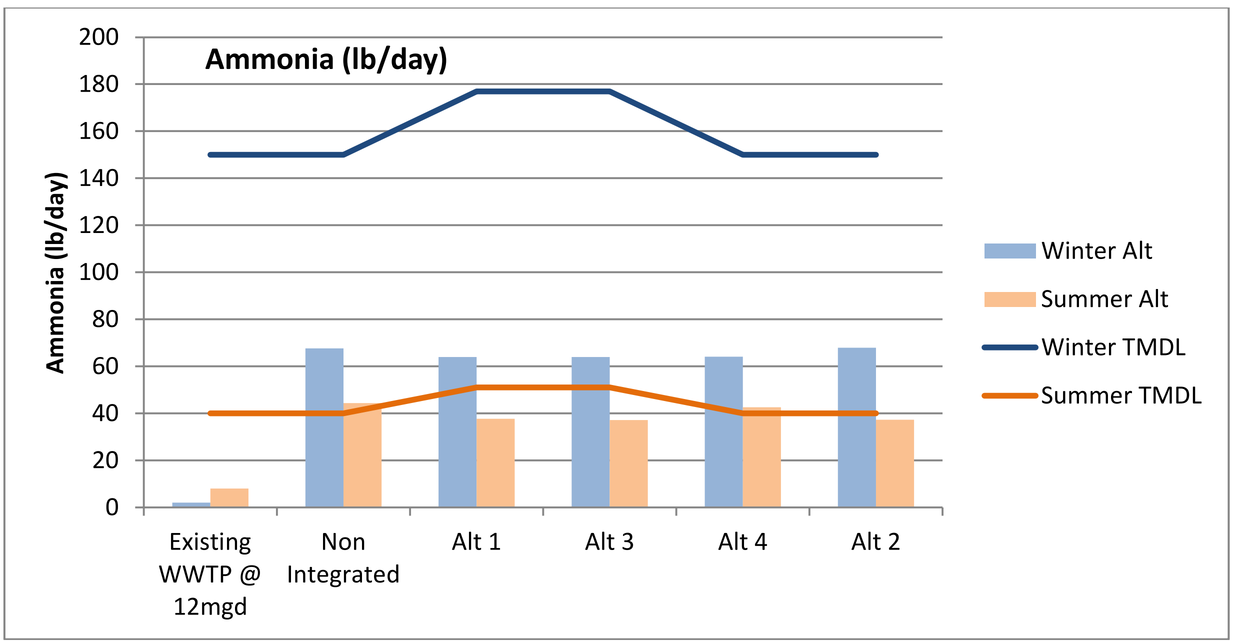


Figure 4-15
IWRP Loads Compared Against Limits for Ammonia

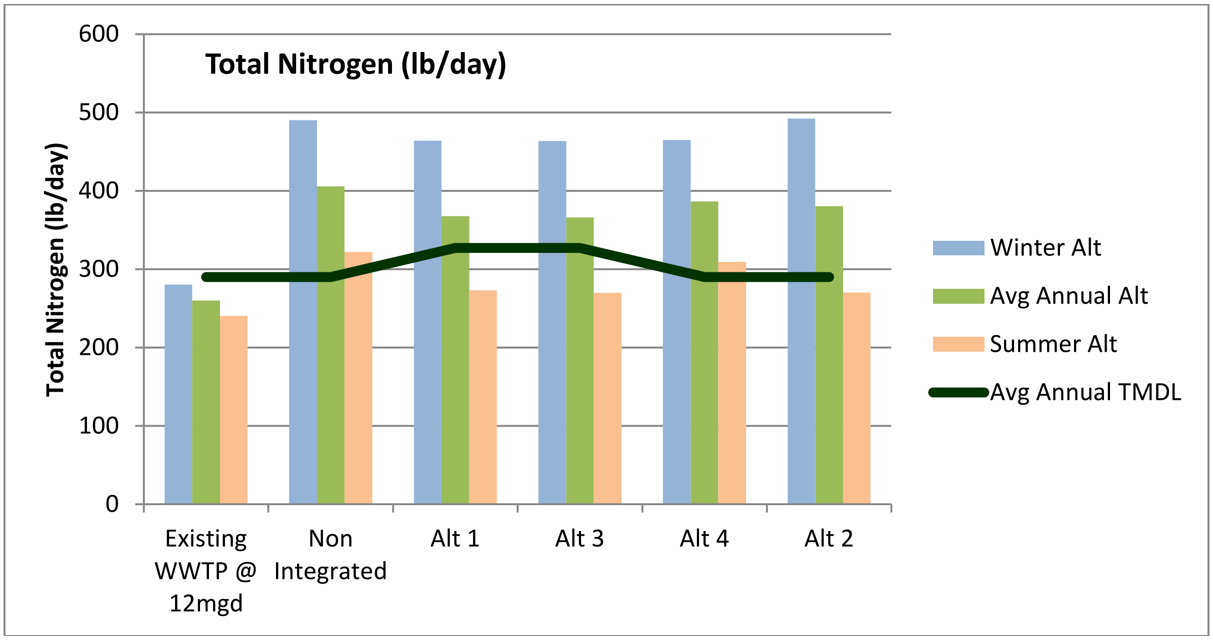


Figure 4-16
IWRP Loads Compared Against TMDL Limits for Nitrogen

4.2.4 Summary and Conclusions of Water Quality Analysis

Based on the technical analysis, the following conclusions can be drawn from the analysis of water quality data and simulation of the IWRP alternatives:

- Water quality is impaired by the time the Harpeth River reaches Franklin; improving upstream water quality is beyond the scope of this IWRP and the authority of the City
- The seasonal decrease that causes exceedance of water quality standards is largely a result of upstream pollutant loads and the sediment oxygen demand throughout the river
- The IWRP plans do little to affect dissolved oxygen, except for some improvement upstream of the water intake dam based on the removal of the low-head dam and implementation of the proposed South WWTP.
- The preferred plan (Alternative #1) can provide significant benefits for the seven river miles located between the proposed South WWTP and the existing North WWTP due to flow augmentation, high oxygenation of the south plant's effluent and removal of the low-head dam. This is an important factor because this is arguably the most stressed reach of the river during low-flow conditions.
- The preferred plan (Alternative #1) exhibits lower dissolved oxygen levels downstream of the North WWTP compared to the other alternatives, but only by a small level and these differences converge within 5-10 miles downstream of the plant. Advantages of

the preferred plan upstream of the existing plant appear to outweigh the disadvantages of the plan downstream of the existing plant.

- If upstream water quality was improved to satisfy state standards for dissolved oxygen, the preferred plan would not degrade the water quality as it travels through the Harpeth River within the City of Franklin.

- The preferred plan satisfies the TMDL requirements into the future, with the exception of annual nitrogen limits. However, during the summer period, the preferred plan produces nitrogen concentrations lower than the annual TMDL target.

4.3 Drinking Water

An analysis was performed on the drinking water system within the City, including an analysis of the long-term plan for water treatment supply and capacity, as well as an analysis of the long-term water distribution needs and improvements to meet existing and upcoming regulations. As part of this analysis, a reevaluation of costs for the upgrades to the WTP and water distribution system was completed. Detailed discussions of these evaluations and associated costs are provided in the technical memoranda provided in Appendix B.

4.3.1 WTP Evaluation

As part of the IWRP, the City of Franklin opted to re-evaluate the plan for improvements and capacity upgrades, as well as the proposed costs associated with the potential upgrading of the existing WTP. In order to develop the information necessary for development of the integrated model, CDM Smith reviewed and analyzed the July 2006 CTE/AECOM report titled *Deign Report for the Franklin Water Treatment Plant*. The report discussed the previously performed analysis of the potential upgrade to a 4.0 mgd capacity treatment plant and the associated upgrades and improvements required for the aging plant. In addition, the Long Term Enhanced Surface Water Treatment Rule (LT2ESWTR) is discussed in the report and leads to the current knowledge that testing by the City resulted in source water concentrations of Cryptosporidium above the limits requiring a higher level of inactivation. Compliance with LT2ESWTR includes multiple options including operations management practices, UV disinfection, and/or membrane filtration to meet the requirements. Each of these options were evaluated as potential modifications for the plant, as described in Appendix B, with the IWRP recommendation for the option of UV disinfection with the additional option for an UV-UV-AOP treatment process as an additional oxidation process improvement, particularly associated with the treatment of taste and odor and emerging contaminants of concern.

In addition to expansion of the existing plant, the potential options for the City of Franklin in regards to water supply for the future included constructing a raw water pipeline to the Cumberland River as a potential source for potable water. This analysis had previously been evaluated and these past estimated costs were reviewed and escalated to current costs. This option would include the City of Franklin expanding the existing plant to meet the demand of all existing and future customers for the planning period. Another potential water option for the City was the decommissioning of the existing WTP with the City moving to a full wholesale agreement with HVUD. Both of these options were evaluated in order to develop the necessary data to compare the potential potable water options as part of the model analysis.

The recommended additional upgrades and improvements to the WTP facility, as discussed in the 2006 Report, were also reviewed and have been confirmed for each of the unit processes. The recommended alternative for the WTP is to expand the WTP's capacity to 4.0 mgd by providing the following upgrades at the WTP:

- Constructing a new raw water pump station with traveling water screen
- Replacing the existing flocculation basin equipment
- Upgrading the existing sedimentation basins, including constructing a new sedimentation basin for additional capacity
- Upgrading the existing gravity filters
- Replacing the clearwell transfer pump
- Increasing the finished water high service pumping capacity
- Adding a scrubber to the existing chlorine storage building
- Upgrading the existing chemical feeder system
- Constructing a new UV disinfection system
- Additional miscellaneous site work and piping improvements at the existing site as needed for the additional capacity

The costs included in the TM were escalated from the original report to account for current estimated costs. In addition, contingencies were accounted for in the estimates and each option discussed was evaluated including the potential for installation of membrane filtration technology. The recommended improvements above include a total estimated project cost of approximately $9.1 million. A summary of the costs can be seen in **Table 4-4**.

4.3.2 Water Distribution System

The City's water distribution system spans approximately 19,300 acres with 2010 average day and maximum day water demands of 6.3 and 8.5 mgd, respectively. The system is comprised of nearly 500 miles of ¾-inch to 36-inch diameter mains, with the City's WTP, rated at a maximum capacity of 2.1 mgd, located near the center of the distribution system, along the Harpeth River on Lewisburg Highway (State Road 431). Water is also provided by a wholesale utility, Harpeth Valley Utility District (HVUD), through connection points located at the northern end of the system. The majority of the distribution system is well looped with 12-inch to 36-inch diameter trunk transmission mains. There are 7 ground storage tanks with a total system storage capacity of 10 million gallons (MG).

