Southwest Florida Water Management District

Economic Feasibility of Reclaimed Water Use by Non-Utility Water Use Permittees and Applicants

For the Southwest Florida Water Management District

FINAL Report

Agreement No. 09CC0000009

June 2010

Prepared by HAZEN AND SAWYER Environmental Engineers & Scientists

in association with HSW Engineering, Inc.

44302-000T002

HAZEN AND SAWYER
Environmental Engineers & Scientists

Hazen and Sawyer, P.C.
4000 Hollywood Boulevard, 750N
Hollywood, Florida 33021
(954) 987-0066
Fax: (954) 987-2949

June 30, 2010

Mr. Don Rome
Business Process Analyst
Performance Management Office
SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT
2379 Broad Street
Brooksville, FL 34604-6899

Economic Feasibility of Reclaimed Water Use
by Non-Utility Water Use Permittees and Applicants,
FINAL REPORT, Agreement No. 09CC0000009

Dear Mr. Rome:

We are pleased to submit the report titled "Economic Feasibility of Reclaimed Water Use by Non-Utility Water Use Permittees and Applicants". This document describes the results of a literature review and survey of reclaimed water users in Florida. This information was used to develop evaluation criteria and the types of information that a non-utility water use permittee or applicant would provide to the District to document the economic feasibility of reclaimed water. These evaluation criteria and the evaluation models titled "Reclaimed Water Benefit-Cost Calculator for Irrigation and Industrial Applications" are presented in this document.

Project team members responsible for this study are myself, as project manager, Jenaveve Miller, Julie Karleskint, P.E., and Caitlin Feikle of Hazen and Sawyer and Heidi Swanson, Dean Mades, P.E., and Dennis Stone, P.E. of HSW Engineering, Inc. We thank the 37 survey respondents who gave their time and effort to complete the detailed survey. The information they submitted was essential to the completion of this project.

We enjoyed working with you throughout this project. We thank you and all District staff who provided comments on the draft report and the presentation of this study which were incorporated into this document. We thank Carl Wright, District Senior Water Conservation Analyst, and the District's Resource Projects, Conservation & Utility Outreach section for producing the original Excel model that began the identification of benefits and costs of reclaimed water to a user. This original Excel model provided the web links for the fuel and fertilizer cost data.

We thank Anthony Andrade, District Senior Water Conservation Analyst, for his recommendation to amend the evaluation models to address partial offsets. We also thank you for your excellent recommendation, which we adopted, regarding how to treat partial offsets in evaluating the benefits and costs of reclaimed water.

Very truly yours,

HAZEN AND SAWYER, P.C.

Grace Johns

Grace M. Johns, Ph.D.
Senior Associate and Economist

Enclosure

c: File No. 44302-000

O:44302-000L003

Table of Contents

Tables

O:\44302-000\Wpdocs\R3

O:\44302-000\Wpdocs\R3

O:\44302-000\Wpdocs\R3

O:\44302-000\Wpdocs\R3

O:\44302-000\Wpdocs\R3

Figure

O:\44302-000\Wpdocs\R3

Executive Summary

1.0 Study Purpose and Goals

Reclaimed water can be an effective way to diversify Florida's water resources in order to use fresh water more efficiently. The Southwest Florida Water Management District (District) water use permitting rules require agricultural, recreational/aesthetic, and industrial/commercial water use permittees and applicants in Water Use Caution Areas to investigate the feasibility of using reclaimed water. These permittees and applicants are required to use reclaimed water if it is technically, environmentally, and economically feasible. In general, reclaimed water is economically feasible to a water use permittee or applicant if the present value of the benefits to the permittee or applicant from using the reclaimed water is comparable to or greater than the present value of reclaimed water costs to the permittee or applicant.

For the purposes of this study, the reclaimed water is provided by a utility and is defined as water that flows out of a wastewater treatment plant and has received at least secondary treatment and required disinfection. Also, Agriculture and Recreation / Aesthetic water users use reclaimed water exclusively for irrigation, including crop establishment and frost/freeze protection, and Industrial water users use reclaimed water in certain production processes, primarily as cooling water.

This study gathered the available information from literature reviews, survey research and interviews to address the following study goals.

1. Improve the District's ability to assist water users in assessing the benefits and costs of reclaimed water to them;
2. Identify areas of future research that address how the net benefits of reclaimed water to water users can be as great as possible; and
3. Better assess whether or not reclaimed water is economically feasible to specific water users.

This report describes the results of a literature review and survey of reclaimed water users in Florida. From this information, evaluation criteria and two Excel models were developed that a non-utility water use permittee or applicant would use to document the economic feasibility of reclaimed water.

2.0 Literature Review

The literature review included internet and web site searches accompanied by email and telephone requests of numerous organizations. While there is an abundance of information regarding the production and uses of reclaimed water, only five documents were lo-

O:\44302-000\wpdocs\R3

cated that address the benefits and costs of reclaimed water to users. No documents were located that describe how potential reclaimed water users should evaluate the potential benefits and costs of reclaimed water to their operations.