Table 4-4 WTP Improvement Cost Summary

Improvement	4.0 mgd Conventional Treatment Upgrades
New Raw Water PS with Travelling Water Screen	$1,300,000
Replace Existing Flocculation Equipment	$50,000
Upgrade Existing Settling Basins (No. 1, 2 & 3)	$340,000
Construct New Settling Basin	$2,000,000
Upgrade Existing Gravity Filters	$1,500,000
Replace 2 mgd Clearwell Transfer Pump	$300,000
Increase High Service Pumping Capacity from 2 mgd to 4 mgd	$800,000
Add a Scrubber to Existing Chlorine Storage Building	$500,000
Upgrade Existing Chemical Feeder System	$50,000
New UV Disinfection System	$700,000
Miscellaneous Site work and Piping Improvements	$750,000
Subtotal	$8,300,000
Design and Technical Service (10%)	$830,000
Project Total	$9,100,000

In addition to the analysis associated with the treatment plant, the reports describe the Stage 2 Disinfectants and Disinfection Byproducts Rule (Stage 2/DBPR), promulgated in January 2006, that required systems to first conduct an Initial Distribution System Evaluation (IDSE) to identify compliance monitoring sites for the Disinfection Byproduct Maximum Contaminant Levels (DBP MCLs). The compliance monitoring sites show multiple locations that have average values that exceed regulatory limits for both TTHM and the five regulated haloacetic acids (HAA5). As a result, these levels may require changes at the WTP and the distribution system to comply with these regulations. CDM Smith reviewed the July 2009 draft *Drinking Water Quality Evaluation and Recommendations* developed by Metcalf and Eddy/AECOM in conjunction with Hazen and Sawyer which was developed to identify the most appropriate methods to reduce the potential for water quality issues in the City's distribution system and appropriate system modifications to reduce the risks of water quality issues in the future. CDM Smith is in concurrence with the findings that reducing the water age and reducing the chlorine residual can help to reduce THMs, using booster chlorine can allow lower residuals earlier in the system and lower THMs, and automatic flushing devices can help lessen THMs. The report also points out that HVUD will be required to assist with THM and HAA compliance per the State of Tennessee rule that states "parent systems designated by the department that routinely sell water to consecutive systems with MCL violations for TTHM or HAA5 shall meet 0.048 mg/L TTHM and 0.036 mg/L HAA5 at the entry point and master meter for the consecutive system in order to demonstrate enhanced coagulation." This is an important consideration in the overall management of DBPs along with the analysis of data in the draft report that indicates that retreating HVUD water, which is a practice that is used to maintain distribution pressures during low Harpeth River flows, appears to increase TTHMs.

CDM Smith also evaluated the City of Franklin water distribution system to include a review of the existing water distribution system hydraulic model including a long-term review of the hydraulic capacity of the system under build-out demand conditions. This review of the existing water distribution system primarily focused on the distribution water quality and on reducing the high water age within the City's system. These evaluations were conducted using an existing computer hydraulic model of the water distribution system, previously calibrated by CTE in 2009 to tracer testing.

Information on the HVUD distribution system was limited at the time of the study; therefore the specific age of the water supplied from that system is unknown. Based on field testing results conducted previously, the total trihalomethanes (TTHM) and HAA5 concentration measured at the HVUD supply points currently are near or exceed the 60-percent Rule established by the Tennessee Department of Environment and Conservation (TDEC), in November 2008, resulting in "old" water entering the City's distribution system.

Evaluation criteria were developed from conversations with the City for analyses of the distribution system that would form the basis for all recommendations. These criteria included maintaining system pressure greater than 20 psi under all flow conditions, maintaining fire flows of at least 500 gpm with system pressure at minimum 20 psi, maintaining storage capacity equal to or exceeding 6.3 MG (equal to seasonal existing average daily demand), maintaining a water age less than 168 hours in all pipes based on a 7-day standard for maximum DBP formation potential, and maintaining an average pipe velocity less than 5 feet per second (fps) and peak velocity less than 10 fps.

To improve the water age, the evaluation criteria listed above were developed into goals the City wanted to establish for the distribution system. Goals included reducing the hydraulic grade line elevation from the two HVUD feeds in a controlled fashion to improve the hydraulic effectiveness of the existing storage facilities, decreasing the storage to demand ratio by either removing tanks which do not receive adequate turnover, operating them at lower levels (decreasing storage), or by increasing the zone of influence of existing tanks (increase demand on individual tanks), and increasing the volume of new water to the southern extents of the City's system.

The following improvements were recommended to be implemented in sequential order, as presented, to effectively decrease water age and degrading water quality within the system. Further explanations of these recommendations are defined in Appendix B. Recommendations include reducing pressure from the HVUD supply points, removing the Grassland storage tank from service, removing the Royal Oaks tank from service, reducing tank levels in the Curd Lane tank, installing a PRV connecting Curd Lane to re-pump to the low pressure zone, installing a main near the Ash Drive tank to enlarge the demand zone of the tank, directing WTP production south, reducing levels and expanding the initial service area of the new Long Lane II tank, and installing a check valve to limit the Long Lane II tank service area.

The estimated cost of implementation of these recommended improvements is $2.0M and is summarized in **Table 4-5**.

Table 4-5 Distribution System Project Cost Summary

Project	Item Description	Unit	Quantity	Unit Cost	Material Cost
1	24-inch PRV at HVUD supply vault	LS	1	$200,000	$200,000
1	36-inch PRV at HVUD supply vault	LS	1	$350,000	$350,000
2	Demolition of Grassland Tank	LS	1	$200,000	$200,000
3	Install PRV between Curd Lane repump and Low Pressure zone	LS	1	$100,000	$100,000
4	12-inch DIP in Liberty Pike near Ash Drive	LF	3,000	$130	$390,000
Material Subtotal					$1,240,000
Construction Contingency (30%)					$372,000
Construction Subtotal					$1,612,000
Engineering, Legal, Administration Fees (25%)					$403,000
Total Cost					$2,015,000

In addition to these new distribution system improvements, a new, comprehensive SCADA system is also recommended for implementation to improve overall system operations, monitoring, and control of the new PRVs, system tanks, booster pump stations and WTP low-service and high-service pumping operations. This will allow the City to better monitor and control the overall water system and provide better control and response to system issues. The design and installation of a new, comprehensive SCADA system is estimated at approximately $830,000.

In addition to the water quality analysis, the model indicates the system has difficulty conveying flow from the HVUD supply points in the north to the southern extents of the service area. To increase conveyance capacity to the southern extents of the system, it is recommended that the City install approximately 6,000 feet of 24-inch main along Columbia Avenue which would connect the 24-inch main on Downs Boulevard that feeds into the 16-inch main tying into the Columbia Avenue tank. Improvements also include the installation of approximately 10,000 feet of 16-inch main along Oakwood Drive, Henpeck Lane, and Lewisburg Pike to connect into the 16-inch main running north and south between Oakwood Drive and Wisteria Drive, and the installation of larger flow meters and associated piping in the HVUD vaults. The total estimated cost of these projects is $5.9M. The timing of these hydraulic improvements will be based on the continued development and population growth in the southern portion of the City.

4.4 Wastewater

The existing WWTP was analyzed to account for the condition of the existing facilities and the biological and hydraulic capacity of the plant. In addition to the analysis of the treatment capacity, the treatment of biosolids was analyzed separately to determine new processes and potential new facilities to process and dispose of the City's residuals. The effluent disposal of the treated effluent was also analyzed and potential improvements and changes were determined to expand the City's facilities. The need for a new WWTP was also evaluated to provide capacity through the entire planning period. These discussions and additional details are summarized and provided in Appendix C.

4.4.1 Existing WWTP

As part of the IWRP, CDM Smith analyzed the operability of the existing WWTP and the biological and hydraulic capacity of the WWTP as these relate to the planning period design flows. As part of this analysis, CDM Smith conducted a site visit to the WWTP in January 2011 to perform a condition assessment of the existing facility which included an evaluation of the mechanical and electrical equipment and facility structures to develop a Criticality Analysis for the processes at the WWTP.

The scores from this analysis indicate that many pieces of the equipment are nearing their expected service life and, either equipment replacement and/or upgrade is required in the near future. A number of the structures at the WWTP are also in need of repair in order to maintain an adequate capacity the WWTP can continue to treat throughout the planning period. The detailed analysis is provided in Appendix C. This analysis is an estimation tool based on conversations with WWTP staff and visual observations; a more accurate, detailed condition assessment is recommended to be performed prior to equipment upgrade.

An additional analysis was performed that discussed the biological and hydraulic capacity at the WWTP and defined the potential for the expansion of the existing facilities along with the associated costs for the recommended improvements. An influent analysis was performed to characterize the flow for appropriate sizing of downstream processes and to characterize the influent constituents to identify varying wastewater strengths for which certain processes or equipment may or may not be a viable option for treatment. To perform this analysis, MORs from 2008 to 2010 were reviewed to account for seasonal fluctuations and annual variations in the wastewater.

The model analyzed the oxidation basins, final clarifiers, and denitrification filters using a quantitative desktop approach to determine the annual average flow and loadings that can be treated through the existing WWTP. It was anticipated that with increasing focus on the nutrient loads to the Harpeth River, more stringent permit limits would evolve for the City for their future NPDES permits, so scenarios were run at effluent phosphorus concentrations of 0.3, 0.5, and 1.0 mg/L. Each of the models was run using an anaerobic/anoxic wastewater process with new fermentation basins constructed outside of the existing oxidation structures. The analysis also assumed that chemical phosphorus removal would be necessary to polish effluent phosphorus to meet potential future permit limits.

A maximum feasible biological treatment capacity of 16 mgd was determined to be available at the existing plant without major plant reworking or improvements. It was determined that additional filtration area was likely required to treat the 16 mgd flows. An additional filter was added to the analysis which removed the filters as the bottleneck for the biological capacity and allowed for an evaluation of the maximum biological capacity the existing WWTP could treat, with minor improvements, to achieve adequate performance during the planning period.

In addition, a hydraulic analysis was also completed to identify the hydraulic restrictions observed by WWTP staff during operations. Each of the hydraulic elements at the WWTP was analyzed for the ability to pass the anticipated flows. Field verification was performed during high flows to verify this analysis, along with additional survey to confirm elevations. A detailed analysis of each of the hydraulic systems at the WWTP is provided in Appendix C. At varying flow and flood levels, the cascade aeration system, clarifier influent distribution box, settled water junction box, final clarifier weirs, influent oxidation basin splitter box, and the headworks will be flooded above the wall elevations for each of these structures.

The recommended improvements to treat 16.0 mgd biologically and hydraulically were estimated to determine an overall conceptual cost. The construction costs include permit and contractor's costs, with estimated contingencies associated with each task. The overall cost of adding all of these improvements to the existing WWTP is approximately $18.6 M; however, individual costs are also provided in case the City chooses to implement these changes in a phased plan for construction.

4.4.2 Biosolids

The existing biosolids handling system at the Franklin WWTP is in need of significant improvements to achieve sustainable, long lasting solids processing. Current practice involves thickening the sludge as it is wasted from the final clarifiers by dissolved air floatation and dewatering the solids by belt filter press prior to disposal in a landfill, over 100 miles away, in Camden, Tennessee.

The work completed during the analysis of the biosolids handling system includes a discussion on the potential biosolids use/disposal options and associated solids processing requirements, presentation of conceptual design of improvements to the solids processing facilities at the existing and potential future WWTP and presentation of an updated financial analysis including an opinion of probable construction cost, annual operation and maintenance costs, and life cycle costs.

4.4.2.1 Preliminary Analysis

The first biosolids workshop was held on February 2, 2011 to determine the preliminary treatment technologies and potential solids process trains that would be further analyzed during the alternatives selection process. During the workshop, criteria were developed for the future solids treatment train that included providing efficient operations, decreased energy consumption, ensuring a sustainable process, having a diverse portfolio of product use/disposal options, having reliable operations, providing risk reduction, allowing for environmental and public acceptance, producing minimal odors, being an automated process, producing Class A biosolids, and providing an expandable strategy for growth.

The initial technical memorandum for the biosolids analysis described the evaluation and description of the existing conditions of the WWTP biosolids system, provided a preliminary analysis of the current operation and maintenance requirements and costs of solids treatment, and provided an overview of the solids projections based on current conditions and the availability of existing equipment to meet the future needs of the WWTP.

The follow-up memorandum discussed and detailed the selected solids treatment technologies and the four potential process trains in including conceptual sizing of equipment and facilities and development of planning level capital and O&M costs and life cycle costs. The planning level costs for each process train was compared to the O&M costs for the existing solids treatment process developed in TM No. 1 to determine financial feasibility of each of the alternatives. A solid processing train consisting of rotary drum thickening, anaerobic digestion, screw press dewatering, and solar drying was selected to have the lowest treatment cost per dry ton of solids treated.

4.4.2.2 Analysis

A Steering Committee meeting was held on September 28, 2011 to select a biosolids process that would form the basis of the potential future processes for the City. The option consisting of rotary drum thickening, anaerobic digestion, screw press dewatering, and solar drying was selected as the preferred method due to the congruent similarities with the non-cost criteria that were developed during the initial Biosolids Workshop. Anaerobic digestion was selected because it can achieve Class B treatment, reduce the amount of biosolids, and potentially produce energy (methane) in support of the City's sustainability goals. The City also wished to investigate solar drying because of the low O&M costs and the fact that the dried biosolids can offer more beneficial reuse opportunities.

A phased approach to the proposed improvements was considered with respect to the WWTP liquid process improvements and expansion of wastewater treatment capacity. The liquid process improvements are proposed to expand WWTP capacity to 16 mgd requiring a solids facility expansion to 16 MGD capacity. In addition, the recommended two additional 4 MGD expansions will also require biosolids upgrades to reach the ultimate WWTP capacity of 24 MGD for the planning period.

Descriptions of the technologies, design parameters, and proposed solids treatment process design criteria can be seen in Appendix E for the selected biosolids train analysis. The estimated costs of the recommended improvements is estimated at $66 M although this is still a high level cost and should be further evaluated as part of the preliminary and detailed design to define the potential for reuse of existing facilities and the potential for a more staged approach to the upgrades. The cost breakdowns for the improvements recommended are detailed further in the documents in Appendix E.

4.4.3 Effluent Reuse

As part of the IWRP, Smith Seckman Reid (SSR) assisted with an update of the analysis of the reclaimed water system. This included a review and updates of the analysis of the *Franklin*

Reclaimed Systems Report completed in February 2009. This review included an analysis of the supply and demand associated with the estimated population growth and continued development and expansion of the system. The *City of Franklin Development Report*, prepared by the Franklin Planning Department, was used to gauge progress and to project development for the planning period. The updated average daily demand for the existing reuse customers is approximately 1.55 mgd, with maximum daily demands of approximately 6.85 mgd.

New potential users were evaluated and screened to determine those users that were highly likely to connect to the system if it became available, as well as existing facilities within a reasonable distance of existing infrastructure. Detailed listings of the projected users can be seen in Appendix G. Projections were based on a 2-inch per week irrigation rate, which is typically used by area golf course and park facilities for irrigation on green spaces. From this analysis, the average daily demand for these potential customers increased to 3.76 mgd, with a maximum daily demand increase to 8.13 mgd.

Storage was also analyzed using demands from 2010 to create a typical annual flow scenario for the reuse system. Data from the analysis showed that from the middle of July through the end of October, a deficit of approximately 240 MG exists, and additional storage volume is needed to accommodate the projected demands described above. It is anticipated that the additional storage will take place at the Water Reclamation Facility, at storage facilities within the distribution system, including some existing tanks that could be dedicated for reclaimed storage, and potentially additional storage at the Forest Crossing Golf Course, Legend's Club Golf Course and the Westhaven Golf Course.

4.4.4 New WWTP

One of the long-term options for the City to meet future wastewater demand is to construct a new WWTP in the southern portion of the City's sewer service area. As part of the IWRP, CDM Smith looked at the feasibility of a new WWTP, identified the capital and O&M costs associated with the new construction, and summarized the most reliable alternative as selected by the Stakeholder's. The Technical Memorandum describing this analysis is presented in Appendix D.

Initially, CDM Smith worked with the Steering Committee and WWTP staff to identify criteria that would be critical for success of a new WWTP project. As a result, three biological processes for the new WWTP were identified for further evaluation for the proposed WWTP conceptual design.

- Option 1 is a conventional plug-flow, activated sludge process, also referred to as an "A2O" process, with tertiary filtration and UV disinfection. The A2O process consists of a fermentation zone, pre-anoxic zone, and aeration zone. Following these three zones is secondary clarification, tertiary filtration employing denitrification filters, and UV disinfection.

- Option 2 utilizes a biological treatment process similar to Option 1; however, instead of using rectangular basins with diffused aeration, Option 2 provides oxidation ditches. The proposed configuration consists of a fermentation zone and pre-anoxic zone followed by an oxidation ditch with internal recycle back to the pre-anoxic zone.

- The third biological treatment process option includes a 5-stage Bardenpho process with an integrated membrane. The MBR process is provided with flow equalization and UV disinfection. This option would have three process trains consisting of one fermentation tank, one pre-anoxic tank, one aeration tank, and one post-anoxic basin per train.

Costs during the first stage of this analysis were developed based on the general requirements of each system, including major equipment requirements. The final costs presented in this memorandum include budgetary costs for equipment capital and installation; contractor overhead and profit, construction contingency, and engineering, administration, and implementation.

It is assumed that advanced treatment processes will be required to meet more stringent permit limits than in the existing WWTP permit. Thus, in addition to garnering public acceptance necessary for permitting and regulatory support, the proposed WWTP will include consideration of a MBR and tertiary polishing wetlands. The Harpeth River, which would be the discharge point for the new WWTP, is currently impaired due to nutrients and has significant low flows during the summer months upstream of the existing WWTP, thus construction of an advanced WWTP upstream of this river segment could result in an enhancement of the low flow conditions to positively impact ecological flows, as well as the ability of the existing water treatment plant to withdraw water from the Harpeth River. Thus, based on discussions with TDEC, technology based limits will be assumed for design of the new WWTP.

The estimated flows to the proposed new treatment facility, by the year 2040, could range between 3.6 mgd and 6.6 mgd, with a total service area build-out of 8 mgd depending on the rate and pattern of population growth over the planning period.

Conventional spreadsheet calculations have been developed and were supplemented with BIOWIN modeling to evaluate each of the potential options and determine the optimum internal recycle flows that would minimize operating costs and meet the anticipated treatment requirements for the proposed facility.

The estimated cost of designing and constructing the new WWTP is $60M. This WWTP includes advanced biological treatment utilizing a 5-stage Bardenpho process followed by membrane reactors (MBRs) with flow equalization and UV disinfection. The WWTP is planned to be designed for an average daily flow of 4 mgd and peak hour flow of 8 mgd. The WWTP will have two parallel process trains consisting of one fermentation, pre-anoxic, aeration, and post anoxic basins per treatment train. This process is being utilized based on anticipated permit requirements for nitrogen reduction to 3 mg/L and phosphorus reduction to 0.32 mg/L in the effluent. The fermentation stage acts as the initial phosphorus and BOD removal stage with denitrification occurring in the pre-anoxic tank, where nitrate (NO_3) is converted to nitrogen

(N_2). In the third basin, oxygen is introduced to the aeration basin where nitrification occurs, ammonia (NH_4) and N_2 are oxidized and form nitrate. An internal recycle flow is included, flowing from the pre-anoxic basin back into the fermentation basin. Additionally, a return activated sludge (RAS) flow is included, flowing from the MBR to the pre-anoxic basin. The fourth basin in the process, the post-anoxic basin, is required to remove any remaining nitrogen from the influent flow.

Following the post-anoxic process, the mixed liquor goes to tanks submerged microfiltration (MF) or ultrafiltration (UF) membranes where clean water is separated from it suspended biomass. Mixed liquor must be returned from the membranes to the beginning of the process at flow rates between four and six times the influent flows to remove the solids that accumulate around the membranes, and return them to the process. Waste sludge is intermittently removed from the MBR process using dedicated waste sludge pumps.

A full description and analysis of the South WWTP option is included in Appendix D.