3.0 Survey of Reclaimed Water Users

The results of a survey of reclaimed water users in Florida were crucial to developing the evaluation criteria for this study. The survey included questions regarding the use of reclaimed water, the costs and benefits of reclaimed water, the economic feasibility of reclaimed water, satisfaction with reclaimed water reliability, quality and quantity and whether the user would do it all over again. Three reclaimed water surveys were developed, one for each water use type: Agricultural; Recreation / Aesthetic; and Industrial, respectively.

About 80 percent of the reclaimed water users who were asked to complete the survey actually completed and returned the survey. The number of completed surveys by type of water user and county is provided in Table ES.1.

Table ES.1
Number of Completed Surveys From Reclaimed Water Users By County

County	No. of Respondents				% of Respondents
	Agriculture	Recreation / Aesthetic	Industrial	Total	
Charlotte	0	1	1	2	5%
Desoto	4	0	0	4	11%
Hernando	0	1	0	1	3%
Hillsborough	0	3	2	5	14%
Manatee	2	1	0	3	8%
Orange (a)	2	0	1	3	8%
Pasco	1	2	0	3	8%
Pinellas	0	3	1	4	11%
Polk	0	0	4	4	11%
Sarasota	1	5	0	6	16%
St. Lucie (a)	0	0	1	1	3%
Sumter	0	1	0	1	3%
Total	10	17	10	37	100%

(a) This county is not in the Southwest Florida Water Management District.

A total of 37 completed surveys were obtained and are comprised of 10 agricultural surveys, 17 recreation / aesthetic surveys and 10 industrial surveys. The project team would like to express their sincere appreciation and thanks to the 37 people who took the time to fill out this survey and explain how reclaimed water has affected their operations in terms of benefits and costs.

O:\4302-000\wpdocs\R3

Of the 16 counties in the Southwest Florida Water Management District, 10 are represented in this survey. Two counties, Orange and St. Lucie, are in the South Florida Water Management District. The four respondents in these two counties were asked to participate in this survey in order to achieve the survey goal. These respondents are believed to be representative of the actual and potential reclaimed water users in the Southwest District.

The survey respondents were very helpful in providing information regarding their benefits and costs associated with reclaimed water and these results were incorporated into the evaluation criteria and the two Excel models.

4.0 Costs of Reclaimed Water Use

The actual costs associated with connecting to a reclaimed water system and using the reclaimed water will vary depending on factors specific to the farm, golf course, landscaped area or industrial firm. There are potentially three types of costs associated with using reclaimed water: (1) installation costs; (2) annual costs; and (3) recurring O&M costs other than annual. A list of the potential installation costs is provided in Table ES.2. A reclaimed water user will not necessarily need to spend money on all of these cost items.

Table ES.2
Potential Installation Cost Items Associated with Using Reclaimed Water For Irrigation and Industrial Applications

(1) Install pipe system to connect irrigation system or industrial operation to reclaimed water pipeline

(2) Install pressure regulating valves to control pressure of water flowing into irrigation system

(3) Install water meter to monitor amount of reclaimed water used

(4) Create storage pond or install storage tank and pump station to match reclaimed water supply with timing of water needs

(5) Disconnect existing water source from irrigation system or industrial operation

(6) For industrial applications, install or expand the water pretreatment system

(7) For micro-sprinkler and drip irrigation systems, install or upgrade filtration and/or chemical injector systems to reduce clogging

(8) Create reclaimed water disposal area such as ditch connection to pasture area during times when reclaimed water flows are higher than crop water needs

(9) For turf and landscape, change plant material to more salt tolerant species

(10) Other costs, if any, specific to the reclaimed water user associated with the provision of water for other uses from the existing water source due to the reclaimed water connection.

A list of the potential annual and periodically recurring costs associated with using reclaimed water is provided in Table ES.3.

Table ES.3
Potential Annual or Periodically Recurring Cost Items
Associated with Using Reclaimed Water for Irrigation or Industrial Applications

1. Reclaimed water payment to the utility
2. Irrigation-related management associated with maintaining reclaimed water meter, pipeline, pump and storage pond; repairing pipeline due to fluctuating water pressure; and repairing or replacing rusty controllers, power boxes and equipment
3. Fertilizer management including water quality and plant tissue testing and nutrient evaluations
4. Salinity and pH management including chemical applications, water blending, soil leaching and mechanical means
5. Pest or algae management including cleaning or repairing microjets or drip nozzles, water chlorination, pesticide applications, and filter replacement
6. Chemicals needed for reclaimed water treatment prior to industrial application
7. Recording water data and providing reports to the water management district and the FDEP

5.0 Benefits of Reclaimed Water Use

The survey responses demonstrated that there are benefits of reclaimed water use relative to using traditional water sources such as ground or surface water. These benefits include cost savings and value-added. The benefits are listed in Table ES.4 in order of importance to the 37 Agricultural, Recreation / Aesthetic and Industrial reclaimed water users surveyed.

The top five benefits are related to having more water available when needed relative to traditional water sources. The top three benefits are: (1) having a guaranteed and reliable water source, (2) able to conserve fresh water for their other uses and (3) able to irrigate more frequently that if a traditional water source was used. About 2 of every 3 respondents said they were receiving at least one of these three benefits.

Table ES.4
Benefits of Reclaimed Water for Irrigation and Industrial Applications
Ranked in Order of Percent of Respondents Who Said Yes to Benefit

Reclaimed Water Benefits	Survey Respondents Who Said Yes to Benefit		
	Number	% of Responses	Total No. of Respondents (a)
1. Have a guaranteed and reliable water source	25	68%	37
2. Able to conserve fresh water for their other uses	25	68%	37
3. Able to irrigate more frequently than if used traditional source	17	63%	27
4. Able to apply more water to the crop/lawn/ landscape than with traditional source	15	56%	27
5. Better able to supply water to crops during drought conditions	5	50%	10
6. Irrigation or water costs are lower	17	46%	37
7. Our permitting requirements have been reduced	3	30%	10
8. Net income is higher than with traditional water source	11	30%	37
9. Fertilization costs are lower	7	26%	27
10. Revenue is higher than with traditional water source	9	24%	37
11. Business has increased during fresh water shortage restrictions	4	24%	17
12. Better able to protect crops from freezing	2	20%	10
13. Crop yield or product quantity has been higher than with a traditional source	2	10%	20
14. Pounds of juice per acre is higher than with traditional source	1	10%	10
15. Our production cost is lower	1	10%	10
16. Water storage costs are lower	3	8%	37
17. Quality of crop/lawn/landscape/product is higher than with traditional source	3	8%	37

(a) The total number of respondents is 37 if the question was asked of Agricultural, Recreation / Aesthetic and Industrial respondents. The total number of respondents is 27 if the question was asked of the Agricultural and Recreation / Aesthetic respondents. The total number of respondents is 10 if the question was asked of only the Agricultural respondents or only the Industrial respondents.

O:\44302-000\wpdocs\R3

The fourth and fifth ranked benefits are also related to having more water and are: (4) Able to apply more water to the crop/ lawn/ landscape than with a traditional source and (5) Better able to supply water to crops during drought conditions. At least 50 percent of the 27 Agricultural and Recreation / Aesthetic respondents stated that they received at least one of these two benefits from using reclaimed water.

The Agricultural and Recreation / Aesthetic respondents were asked the following question regarding the net benefits of reclaimed water to their firm: "Do you believe that the total benefit your firm is receiving from using reclaimed water is greater than the total cost your firm is paying for reclaimed water (after subtracting any money received from government agencies)?" Of the 10 Agricultural respondents, six answered yes, one answered no, one did not know and two did not answer the question. Of the 17 Recreation / Aesthetic respondents, 15 said yes, one said no and one did not know.

All 37 respondents were asked to rate the supply reliability, quantity and quality of their reclaimed water. All of the Industrial respondents were very satisfied or satisfied with their reclaimed water reliability, quality and supply. For the most part, the Agricultural respondents gave favorable ratings to their reclaimed water. Six of the 10 Agricultural respondents were satisfied with their water supply reliability and water quality and five were satisfied with their water quantity. Three were very satisfied with their reclaimed water quantity and quality and four were very satisfied with their water supply reliability. The 17 Recreation / Aesthetic respondents also gave favorable ratings for their reclaimed water. Nine respondents are very satisfied with the supply reliability of their reclaimed water while 11 respondents are satisfied with their reclaimed water quantity and 10 are satisfied with its quality.

All 37 respondents were asked the following question: "If your firm could do it all over again, would your firm agree to connect to the reclaimed water system? If you cannot speak for your firm, would you agree to connect this facility if the choice was yours alone?" Of the 10 Agricultural respondents, nine would connect again because the reclaimed water saves the farm money and one would not connect, citing the added cost of grove maintenance associated with using the reclaimed water.

All of the 17 Recreation / Aesthetic respondents said they would connect to reclaimed water if they had to do it all over again. The most common reasons were that the reclaimed water is needed as a supplemental water source and is it available during fresh water shortage restrictions. Four said that irrigation is a good use of reclaimed water and three said that reclaimed water is affordable or saves money.

All of the 10 Industrial respondents would use reclaimed water as a supply source for their industrial operations if they had to make the decision again. Three of the 10 survey respondents are interested in obtaining additional reclaimed water quantities.

6.0 Evaluation Criteria and the Reclaimed Water Benefit-Cost Calculator

This study used survey research and the available literature to develop evaluation criteria that may be used to assess the economic feasibility of reclaimed water for irrigation of crops, turf and landscape; and for industrial applications. These evaluation criteria were incorporated into two Excel models that can assist the District and the potential reclaimed water user in organizing the information needed to make an assessment of economic feasibility. These models guide the user in collecting and assembling the necessary information and provide estimates of the benefits, costs and net benefits of reclaimed water to the user.