4.5 Stormwater and Ecological Restoration

In October of 2011, the EPA issued a memorandum to all EPA Regional Administrators titled "Achieving Water Quality through Integrated Municipal Stormwater and Wastewater." The memorandum recognizes the stress on local governments today to keep pace with ever-increasing water quality regulations in the face of population growth, aging infrastructure and the current economic challenges. It also recognizes that the current complexities resulting from separate regulatory processes may have the unintended consequence of constraining a municipality from addressing, in a cost-effective manner, its most serious water quality issues first. Ultimately, the memorandum is an introduction to and an announcement for a new EPA initiative to assist states and local governments in the development of integrated municipal stormwater and wastewater plans to provide sustainable and comprehensive solutions to water quality problems.

Prior to the release of the EPA memorandum, however, the City recognized the importance of considering the water quality improvements that may be provided from implementing stormwater and ecological restoration projects in addition to the proposed wastewater system improvements. Many of these projects were already evaluated as a part of the City's Stormwater Master Plan program where the city considered improvements for eight watersheds within the jurisdiction. This section summarizes the stormwater management alternatives considered, including green infrastructure/low-impact development, best management practice (BMP) retrofits, and stream/ecological restoration opportunities. Combined, these stormwater management improvement alternatives support city-wide flood control, erosion control and water quality improvements while also helping to reduce the burden on long-term water supply needs and wastewater treatment upgrades. Detailed technical memoranda regarding the City's Stormwater system can be found in Appendix D.

4.5.1 Green Infrastructure and Low Impact Development

Green Infrastructure (GI) and/or Low Impact Development (LID) techniques are terms used to describe an array of management practices, products, and/or technologies that use natural systems and/or engineered systems to capture, manage, and reduce stormwater runoff volumes and enhance overall environmental quality. As a general principal, GI techniques use soils and vegetation to infiltrate, evapotranspire, treat and/or recycle stormwater runoff. This approach is an enhancement of traditional stormwater controls to add more sustainable and cost-effective solutions.

The EPA has made GI a key administration priority, as stated in the "Strategic Agenda to Protect Waters and Build More Livable Communities through Green Infrastructure". Key policies and regulatory guidance were also provided by the EPA in a guidance document developed to assist NPDES permit writers in developing municipal separate storm sewer system (MS4) stormwater permit language. The State of Tennessee has incorporated much of the guidance regarding GI into local MS4 permits. As such, the City wished to evaluate the potential benefits of a GI program as an element of the Franklin IWRP project.

CDM Smith performed a comparison of the predicted water quality benefits achieved through the City's current stormwater management ordinance and the required "runoff reduction" program in the City's new MS4 permit. The comparison specifically considered reductions in nutrient loading to the Harpeth River, as the city's WWTP is already responsible for compliance with a TMDL on the Harpeth that restricts discharges to 300 lbs/day of total nitrogen (TN). Three scenarios were evaluated: 1) Build-out conditions with no stormwater controls, 2) Build-out conditions with traditional BMP controls (i.e. current ordinance), and 3) Build-out conditions with GI/LID controls. **Table 4-6** provides a summary of the findings for predicted nutrient reductions in the City's stormwater runoff.

Table 4-6 Predicted Pollutant Load Reductions for Various Scenarios

Scenario	% TN Reduction	% TP Reduction
Build-out w/ no controls	--	--
Build-out w/ traditional controls	28%	37%
Build-out w/ GI/LID controls	34%	66%

While the scenario using traditional stormwater controls provides significant pollutant reduction over the build-out with no controls scenario, the analysis showed that additional benefits will be gained when the City implements the GI/LID ordinance required by the NPDES Phase II MS4 permit. As a point of comparison, the GI ordinance will result in an additional reduction of approximately 5 lbs/day of TN when applied to currently vacant lands throughout the city.

4.5.2 Traditional Stormwater Management BMPs

In addition to the GI ordinance evaluation, the City also considered the potential pollutant removal benefits of projects previously identified in the City's stormwater basin plans. In late the 1990s and early 2000s, the city completed several stormwater basin master plans to identify water quality and flood improvement projects. These plans were re-evaluated during the IWRP process to consider the potential for water quality retrofits to the previously identified BMP projects.

The EPA Spreadsheet Tool for Estimating Pollutant Load (STEPL) was used to generate desktop estimates of pollutant loads delivered to each potential BMP site (seven previously identified project sites remained available for implementation). Next, industry-standard pollutant removal efficiencies were applied to the predicted loadings to determine the total pollutant removal potential of the designated BMP sites. Based on this evaluation, the study estimated the City could expect potential total nitrogen (TN) reductions of approximately 2,500 to 5,900 lbs/yr of TN (or, 7 to 16 lbs/day) from the implementation of the seven BMP sites, depending on the types of BMP(s) ultimately installed. The total estimated construction cost of these identified BMP improvements is approximately $14.1 million. A description of the projects, location in the Harpeth River Watershed and the associated estimated project costs are presented in **Table 4-7** below.

Table 4-7 Pollutant Load Reductions from Each Scenario

ID	Stream	Watershed	Project Description	Cost
W1	Sharps Branch	Sharps Branch	Detention Facility, 40 ac-ft of storage, WQ upgrades	$1,800,000
W2	Quarry Branch	Sharps Branch	Detention Facility, 30 ac-ft of storage, WQ upgrades	N/A for future implementation
W3	North Ewingville Creek	Ralston Creek	Detention facility, retrofit existing facility with WQ upgrades	$2,400,000
W4	North Ewingville Creek	Ralston Creek	Detention facility with WQ upgrades, upstream of Stanwick Dr.	$800,000
W5	Liberty Creek	Liberty Creek	Detention facility, 10 ac-ft of storage with WQ upgrades	$1,200,000
W6	Saw Mill Creek	Saw Mill Creek	Detention facility with WQ upgrades	$2,400,000
W7	Donelson Creek	Donelson Creek	Detention facility with WQ upgrades	$4,700,000
W8	Goose Creek	Five Mile Creek	Detention facility, 10 ac-ft storage, retrofit with WQ upgrades	$800,000
Estimated Total Construction Cost				$14,100,000

4.5.3 Stream/Ecological Restoration Alternatives

A third suite of water resource system improvements considered in the IWRP was opportunities for improvements to stream conditions and aquatic habitat in the Harpeth River and its tributaries. The primary objectives of the evaluation were to identify candidate stream restoration, bank stabilization, and riparian restoration projects along the river, develop conceptual opinions of probable cost, and describe and quantify potential benefits associated with the identified projects.

Available data and information pertaining to the conditions of the main stem and tributaries of the Harpeth River in the city were reviewed, which included studies conducted by the Harpeth

River Watershed Association (HRWA), visual assessment information generated by City staff, geographical information system (GIS) data, and available stormwater and watershed master plan reports. From this information, CDM Smith compiled a list of potential stream channel restoration, bank stabilization, and riparian restoration projects. In total, approximately 26,000 feet of potential stream stabilization/restoration projects were identified.

Similar to the BMP evaluation above, CDM Smith quantified the pollutant removal benefits and associated costs of these stream/ecological restoration improvement projects. Based on this evaluation, CDM Smith projected potential TN reductions of approximately 520 lbs/yr of TN (or, 1 to 2 lbs/day) from the 26,000 feet of restoration. Additionally, stream restoration can provide benefits beyond pollutant removal, such as reduced bank erosion and channel sedimentation, improved wildlife habitat, and improved aesthetics for recreation. The total cost of these improvements was estimated at $28 million city-wide. A description and the location and cost for the projects are presented in **Table 4-8**.

Table 4-8 Summary of Candidate Stream Restoration/Stabilization Projects

Location	Type	Source	Length/ Area	Unit Cost	Estimated Budgetary Cost
Five Mile Creek	Cattle Exclusion	HRWA Watershed Plan	7.7 miles	$4 / LF	$160,000
Five Mile Creek	Stabilization (Cedar Revetments and Mulch Socks)	HRWA Watershed Plan	8 miles	$50 / LF	$2,110,000
Five Mile Creek	Riparian Buffer Planting	HRWA Watershed Plan	20 miles	$1,050 / acre	$305,000
Sharps Branch	Restoration / Stabilization	Sharps Branch Stormwater Master Plan (CDM, 2002)	1,700 LF	$400 / LF	$667,000
Harpeth Main Stem	Meander Restoration	Aerial Photography Review	750 LF	$1,000 / LF	$750,000
Harpeth Main Stem	Bank Stabilization	Aerial Photography Review	8,500 LF	$500 / LF	$4,250,000
Harpeth Main	Riparian Buffer	Aerial Photography	7,800 LF	$50 / LF	$390,000
Franklin Tributaries	Stream Restoration (common erosion)	Visual Assessment	11,000 LF	$400 / LF	$4,400,000
Franklin Tributaries	Bank Stabilization (occasional erosion)	Visual Assessment	4,100 LF	$400 / LF	$1,640,000
Franklin Tributaries	Riparian Buffer Planting	Aerial Photography Review	53 miles	$50 / LF	$14,000,000
Total					$28,672,000

Additional potential programs evaluated as part of the IWRP process included rainwater harvesting, residential rain barrel programs, and multiple water conservation programs, including fixture replacement programs and more restrictive irrigation controls. Additional information on these alternatives can be found in the Appendices of this document.

4.5.4 Summary

The analyses provided in this section show that requiring GI/LID for new development, implementing water quality retrofits to past proposed regional BMP plans, and targeted ecological restoration produce quantifiable improvements in pollutant reductions. However, some of these improvements may be contingent upon the specific pollutants of concern for the City (for example, stream stabilization was cost effective for sediment reduction, but did not appear cost effective for nutrient reduction).

Historically, improvements related to water supply and wastewater treatment were relied upon to resolve water quality and supply issues. However, with the increased focus on TMDL development and water quality from non-point sources, it is becoming increasingly important to develop total solutions to water resources management issues, which include consideration of stormwater management and ecological restoration alternatives. While TMDL allocations can sometimes be met exclusively and cost-effectively though reductions in pollutant loads from point source discharges, the results often provide limited benefits to overall water quality. By integrating progressive stormwater management approaches to meet water resource challenges, water quality improvements can be achieved City-wide.

Section 5
Phase II Alternatives and Results

5.1 Phase II Alternatives

As described in Section 3, the steering committee studied the combinations of project options that resulted in higher scoring alternatives and ultimately recommended moving forward to Phase II with four hybrid alternatives, named from the original alternative that was the basis for the hybrid: 1) Efficiency + Safety & Security; 2) Revised Reliability; 3) Water Quality Plus; and 4) Revised Low Cost. The four recommended alternatives are henceforth referred to by their numeric indicators, Alternative (Alt) 1 through 4.

Each of the four alternatives studied in Phase II contained a different configuration for water supply and wastewater treatment as well as various other options within the other water resources sectors (collection system, stormwater, etc). A summary of each alternative and its associated options is provided in **Table 5-1**, while **Table 5-2** lists the specific project options included in each of the alternatives.

Table 5-1 Summary of IWRP Alternative Options

	Non-Integrated	Alt 1 *Efficiency + Safety & Security*	Alt 2 Revised *Reliability*	Alt 3 *Water Quality Plus*	Alt 4 *Revised Low Cost*
Low-Head Dam Removal	No	Yes	No	Yes	Yes
Water Treatment Plant	2.1 mgd & HVUD Purchase	4 mgd & HVUD Purchase	Line to Cumberland & 12.5 mgd WTP	Decommission WTP & HVUD Purchase	2.1 mgd & HVUD Purchase
Water Distribution System	No	Model, WQ/Quantity Improvements, advanced metering	Model, WQ/Quantity Improvements	Model, WQ/Quantity Improvements, Advanced metering	Model, Advanced metering
Conservation	No	5% savings	2% savings	2% savings	No
Stormwater BMPs and LID	No	BMPs + LID	LID	BMPs + LID	No

Table 5-2 Description of IWRP Project Options

	Non-Integrated	Alt 1 *Efficiency + Safety & Security*	Alt 2 Revised *Reliability*	Alt 3 *Water Quality Plus*	Alt 4 *Revised Low Cost*
Ecological Restoration	No	Low Head Dam Removal & Specific Restoration Projects	No	Low Head Dam Removal & Watershed Projects	Low Head Dam Removal
Existing WWTP	24 mgd	16 mgd	18 mgd	24 mgd	24 mgd
New Southern WWTP	None	8 mgd	6 mgd	None	None
Berry's Chapel/ Cartwright Flows	No	Yes	No	Yes	No
Collection System	Pump to Existing WWTP	Model, Septic Users, I/I Reduction	Model, Septic Users	Model, Septic Users ,I/I Reduction, Pump to Existing WWTP	Model, I/I Reduction, Pump to Existing WWTP
Reclaimed Water	No	Upgrade Pumping to 12 mgd & add Probable Customers	Upgrade Pumping to 12 mgd & add Probable Customers	Upgrade Pumping to 12 mgd & add Probable Customers	No

5.2 Phase II Modeling Results (Performance)

Each of the alternatives was scored based on the objectives and weights determined in Phase I by the stakeholder team. There were nine objectives for the IWRP, each weighted with a percentage according to its importance to the stakeholders. The stakeholder team also developed performance measures by which to gauge the success of each alternative in meeting each objective. The performance measure scores came from the integrated systems model (quantitative scores) or consensus among the steering committee (qualitative scores). The IWRP objectives, weights, performance measures, and scores are listed in **Table 5-3**. These scores were then normalized and multiplied by their respective weights and sub-weights to determine composite alternative scores.

Table 5-3 Franklin IWRP Final Alternatives Scorecard

Weight	Objective	Performance Measure	Sub-Weight	Unit	Better scores are:	Non Integrated	Alt 1	Alt 2	Alt 3	Alt 4
31.1%	Meet current and future demands for water and wastewater reliably	1.1 % time all demands met	25%	% time all days)	high	100	100	100	100	100
		1.2 Freq of No Allowable Harpeth Withdrawal	25%	% time (all days)	low	16	3	3	16	16
		1.3 Vol of WW capacity surplus or shortfall	25%	average annual MGD	high	5.0	5.9	5.0	5.9	5.9

		1.4 Supply redundancy	25%	% of demand met (vol)	high	23	37	100	0	23

Table 5-3 Franklin IWRP Final Alternatives Scorecard, Continued

Weight	Objective	Performance Measure	Sub-Weight	Unit	Better scores are:	Non Integrated	Alt 1	Alt 2	Alt 3	Alt 4
15.5%	Maximize efficiency of water use and value of water resources	2.1 Percent of stormwater reduced through LID	20%	% volume	high	0.0	33.2	0.0	33.2	0.0
		2.2 % total reuse demand satisfied	20%	% volume	high	100	100	100	100	100
		2.3 % demand reduction	20%	% volume	high	0	5	2	2	0
		2.4 Reduction in inflow and infiltration	20%	% volume	high	0	11	0	11	11
		2.5 % reduction in unaccounted for water	20%	% volume	high	0	4	0	4	4
13.5%	Improve water quality and ecological health of Harpeth River	3.1 Change in September Median Flow at USGS Gage 2350	20%	CFS, above or below 5.7	high	0.0	2.1	4.0	0.0	0.0
		3.2 Average summer BOD load	20%	LB/day (summer only)	low	1121	1152	1159	1106	1122
		3.3 Average summer nitrogen load	20%	LB/day (summer only)	low	325	281	288	265	316
		3.4 Ecological indicators	20%	qualitative	high	3.0	4.5	3.5	4.5	4.0
		3.5 Negative impacts of stormwater reduced	20%	qualitative	high	3.0	3.5	3.0	3.5	3.0
13.2%	Provide level of services at a reasonable cost	4.1 Life-cycle cost of projects and policies	40%	million $	low	585	785	793	870	752
		4.2 Capital Cost	40%	million $	low	132	216	286	254	193
		4.3 Meet secondary drinking water standards	20%	qualitative	high	3.5	5.0	4.0	2.5	3.5
8.3%	Provide safety and security of water resources systems	5.1 % of total wastewater on septic	25%	% volume	low	4	0	0	0	4
		5.2 Change in 100 year flood elevation	25%	qualitative	high	3.0	5.0	3.0	4.0	3.0
		5.3 Vulnerability of infrastructure & facilities	25%	qualitative	high	1.5	4.0	4.0	1.5	4.0
		5.4 Emerging water quality concerns	25%	qualitative	high	4.0	3.0	4.0	4.0	3.5
5.7%	Achieve regional	6.1 Extent of regional focus	50%	qualitative	high	3.0	3.5	3.0	4.5	3.0

	acceptance	6.2 Likelihood of public acceptance	50%	qualitative	high	1.0	2.0	2.5	3.0	4.0

Table 5-3 Franklin IWRP Final Alternatives Scorecard, Continued

Weight	Objective	Performance Measure	Sub-Weight	Unit	Better scores are:	Non Integrated	Alt 1	Alt 2	Alt 3	Alt 4
4.7%	Achieve sustainable biosolids management	7.1 Biosolids handled sustainably	100%	qualitative	high	1.0	5.0	5.0	5.0	5.0
4.5%	Provide improved access and aesthetics of Harpeth River	8.1 % of streamflow that is WWTP effluent	25%	% volume (Sept. only)	low	48.8	30.6	27.0	46.7	48.0
		8.2 Extent of bank stabilization	25%	miles	high	0	39	0	95	0
		8.3 Erosion potential	25%	qualitative	high	3.0	4.0	3.0	4.5	3.0
		8.4 Public accessibility	25%	qualitative	high	2.0	3.0	2.0	4.0	2.0
3.5%	Minimize carbon footprint of water resources operations	9.1 Average energy requirements	100%	Average kWh/day	low	59565	78161	99793	77666	74319

5.3 Phase II Alternative Rankings and Sensitivity

The final alternatives scores are shown in **Figure 5-1**. Each stacked bar represents the composite score for each alternative; the individual objective scores are shown in the colored components of the stack. The objective weights affect the final ranking such that higher weighted objectives contribute more to the composite score.

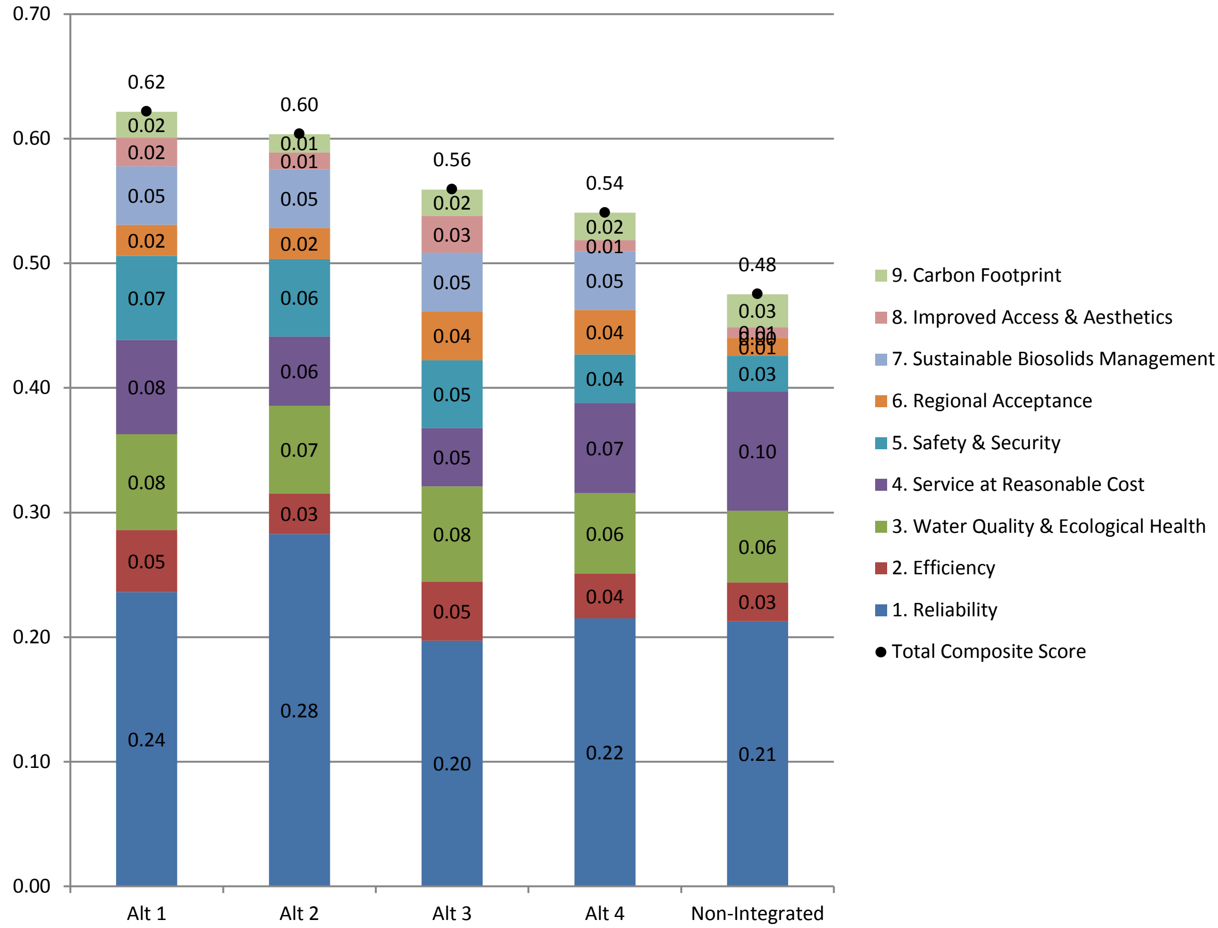


Figure 5-1
Franklin IWRP Final Alternative Composite Scores

The final ranking places Alt 1 ahead of the other alternatives and the Non-Integrated approach (the baseline alternative). Alt 1 scores better than Alt 2 in most objectives, countering the advantage that Alt 2 has in reliability. Alt 2 involves building a pipe to the Cumberland River, which would set up a redundant supply system when coupled with the existing HVUD pipe to Franklin. This option is expensive, but it is also very reliable, resulting in a low score for cost and a high score for reliability.