Farmers, golf course owners, homeowner and condominium associations, and any entity with a beneficial need for irrigation water would use the Excel model called "Reclaimed Water Benefit-Cost Calculator for Irrigation". Industrial firms would complete the Excel model called "Reclaimed Water Benefit-Cost Calculator for Industrial Applications". The use of each model is described in this report. The evaluation criteria contained in these models attempt to measure and compare the benefits of reclaimed water to the costs of reclaimed water. These models can be used to conduct sensitivity analyses to evaluate uncertainties in the input data.

The Reclaimed Water Benefit-Cost Calculators for Irrigation and Industrial Applications are to be used to provide guidance as to the economic feasibility of using reclaimed water for a specific purpose. The values that the user will input into the model are estimates and the model results should not be the only factor in determining economic feasibility. Instead, the model results should be viewed in the proper context of all other information submitted and relevant to the water use permit application or renewal.

The evaluation model compares the costs associated with accessing and using reclaimed water (RW) with the costs to access and use water from the next available water source (NAWS). The model also provides guidance in estimating the benefits of reclaimed water to the user. These benefits include:

- Nitrogen fertilizer cost savings - annual
- Change in value of crop production – annual
- Change in quality of crop, lawn and/or landscape – annual
- Value of additional water available from reclaimed water source – annual
- Value of additional water "freed up" by the reclaimed water use (that can be used by the reclaimed water user)
- Value of water available during NAWS water shortage restrictions – annual

The evaluation criteria and the order of benefits and costs in the Reclaimed Water Benefit-Cost Calculator are provided in Table ES.5. The model can also evaluate partial offsets, where only a portion of the next available water source, NAWS, is replaced with reclaimed water. A user guide for the irrigation model and the industrial applications model is provided in Chapter 3.0 and Chapter 4.0, respectively.

7.0 Recommendations for Further Research

In the course of this study, several areas of further research to address information gaps were identified. These study areas are as follows.

- Support research and develop a method to estimate the influence of reclaimed water on the amount of macro and micro nutrients taken up by plants, including citrus, tomato, turf, etc. This information would be useful to estimating the cost savings associated with reduced fertilizer requirements.

- Conduct scientific field trials to determine the impact of reclaimed water features on crop productivity per acre for crops commonly produced in Florida that would have access to reclaimed water. Reclaimed water features include differences in water quality and water availability relative to traditional water sources. This information would be useful to estimating the change in the value of crop production associated with reclaimed water use.

- Conduct scientific field trials to determine the impact of reclaimed water features on turf and landscape plant quality. Given these results, conduct research to document the impact of these quality changes on net revenue to the reclaimed water user. This research should be conducted at the nursery production and sales level and at the plant end user level such as golf course and homeowner associations. Reclaimed water features include differences in water quality and water availability relative to traditional water sources. This information would be useful to estimating the change in net revenue from changes in plant quality associated with reclaimed water use.

- Conduct research to estimate representative values of water used for irrigation by type of plant irrigated. The plant types would include those commonly produced and/ or irrigated in Florida that would have access to reclaimed water, such as citrus, tomatoes, St. Augustine grass, and Bermuda grass. These estimated values would be used in estimating the benefits of reclaimed water as well as the benefits of all other alternative water supplies.

O:\44302-000\wpdocs\R3

Table ES.5
Evaluation Criterion and Order of Benefits and Costs Presented
In the Reclaimed Water Benefit-Cost Calculators For Irrigation and Industrial Applications

Benefit or Cost Item	Measure of Benefit Or Cost Item	Evaluation Criterion (a)
A. Amount of water needed and available in million gallons – annual	Amount of water needed and available in million gallons – annual	Negative of Difference in amount of water needed and available (RW minus NAWS)
B. Installation costs	Total annualized installation cost and Per 1,000 gallons	Difference in annualized installation cost (NAWS minus RW)
C. Annual O&M costs	Total annual O&M cost and Per 1,000 gallons of water	Difference in annual O&M cost (NAWS minus RW)
D. Recurring O&M costs, other than annual	Total annualized recurring O&M cost and Per 1,000 gallons of water	Difference in annualized recurring cost (NAWS minus RW)
E. Nitrogen fertilizer cost savings – annual (Irrigation Only)	Total annual nitrogen fertilizer cost savings and Per 1,000 gallons of water	Nitrogen fertilizer cost savings
A. through E.	Total annualized cost and cost savings and Per 1,000 gallons of water	
F. Change in value of crop production – annual (Irrigation Only)	Net value of change in crop production – annual	
G. Change in quality of crop, lawn and/or landscape – annual (Irrigation Only)	Change in net revenue (market value minus variable cost) – annual	
H. Value of additional water available from reclaimed water source – annual	Value of additional water – annual	
I. Value of additional water “freed up” by the reclaimed water use - annual (that can be used by the reclaimed water user)	Value of “freed up” NAWS water – annual	
J. Value of water available during NAWS water shortage restrictions – annual	Value of water available during NAWS water shortage restrictions – annual	
F. through J.	Total benefit value of reclaimed water (other than cost savings) and Per 1,000 gallons	
A. through J.	Net benefit of reclaimed water use relative to next available water source and Per 1,000 gallons	

(a) Positive values are benefits of reclaimed water and negative values are costs of reclaimed water.