The IWRP process is designed to give more importance to objectives that stakeholders agree should have higher weights. Each stakeholder comes to the process with different views and opinions about how the city's water resources should be managed, and by averaging the individual weights into a consensus weighting scheme, the IWRP aims to represent the view of the group and not any one particular faction. However, it is useful to perform the scoring calculations using different objective weights to determine the strength of the final rankings. **Figure 5-2** shows the composite scores of the alternatives using equal weights for each objective (11.1%). Alt 1 remains the highest scoring alternative, but Alt 3 shifts to the second place rank.

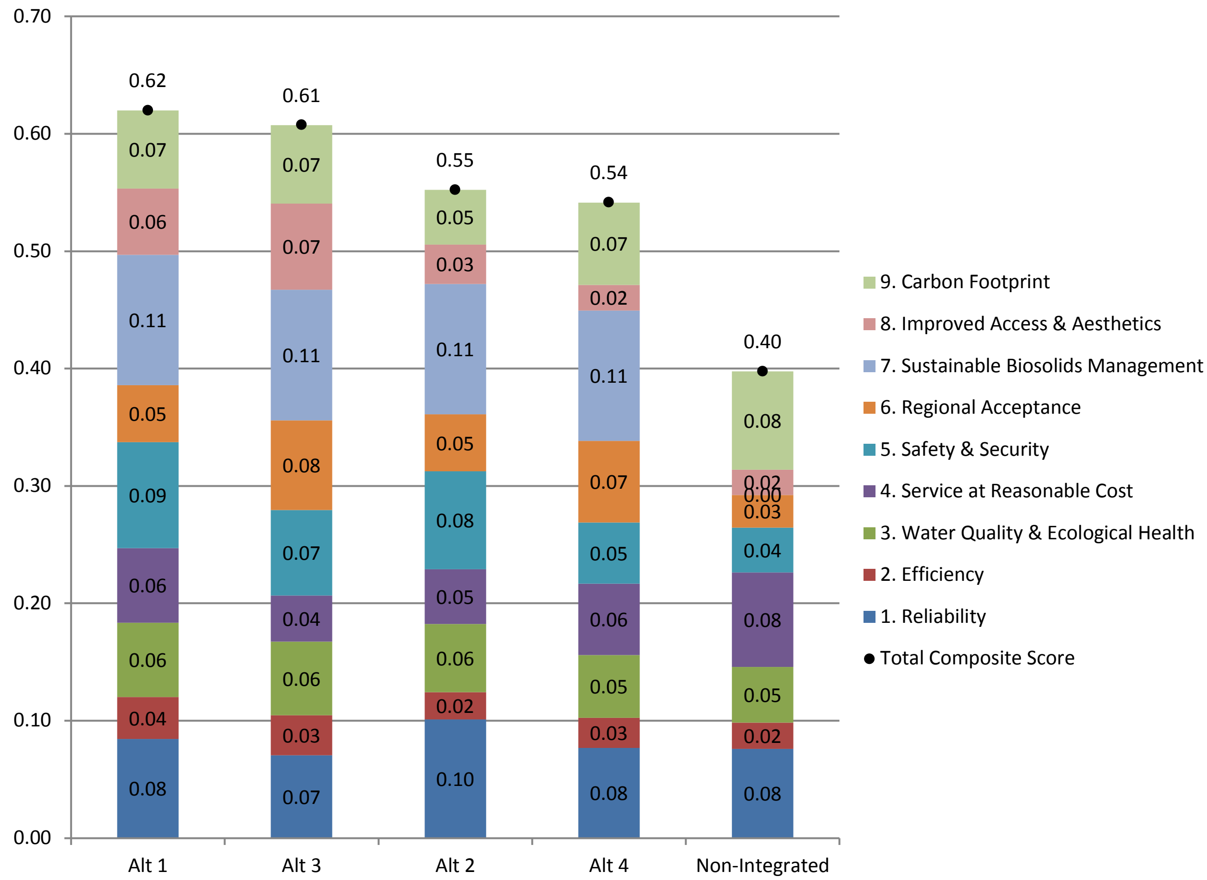


Figure 5-2
Franklin IWRP Equal Weights Composite Scores

In addition to re-scoring the alternatives using equally-weighted objectives, several other weighting scenarios were explored. In four additional scenarios, the four top-weighted objectives – reliability, water quality, safety and security, and cost – were given 30% of the weight while the other eight objectives split the remaining 70% (8.75% each). The results of these scenarios, shown in **Table 5-4**, maintain Alt 1 as the strongest alternative in all scenarios. The table gives the rank of each alternative's composite score and reinforces the benefits of Alternative 1. The final alternative options are shown in **Table 5-5**.

Table 5-4 Alternative Scores – Various Weighting Scenarios

	At 1	Alt 2	Alt 3	Alt 4	Non-Integrated
Stakeholder Weights	1	2	3	4	5
Equal Weights	1	3	2	4	5
Reliability 30%	1	2	3	4	5
Water Quality 30%	1	3	2	4	5
Safety & Security 30%	1	3	2	4	5
Cost 30%	1	4	3	2	5

Table 5-5 Alternative Options

		Non Integrated	Efficiency + Safety & Security	Water Quality +	Revised Low Cost	Revised Reliability
Overall System	SCADA System		X	X	X	X
Wastewater Treatment	*WW Explanation*	*Existing plan capacity not sufficient to meet demands; assumed that capacity is added, as needed basis*	*Maximize existing plant, and build additional capacity at new site*	*Maximize existing plant, and build additional capacity at existing site*	*Maximize existing plant, and build additional capacity at existing site*	*Distribute capacity between existing plant, new capacity at existing location, and new capacity at new location*
	Existing Plant 12mgd	X	X	X	X	X
	Existing Plant 16mgd		X	X	X	
	Parallel 4 mgd Train at Existing Plant					
	Parallel 6 mgd Train at Existing Plant					X
	Parallel 8 mgd Train at Existing Plant			X	X	
	South Plant 4 mgd					
	South Plant 6 mgd					X
	South Plant 8 mgd		X			
	Accept WW from Lynnwood/Cartwright		X	X		
	Higher Standard Effluent in Summer			X		
Water Treatment	Update 2 mgd plant + HVUD Purchase	X			X	
	Upgrade to 4 mgd + HVUD Purchase		X			
	Shut down WTP + HVUD Purchase			X		
	Cumberland River Line (no HVUD or Harpeth supply)					X
Reclaimed Water	Upgrade Pump to 12 mgd		X	X		X
	Add Probable Customers		X	X		X
	Add Uncertain Customers					

Table 5-5 Alternative Options, Continued

		Non Integrated	Efficiency + Safety & Security	Water Quality +	Revised Low Cost	Revised Reliability
Collection System	Collection System Model		X	X	X	X
	Convert Septic Users		X	X		X
	Rehab System for II Reductions		X	X	X	
Distribution System	Distribution System Model		X	X	X	X
	Short Term Water Quality Improvement Projects		X	X		X
	Long Term Supply Projects		X	X		X
	Address Non-Revenue Water		X	X	X	
Stormwater	Stormwater BMPs		X	X		
	LID Practices in New Development		X	X		X
Conservation	Irrigation Controls		X	X		X
	Toilet Replacement Program		X	X		X
	Additional Conservation		X			
Ecological Restoration	Low Head Dam Removal		X	X	X	
	Restore Harpeth Streambanks		X	X		
	Restore Five Mile Streambanks		X	X		
	Restore Sharpe's Branch Streambanks		X	X		
	Restore Additional Tributaries			X		
Biosolids	Anaerobic Digestion & Solar Drying		X	X	X	X
	Hauling to Landfill	X				

Section 6
Recommendations and Conclusions

It is recommended that BOMA adopt this IWRP as its roadmap for planning water resources projects through the next 30 years. The preferred alternative was selected based on stakeholder input through the IWRP process as described in this report. This section includes a discussion of the potential impacts to the City's rate structure for the water and sewer rates and stormwater utility fees as the IWRP projects are implemented. The significant permits required for the proposed projects are listed and a discussion is also provided on how the plan provides implementation flexibility through adaptive management practices.

6.1 Summary of the Preferred Alternative

This IWRP provides the framework for improvements to the City's water resources over the next 30 years, which upon approval, should be reviewed and updated approximately every five years. This approach will allow the City to adapt the plan to meet water resources demands as needed, accounting for population growth and demographic changes. The primary components of this IWRP include:

- Harpeth River low-head dam removal
- Increase water treatment plant (WTP) capacity to 4.0 mgd and addition of ultraviolet (UV) disinfection and an advanced oxidation process (AOP) to address disinfection requirements, as well as aesthetic issues such as taste and odor
- Upgrade the existing WWTP to 16 mgd
- Design and construct 16 mgd of biosolids treatment capacity comprised of thickening, anaerobic digestion, dewatering and solar drying, at the existing WWTP site
- Install the water quality improvements to the potable water distribution system
- Connect probable reclaimed water customers to the existing system
- Improve the City-wide SCADA system for the water and sewer systems
- Upgrade the City's Automated Metering Infrastructure (AMI)
- Create accurate computerized models of both the sanitary sewer and drinking water delivery systems

Initiate a toilet replacement program

Build the new south WWTP initially at 4.0 mgd capacity (2026) with provisions for build-out at 8.0 mgd (2040)

Tie in BCUC and CCUD facilities when the opportunity and capacity is available

The following components of this alternative are recommended annually or other scheduled basis based on availability of funding and/or project need:

Annual rehabilitation of the sanitary sewer collection system (recommended 5 percent – this would provide for a complete rehabilitation of the entire system every 20 years)

Annual rehabilitation of the drinking water distribution system (recommended 5 percent)

The stormwater basin projects should be completed on average once every three years based on the project size and the availability of the stormwater utility funding. Projects include improvements to: Sharps Branch, Quarry Branch, North Ewingville Creek, Liberty Creek, Sam Mill Creek, Donelson Creek, and Goose Creek

A stream restoration project should be scheduled to follow the stormwater basin projects such that the section of restored stream will be downstream of the basin to take advantage of the newly created storage. Projects would include improvements to the Harpeth River, Five Mile Creek and Sharp's Branch

Where existing infrastructure makes it practical, sewer customers should be added from those currently served by septic tanks

6.2 Potential Rate Implications

Based on the full implementation of Alternative 1, CDM Smith examined the potential impacts to the City's water and wastewater rates. For this analysis the following assumptions were made:

Projects were assumed to be financed through debt

An interest rate of 4.0 percent was used

Debt would be financed over a 30 year period

The water system customer base would grow at 1 percent annually

The wastewater system customer base would grow at 2.5 percent annually

The analysis was performed for a 7,000 gallon per month (water) customer

Impact fees to offset the cost of growth related projects

Present day dollar values were used

6.2.1 Water Rate Implications

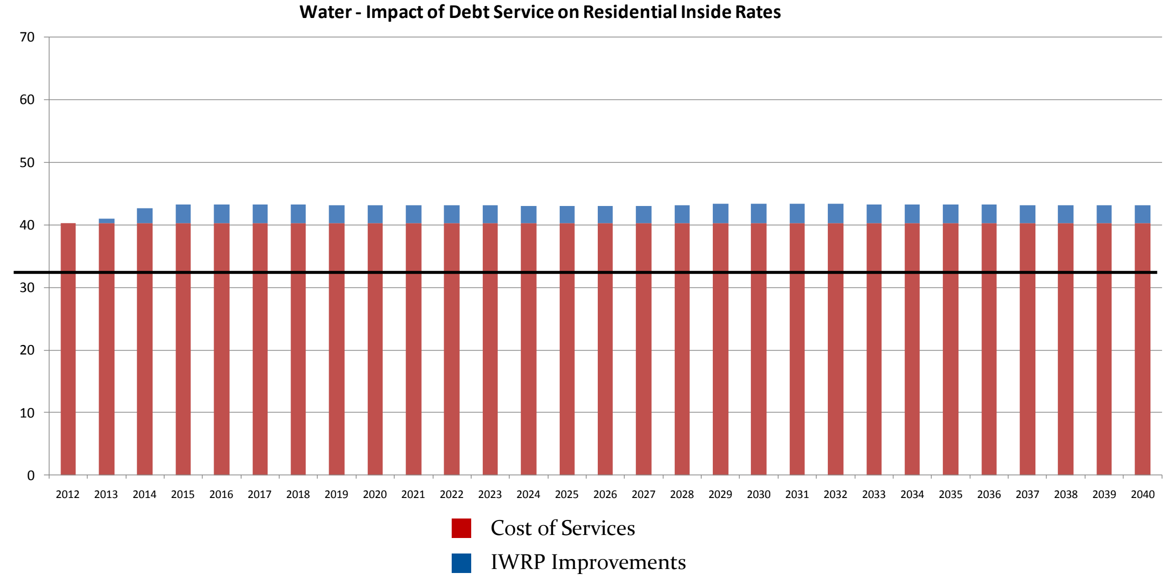
The water system rates are currently $32.74/ month for an average water customer (7,000 gal/ month). Based on the current cost of service study, the actual rate for service is $40.31/ month for an average customer. The recommended IWRP, as shown on **Table 6-1,** includes project options including $20.6 million dollars of capital projects, implemented over the next 30 years. Potential impact to the rates is shown in **Figure 6-1.**

Table 6-1 Drinking Water Projects

Project	Cost	Percent Cost Growth Related
Expand Existing WTP add UV and AOP	$9,134,000	50%
SCADA System	$830,000	0%
Water Quality Improvements (Distribution)	$2,100,000	0%
Distribution Capacity Improvements	$4,000,000	50%
Water System Distribution Model	$200,000	0%
SCADA	$830,000	0%
AMI (meters) Replacement Program	$3,500,000	0%

Note: The recommended annual rehabilitation costs were included as annual maintenance

Figure 6-1
Water - Impact of Debt Service on Residential Inside Rates



6.2.2 Wastewater Rate Implications

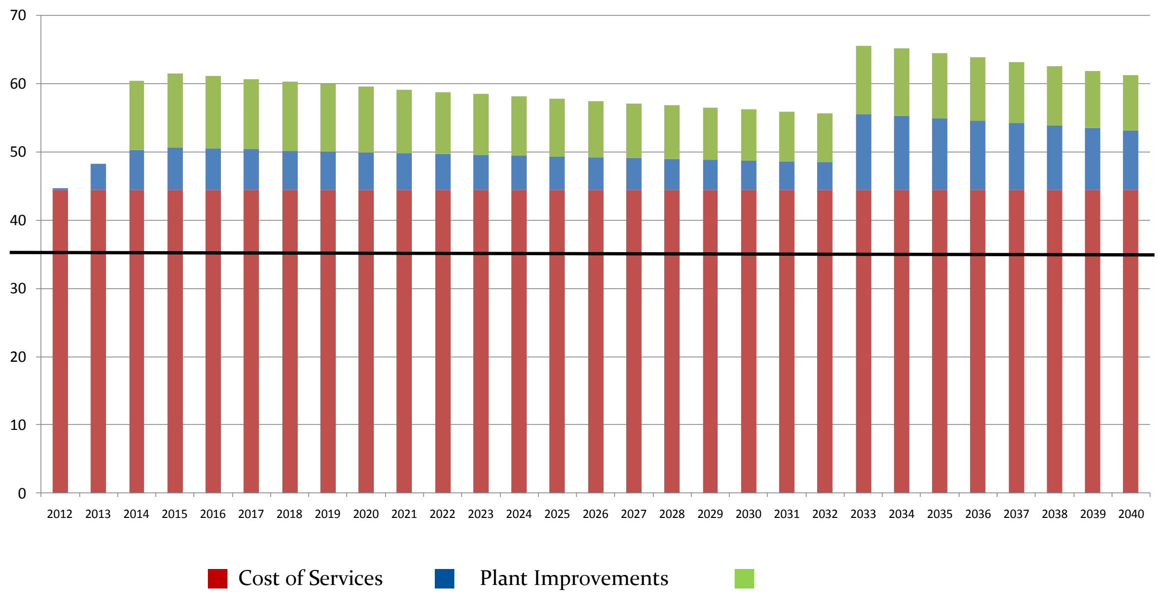
The water system rates are currently at $36.21/month for an average water customer (7,000 gal/ month). Based on the current cost of service study, the actual rate for this service is $44.40/ month for an average customer. The recommended IWRP, as shown in **Table 6-2** includes $207.1 million dollars of capital projects to be implemented over the next 30 years for wastewater collection and treatment. The potential impact to the rates is shown in **Figure 6-2.**

Table 6-2 Wastewater/ Reuse Projects

Project	Cost	Percent Cost Growth Related
Expand Existing WWTP to 16 mgd	$18,600,000	56%
Build the South WWTP (initial 4.0 mgd)	$60,000,000	100%
Additional 4.0 mgd capacity to the South WWTP (8.0 total)	$18,00,000	100%
Sanitary Sewer Model	$400,000	0%
Sewer I/I Correction Program	$16,430,000	0%
SCADA System	$4,800,000	25%
Biosolids (Phase I – 16 mgd total capacity)	$66,000,000	25%
Biosolids (Phase I – 20 mgd total capacity)	$14,000,000	100%
Biosolids (Phase III – 24 mgd total capacity)	$8,000,000	100%

Note: The recommended annual rehabilitation costs were included in the cost of service; Reclaimed water projects were not included in the wastewater rate analysis.

Figure 6-2
Sewer - Impact of Debt Service on Residential Inside Rates



6.2.3 Stormwater Rate Implications

The IWRP study identified approximately $16 million in stormwater BMP projects and approximately $28 million in stream/ecological restoration projects to support long-term environmental and water quality improvements. It is important to evaluate the potential stormwater user fee impacts associated with implementation of these projects in addition to maintaining adequate funds for personnel, operations and equipment.

In 2004, the BOMA passed an ordinance to establish a stormwater user fee to fund stormwater services in the City. User fees are assessed for all developed properties in the City on the basis of the amount of impervious area on the property. The base rate for residential properties is $3.65 per month, while non-residential properties are charged in proportion to the base rate. The Stormwater User Fee generates approximately $2.03 million annually and there is another approximately $60,000 of other stormwater related revenues, including development fees. The City currently projects a fund balance of approximately $4 million at the end of 2012. For the 2012 budget year, the City projected a total cost of approximately $1.5 million for personnel, operations and equipment. CDM Smith evaluated the budget and rate impacts from implementing the capital improvements program over various time periods, a summary of the budget and rate impacts is provided in **Table 6-3**.

Table 6-3 – Budget and Rate Impacts for Various CIP Program Implementation Periods

Category	10-yr CIP	20-yr CIP	30-yr CIP
Annual CIP Budget	$4.4M	$2.2M	$1.5M
Estimated ERU Rate	$9.50	$5.50	$4.50

As shown, a significant rate increase would be required to implement the proposed CIP projects over a 10-year planning horizon, and is not recommended. Implementation over a 20-year or 30-year planning period is a more reasonable approach, and consistent with the timing of other IWRP projects. If shorter implementation periods are to be considered, bonding is recommended to minimize rate increases.

Should the City consider increases to the monthly stormwater user fee, it would be advisable to also evaluate the current rate structure. As noted, the City's stormwater user fee was implemented in 2004. It is common for utilities to re-evaluate rates on a 10-year cycle. The City should also consider that significant, development occurred after the original stormwater fee was developed and these development changes may lead to a change in the definition of the equivalent residential unit.

6.2.4 Alternative Funding Sources

While rate increases could be implemented to address the full cost of projects included in the IWRP, CDM Smith has identified alternative funding sources that could be used to offset rate increases. The two programs that were identified as part of the funding plan included the State Revolving Fund Loan Program and the Clean Tennessee Energy Grant Program.