O:\4430

- Round table discussions with industries within the District that are interested in or currently using reclaimed water may be an effective method to further itemize and quantify potential reclaimed water benefits and costs for industrial applications. Mining interests, power companies, and smaller reclaimed water users will have the technical and local knowledge to efficiently address cost and benefit issues.

Chapter 1.0
Introduction

1.1 Background

Reclaimed water can be an effective way to diversify Florida's water resources in order to use fresh water more efficiently. Fresh water withdrawals in the State of Florida can potentially occur within six main water use categories. These categories are Public Supply, Domestic, Industrial, which includes commercial and mining withdrawals, Agricultural which includes irrigation, aquaculture and livestock watering, Recreational Irrigation which includes golf courses and landscaping, and Thermoelectric which uses a significant amount of water for cooling.[1] Many of these fresh water withdrawals present an opportunity to use reclaimed water as an alternative water supply.

The Southwest Florida Water Management District (District) water use permitting (WUP) rules require agricultural, recreational/aesthetic, and industrial/commercial water use permittees and applicants in designated Water Use Caution Areas (WUCAs) to investigate the feasibility of using reclaimed water. These permittees and applicants are required to use reclaimed water if it is technically, environmentally, and economically feasible. In general, reclaimed water is economically feasible to a water use permittee or applicant if the present value of the benefits to the permittee or applicant from using the reclaimed water is comparable to or greater than the present value of reclaimed water costs to the permittee or applicant.

For the purposes of this study, the reclaimed water is provided by a utility and is defined as water that flows out of a wastewater treatment plant and has received at least secondary treatment and required disinfection. Also, Agriculture and Recreation / Aesthetic water users use reclaimed water exclusively for irrigation, including crop establishment and frost/freeze protection, and Industrial water users use reclaimed water in certain production processes, primarily as cooling water.

Potential reclaimed water users typically do not know all the potential benefits of using reclaimed water or how one might assess these benefits. Thus, the costs of reclaimed water can seem to be higher, and in some cases, significantly higher, than the perceived benefits. In addition, some water users may be uncertain about the potential costs as-

[1] United States Geological Survey (USGS), FDEP, and the Florida Water Management Districts, "Water Use in Florida, 2005 and Trends 1950-2005", 2008, http://pubs.usgs.gov/fs/2008/3080/.

sociated with using reclaimed water, particularly the ongoing operations and maintenance costs. As a result, some water users can be understandably reluctant to accept reclaimed water. This study gathered the available information from literature reviews, survey research and interviews to address the following study goals.

1. Improve the District's ability to assist water users in assessing the benefits and costs of reclaimed water to them;
2. Identify areas of future research that address how the net benefits of reclaimed water to water users can be as great as possible; and
3. Better assess whether or not reclaimed water is economically feasible to specific water users.

To these ends, this report describes the results of a literature review and survey of reclaimed water users in Florida and provides evaluation criteria and the types of information that a non-utility water use permittee or applicant would provide to the District to document the economic feasibility of reclaimed water. The evaluation criteria that would be used to document economic feasibility include all aspects of benefits and costs. The benefits, costs, and criteria are described in this document. Areas of future research to assist the District and water use permittees in assessing the economic feasibility of reclaimed water are also provided. In addition to this report, two Excel models were developed to assist the District and the potential reclaimed water user in organizing the information needed to make an assessment of economic feasibility and that provides estimates of the net benefits of reclaimed water to the user. These Excel models are called Reclaimed Water Benefit-Cost Calculator for Irrigation and Reclaimed Water Benefit-Cost Calculator for Industrial Applications.

1.2 Study Methods

The information in this report was based on a thorough literature review, a survey of reclaimed water users, and consultations with District, government, industry and academic experts.

The literature review included internet and web site searches accompanied by email and telephone requests. The following sources were consulted regarding the benefits and costs of reclaimed water to agricultural, recreation / aesthetic and industrial water users.