6.2.4.1 State Revolving Fund Loan Program (SRF)

The State Revolving Fund (SRF) Loan Program is a low interest loan program managed by the Tennessee Department of Environmental Conservation (TDEC). An amendment to the Federal Clean Water Act in 1987 created the CWSRF Program in order to provide low-interest loans to cities, counties, utility districts, and water/wastewater authorities for the planning, design, and construction of wastewater facilities. The U.S. Environmental Protection Agency awards annual capitalization grants to fund the program, and the State of Tennessee provides a twenty-percent funding match. The current interest rate (April 30, 2012) for these loans is 1.99 percent. In addition to the low interest rate, these loans include 10 percent debt forgiveness for the first 4 million borrowed for clean water projects and 2.5 million for drinking water projects. Assuming the City borrowed the maximum allowable this could result in up to $400,000 and $250,000, respectively, of debt forgiveness for the wastewater and water projects. Utilizing the SRF loan program is a practical way to fund construction of new facilities or upgrades to existing facilities.

As part of the evaluation, CDM Smith prepared project application packages for SRF funding which included both clean water and drinking water projects. Clean water projects and their funding request and rankings were as follows:

Upgrades to the existing WWTP, $18.6M was ranked #6

Biosolids Facility, $66M was ranked #7

Reclaimed Water Upgrades/Expansion, $0.9M was ranked #29

Wastewater SCADA System Improvements, $4.8M was ranged #8

Drinking water projects, their funding approval and SRF ranking included the following:

Drinking Water Treatment Plant Upgrades, $9.2M was ranked #2

Distribution System Upgrades, $6.3M was ranked #36

AMI Transmitter Project, $2.8M was ranked #26

6.2.4.2 Clean Tennessee Energy Grant Program

The Clean Tennessee Energy Grant Program is a grant program also managed by TDEC. The purpose of the program is to select and fund projects that reduce certain categories of pollutants. The program provides assistance to public and private entities in Tennessee in the form of grants to purchase, install and construct projects that fall into one or more of the following categories:

Cleaner Alternative Energy: biomass, geothermal, solar, wind

Energy Conservation: Lighting, HVAC improvements, improved fuel efficiency, insulation, idling minimization

Air Quality Improvement, including Sulfur Dioxide (SO_2), Volatile Organic Compounds (VOCs), Oxides of Nitrogen (NO*x*), Hazardous Air Pollutants (HAPs), Greenhouse Gases

The program was started in 2011 as the result of federal court settlement of an enforcement action under the federal Clean Air Act that resulted in a consent decree with the Tennessee Valley Authority (TVA). Part of the Consent Decree obligates TVA to provide Tennessee $26.4 million to fund environmental mitigation projects. The funds are to be paid over 5 years or longer, with the first-year payment not to exceed $5.28 million. Starting in 2012 a total of $2.25 million will be available in the first round of grants. The maximum grant amount per project is $250,000. The City has several projects that fit the criteria for funding through this program.

6.3 Adaptive Strategy

One of the strengths of the IWRP is the ability to adjust project implementation through the planning period in response to changes in population, environment, technology, and regulatory pressure. A summary and discussion of these potential adaptations are provided in this section.

6.3.1 Drinking Water Supply Plan

The plan to supply drinking water to the City's customers is flexible and provides reliability and redundancy in service. From the perspective of drinking water supply, the plan includes an increase in the amount of potable water that the City can produce internally by way of an increase in the production capacity of the water treatment plant. This increased capacity, coupled with maintaining the connections to the HVUD supply in the North, providing a number of advantages:

By upgrading the existing WTP, the City could produce a greater percentage of its own water, allowing the City to reduce the cost of supply that comes with generating water in lieu of paying for treated water from HVUD; this project could be phased such that the facility upgrades could be expanded to 4 mgd to provide improved services to meet future demands

By retaining the capability of producing drinking water, the City reduces the vulnerability inherent of being a wholesale customer; the city retains control over the finished water quality and doesn't rely completely on a several miles of transmission pipelines

By maintaining their own plant, the City retains two independent sources of supply (Cumberland and Harpeth Rivers respectively), reducing exposure to catastrophic events such as contamination of the supply by a fuel or chemical spill on the river or severe drought

By retaining the connection to the HVUD supply, the City retains the ability to supply customers during peak periods without the need to construct additional WTP capacity; additionally, this provides the capability to supply customers in an emergency without having to build complete redundancy into the City's WTP

By retaining the connection to the HVUD supply, the City may be able to produce its water at off peak electrical times which could reduce its operational costs

6.3.2 Biosolids Disposal Plan

The biosolids disposal plan includes reliability and redundancy for disposal, as well as flexibility with respect to implementation. The recommended plan includes implementation of biosolids facilities to produce a Class A product by solar drying offering a number of benefits:

Each process in the recommended plan (thickening/digestion, dewatering, drying) reduces the total volume of biosolids generated over the City's current practice, as such it can be implemented stepwise, as funding permits

Although the recommended plan calls for new facilities to house the new solids handling equipment, there may be opportunities to reuse existing infrastructure (buildings/ odor control) or equipment (dewatering) or implement the new solids handling facilities in a phased approach as the older existing units reach the end of their useful life

By implementing the thickening and anaerobic digestion processes, the City will be able to produce a Class B biosolids which can be land applied or a portion of which could be mixed with the City's current composting program to produce Class A biosolids

If the dewatering process were added to digested biosolids, the City could dispose them through land application or composting but with a greatly reduced volume

Once the final process (solar drying) is added to the facility, the City will be able to produce a product that has multiple disposal options for the Class A product:

- As fertilizer at City facilities (ball fields, parks, right of ways)
- Stored and distributed to the citizens of Franklin (similar to the composting program)
- Combined with the yard waste compost for distribution to the citizen of Franklin
- Cover for landfills
- As a soil amendment at local farms
- Landfill disposal (worst case) at a significantly reduced volume over current practices

6.3.3 Wastewater Disposal/Reuse Plan

The final plan for treatment and disposal of the City's wastewater includes maximizing the treatment capacity at the City's existing WWTP and construction of a new facility to address additional demands as a result of growth in the southern portion of the City's service area. Once the entire system is constructed, the plan provides the City with multiple benefits for disposal or reuse of the effluent it produces:

Both WWTPs will be tied into the reuse system, providing the ability to supply reuse from either plant, depending on where the demand is located. By having the capability to supply from both plants it reduces the storage needed during peak demands and reduces the scale of the infrastructure required to supply the southern service area from the north WWTP

Construction of the South WWTP increases the flow in the Harpeth River upstream of the existing WTP. This increases the volume that the City can withdraw from the Harpeth River during low flow periods which would reduce the overall cost of water production

Both WWTPs will produce reclaimed quality water which allows the City to serve beyond the probable customers identified; this provides the City greater flexibility in adapting to changing demands by continuing to monitor developing trends and growth patterns, allowing for a final decision to be made later on whether the advantages of the south plant are still valid prior to implementing future design and construction

6.3.4 Stormwater and Conservation Plan

The final plan for expansion of the City's stormwater treatment system includes construction of seven independent stormwater basin projects and associated stream bank restoration. Conservation projects included in the plan provide for a toilet replacement program and upgrades to the City's SCADA and AMI infrastructure. The flexible benefits of these projects include:

Implementation of any of these projects can be phased should any particular basin become a higher priority due to potential funding contributions from increased development or if the proposed site were going to be lost to other uses

The plan has stream bank restoration associated with the corresponding basin so that improvements in each basin can be maximized and the contribution of sediment from runoff in that portion of the Harpeth River through Franklin can be reduced

With respect to conservation, the toilet rebate program was selected as the best method to encourage conservation; if other candidates for conservation arise they could be compared against the toilet rebate program to determine the most effective program for the City

Conservation is another method of improving efficiency of water management practices; installation of a supervisory control and data acquisition (SCADA) system would lower the response time for leaks and other water and wastewater functions; an integrated, central SCADA would increase the overall efficiently of the water/wastewater systems

An Automated Metering Infrastructure (AMI) upgrade project would allow the City, through the installation of two-way transmitters at approximately 17,000 water delivery points, to read water consumption remotely from the Utility Billing offices through a network of four receivers. The technology provides the ability to frequently monitor (including on-demand monitoring) the status of delivery points to readily identify consumption trends, potential leaks, reverse flow, tampering, and other system management functions. These features will enable Franklin Water Management to be more proactive in reducing water loss, improving customer response, and reducing operating expenses and risk associated with traditional meter reading practices.

6.4 IWRP Timeline

Based on the understanding of the needs of the City of Franklin and the implementation of the options associated with the recommended plan, the following schedule is recommended for the implementation of the IWRP. This schedule is developed with the understanding that a great deal of flexibility exists within the plan and the City may adjust the schedule as necessary based on interim reviews, preference or more immediate needs. The timeline is presented in **Table 6-4** in 5-year segments with recommended implementation marked**.**

Table 6-4 – IWRP Adaptive Strategy Schedule

City of Franklin IWRP Selected Plan Components	Update Year 2012	2017	2022	2027	2032	2037	2042
Non- Structural Components							
BOMA to Adopt IWRP	X						
Update IWRP		X	X	X	X	X	X
Evaluate Implementing Conservation Policies (toilet replacement program)		X	X	X	X	X	X
Water							
Expansion of the WTP to 4.0 mgd and Add AOP	X						
AMI Improvements	X						
Water Quality Distribution Improvements	X						
Distribution Capacity Improvements							
AMI Replacement Program	X						
Distribution System Model	X						
SCADA	X						
Wastewater							
Expansion of the Existing WWTP to 16.0 mgd	X						
Evaluate Location of Initial South WWTP (4.0 mgd)			X				
Evaluate Build Out Capacity South WWTP (8.0 mgd)					X		
Biosolids Phase I	X						
Evaluate Biosolids Phase II			X				
Evaluate Biosolids Phase III					X		
Sewer I/I Correction Program	X						
Sanitary Sewer Model	X						
SCADA	X						
Consider Tie in of BCUC and CCUC systems			X				
Consider Tying in Possible Septic Users		X	X	X	X	X	X
Reclaimed Water							
Upgrade Reclaimed Pump Station		X					
Addition of Probable Reclaimed Water Customers		X					
Consider Additional Reclaimed Water Customers			X	X	X	X	X
Stormwater							
Evaluate Stormwater Basin Projects	X	X	X	X	X	X	X
Evaluate Stream Bank Erosion Projects	X	X	X	X	X	X	X
Low Head Dam Removal	X						

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