- American Water Works Association
- American Water Resources Association
- Conserve Florida Water
- Florida Department of Agriculture and Consumer Services

- Florida Department of Environmental Protection
- Florida Institute of Phosphate Research
- Florida Turfgrass Association
- Golf Course Industry
- Golf Course Superintendents Association of America
- Irrigation Association
- Metropolitan Council Environmental Services
- Mid-Florida Citrus Foundation of Water Conserv II - City of Orlando and Orange County
- Minnesota Metropolitan Council
- National Golf Foundation
- North Carolina Division of Water Quality
- Orange Water and Sewer Authority, North Carolina
- South Florida Water Management District
- Southwest Florida Water Management District
- St. Johns River Water Management District
- Texas Natural Resource Conservation Commission
- Texas Water Development Board
- U.S. Environmental Protection Agency
- United States Department of Agriculture
- University of California Cooperative Extension
- University of Florida Institute of Food and Agricultural Sciences
- University of Florida Science Library
- WateReuse Foundation

A general internet search yielded other universities and government agencies that published relevant documents relied upon in this study. All documents found to be relevant and used in this study are listed in Chapter 6.0 References. While there is an abundance of information regarding the production and uses of reclaimed water, only five documents were located that address the benefits and costs of reclaimed water to users. One of these documents describes the results of a survey of container nursery growers in Florida and another document describes the results of a survey of golf course opera-

tors in Texas. Each of these surveys included questions regarding the benefits and costs of reclaimed water to the reclaimed water users. Two other documents describe the results of crop irrigation experiments on crop yield and plant quality.

An industrial reclaimed water survey prepared for the Texas Water Development Board was useful as an example survey instrument that helped identify the types of information that water use permittees and applicants would need to provide to the District. A few other industrial survey instruments were found in the literature and used as reference sources.

No documents were located that describe how potential reclaimed water users should evaluate the potential benefits and costs of reclaimed water to their operations.

The most important part of this study was a survey of reclaimed water users in Florida, particularly those located in the Southwest Florida Water Management District. The results of these surveys were crucial to developing the evaluation criteria for this study. The survey was developed during this study and included questions regarding the use of reclaimed water, the costs and benefits of reclaimed water, the economic feasibility of reclaimed water, satisfaction with reclaimed water reliability, quality and quantity and whether the user would do it all over again. Appendix A provides a copy of the three reclaimed water surveys, one for each water use type: Agricultural, Recreation / Aesthetic and Industrial, respectively.

The surveys were emailed or mailed to selected reclaimed water users in Florida who were identified by the District and the project team. These potential survey respondents were contacted via telephone and asked to complete the survey. For those who agreed, their preference regarding who would fill out the survey and the method by which the survey should be provided (email, mail or internet) was obtained. Most people preferred to obtain the survey via email.

About 80 percent of the reclaimed water users who were asked to complete the survey actually completed and returned the survey. The number of completed surveys by type of water user and county is provided in Table 1.1. A total of 37 completed surveys were obtained and are comprised of 10 agricultural surveys, 17 recreation / aesthetic surveys and 10 industrial surveys. These completed surveys met the survey goal of 35 completed surveys – 10 from agriculture, 15 from recreation / aesthetic and 10 from industrial reclaimed water users. The project team would like to express their sincere appreciation and thanks to the 37 people who took the time to fill out this survey and explain how reclaimed water has affected their operations in terms of benefits and costs.

Of the 16 counties in the Southwest Florida Water Management District, 10 are represented in this survey. Two counties, Orange and St. Lucie, are in the South Florida

O:\44302-000\wpdocs\R3

or the St. Johns River Water Management Districts. The four respondents in these two counties were asked to participate in this survey in order to achieve the survey goal. These respondents are believed to be representative of the actual and potential reclaimed water users in the Southwest District.

Table 1.1
Number of Completed Surveys From Reclaimed Water Users By County

County	No. of Respondents				% of Respondents
	Agriculture	Recreation / Aesthetic	Industrial	Total	
Charlotte	0	1	1	2	5%
Desoto	4	0	0	4	11%
Hernando	0	1	0	1	3%
Hillsborough	0	3	2	5	14%
Manatee	2	1	0	3	8%
Orange (a)	2	0	1	3	8%
Pasco	1	2	0	3	8%
Pinellas	0	3	1	4	11%
Polk	0	0	4	4	11%
Sarasota	1	5	0	6	16%
St. Lucie (a)	0	0	1	1	3%
Sumter	0	1	0	1	3%
Total	10	17	10	37	100%

(a) This county is not in the Southwest Florida Water Management District.

1.3 Report Organization

This report is comprised of an Executive Summary, Supporting Chapters, and two Appendices. Chapter 1.0 is this introduction. Chapter 2.0 addresses the benefits and costs of reclaimed water for irrigation by Agricultural and Recreation / Aesthetic water users. Chapter 3.0 describes the Reclaimed Water Benefit-Cost Calculator for irrigation uses, the evaluation criteria for irrigation and recommendations for additional research. Chapter 4.0 addresses Industrial water users including the benefits and costs of reclaimed water, the Reclaimed Water Benefit-Cost Calculator for industrial water users, evaluation criteria and recommendations for additional research. Chapter 5.0 summarizes the evaluation criteria and the Reclaimed Water Benefit-Cost Calculators and Chapter 6.0 provides a list of this study's reference documents. Appendix A provides a copy of the three reclaimed water surveys, one for each water user type. Appendix B describes Total Dynamic Head.

O:\44302-000\wpdocs\R3

Chapter 2.0
Benefits and Costs to Agricultural and Recreation / Aesthetic Water Users

In this study, Agriculture and Recreation / Aesthetic water use permittees and applicants would use the reclaimed water for irrigation. As such, the benefits and costs of reclaimed water are similar between the two water use categories. Agricultural permittees and applicants irrigate crops including citrus, vegetables, field crops and nurseries. Recreation / Aesthetic permittees and applicants irrigate the turf grasses and landscapes located on golf courses, parks, cemeteries, schools and residential common areas.

2.1 Responses to Agricultural and Recreation / Aesthetic Surveys

This chapter summarizes the responses to the Agricultural and Recreation / Aesthetic surveys. The information from these surveys assisted in the identification the benefits, costs and evaluation criteria documented in this study.

Location

The 10 agricultural survey respondents were located in five counties, four of which are in the Southwest Florida Water Management District. These four counties are Desoto, Manatee, Pasco and Sarasota. Two respondents are located in Orange County which is in the St. Johns or the South Florida Water Management Districts. The distribution of county locations is provided in Table 2.1.1.

Table 2.1.1
Location of Agricultural Reclaimed Water User Respondents

County	No. of Respondents	% of 10 Respondents
Desoto	4	40%
Orange (a)	2	20%
Manatee	2	20%
Pasco	1	10%
Sarasota	1	10%
Total	10	100%

(a) This county is not in the Southwest Florida Water Management District.

The 17 Recreation / Aesthetic reclaimed water users surveyed are located in eight counties of the Southwest Florida Water Management District. Sarasota County is home to five of these respondents. The others are located in Charlotte, Hernando, Hillsborough, Manatee, Pasco, Pinellas and Sumter counties. The distribution of county locations is provided in Table 2.1.2.

Table 2.1.2
Location of Recreation / Aesthetic Reclaimed Water User Respondents

County	No. of Respondents	% of 17 Respondents
Charlotte	1	6%
Hernando	1	6%
Hillsborough	3	18%
Manatee	1	6%
Pasco	2	12%
Pinellas	3	18%
Sarasota	5	29%
Sumter	1	6%
Total	17	100%

Reclaimed Water Utility

The 10 Agricultural respondents receive reclaimed water from five utilities: City of Arcadia, City of Orlando, Manatee County, Pasco County and City of Sarasota. The distribution of utilities is provided in Table 2.1.3.

Table 2.1.3
Utility Providing Reclaimed Water To Agricultural Respondents

Name of Utility	No. of Respondents	% of 10 Respondents
City of Arcadia	4	40%
City of Orlando Water Conserv II	2	20%
Manatee County	2	20%
Pasco County	1	10%
City of Sarasota	1	10%
Total	10	100%

The 17 Recreation / Aesthetic respondents are served by 11 utilities. The distribution of utilities is provided in Table 2.1.4.

O:\44302-000\wpdocs\R3

Table 2.1.4
Utility Providing Reclaimed Water To Recreation / Aesthetic Respondents

Name of Utility	No. of Respondents	% of 17 Respondents
Hillsborough County	3	18%
Pinellas County	2	12%
Charlotte County	1	6%
Pasco County	2	12%
Sarasota County	2	12%
North Port Utilities	1	6%
Manatee County	1	6%
City of Venice	2	12%
Little Sumter Service Area	1	6%
Hernando County	1	6%
Town of Belleair	1	6%
Total	17	100%

Areas Irrigated with Reclaimed Water

The area irrigated with reclaimed water by the agricultural respondents ranged from 37 to 6,000 acres with an average of 940 acres and a median of 90 acres. Most of the respondents use reclaimed water on 100 acres or less. However, two respondents are large farmers using reclaimed water on at least 2,000 acres. The acreage distribution is provided in Table 2.1.5.

Table 2.1.5
Size of Area Irrigated with Reclaimed Water By Agricultural Respondents

Acres Irrigated	No. of Respondents	% of 10 Respondents
37 to 100 acres	6	60%
300 to 800 acres	2	20%
2,000 to 6,000 acres	2	20%
Total	10	100%
Average Acreage	942	
Median Acreage	90	
Range of Acreage	37 to 6,000	

O:\44302-000\wpdocs\R3

The 10 Agricultural respondents irrigate a variety of crops with reclaimed water, including pasture, citrus, sod / turf grass, tree nurseries, and tomatoes. A total of four acres of pecans, grapes, peaches and plums are also irrigated with reclaimed water. The acreage associated with each crop and irrigation system is provided in Table 2.1.6. Together these respondents irrigate a total of 10,000 acres with reclaimed water.

Table 2.1.6
Crops Irrigated with Reclaimed Water and Irrigation Systems Used by Agricultural Survey Respondents

Crop and Irrigation System	Acres
Pasture using seepage/ open ditch/ overhead	5,000
Citrus, including oranges and tangerines, using micro-sprinklers or drip irrigation	2,399
Sod / Turf grass using semi-closed seepage, lateral move, open ditch or overhead	1,254
Fall Tomatoes using seepage	721
Spring Tomatoes using seepage	385
Tree Nursery using micro-jet	203
Pecans using micro-sprinklers	2
Grapes using micro-sprinklers	1
Peaches / Plums using micro-sprinklers	1
Total	9,967

Of the 17 Recreation / Aesthetic Respondents, 16 are golf courses. Some of these properties with golf courses also use irrigation water on common area landscaping, lawns and, in one case, a playing field. The 17th respondent is a homeowners association (HOA) where reclaimed water is used to irrigate the common areas and residents' yards. The areas irrigated with reclaimed water are provided in Table 2.1.7 and include golf course greens, fairways, tees and roughs, ornamental landscape, playing fields, and lawns.

O:\44302-000\wpdocs\R3

Table 2.1.7
Areas Irrigated with Reclaimed Water
By Recreation / Aesthetic Respondents

Area	No. of Respondents	% of 17 Respondents
Golf Course Greens	16	94%
Golf Course Fairways	16	94%
Golf Course Roughs	14	82%
Golf Course Tees	16	94%
Ornamental Landscape	14	82%
Playing Fields	1	6%
Other Lawn	11	65%
Other	4	24%

The 17 Recreation / Aesthetic respondents use reclaimed water on 14 to 314 acres. Almost one-half of the respondents use reclaimed water on 50 to 100 acres. The distribution of respondents by acreage irrigated with reclaimed water is provided in Table 2.1.8.

Table 2.1.8
Acres Irrigated with Reclaimed Water
By Recreation / Aesthetic Respondents

Acres	No. of Respondents	% of 17 Respondents
14 (a)	1	6%
50 to 100	8	47%
101 to 150	3	18%
151 to 200	2	12%
201 to 300	2	12%
314	1	6%
Total	17	100%

(a) The 14 acres is the estimate for the HOA.

The acreage of the grass and landscape types irrigated with reclaimed water is provided in Table 2.1.9. Of the 2,100 acres of plants irrigated with reclaimed water by Recreation / Aesthetic users, almost 1,500 acres, or 70 percent, is Bermuda grass. St. Augustine grass is the next most common plant irrigated with reclaimed water but it represents only 197 acres or 9 percent of the total acreage irrigated with reclaimed water among the 17 respondents. Other plant types irrigated with reclaimed water include Supreme Paspalum, trees, flowers, bahia grass, and shrubs.

Table 2.1.9
Types of Grass and Landscape Irrigated with Reclaimed Water by Recreation / Aesthetic Respondents

Grass and Landscape Types	Acres	% of Acres
Bermuda	1,462	69%
St. Augustine	197	9%
Hybrid Bermuda	135	6%
Supreme Paspalum	120	6%
St. Augustine/Bahia/Zoysia Mix	86	4%
Bermuda, Trees, Landscape	85	4%
Trees, Flowers, and/or Shrubs	29	1.34%
Clubhouse Landscaping and Turf	9	0.44%
Bahia	5	0.23%
Pine/oak trees on golf course	0.5	0.02%
Tennis courts	0.5	0.02%
Total	2,128	100%

Sprinkler irrigation systems were used on about 90 percent of the acreage irrigated with reclaimed water by Recreation / Aesthetic users. The remaining acreage was irrigated with subsurface automatic and drip. This distribution is provided in Table 2.1.10.

Table 2.1.10
Type of Irrigation System Used
By Recreation / Aesthetic Respondents

Irrigation System Type	Acres	% of Acres
Sprinkler	1,885	89%
Subsurface automatic	145	6%
Drip and Sprinkler	98	5%
Total	2,128	100%

Length of Time and Amount of Reclaimed Water Used

The 10 Agricultural respondents had been using reclaimed water from 2 to 23 years. The median use was 18 years. The 17 Recreation / Aesthetic respondents had been using reclaimed water for less than a year to 30 years. The median use was 13 years.

Currently, the average daily reclaimed water use of the 10 Agricultural respondents ranges from 26,300 gallons per day (gpd) to 2.5 million gpd, on average, with a median use of 55,000 gpd**.** The average daily reclaimed water use of the 17 Recreation / Aes-

O:\44302-000\wpdocs\R3

thetic respondents ranges from 23,000 gpd to 1.4 million gpd with a median use of 233,000 gpd.

For the Agricultural respondents, reclaimed water comprises from 20 to 100 percent of the irrigation water use. Three of these respondents use reclaimed water for all of their irrigation needs. The distribution of these percentages among the 10 Agricultural respondents is provided in Table 2.1.11.

Table 2.1.11
Percent of Agricultural Respondents' Total Irrigation Water Use That is Reclaimed Water

% of Total Water Use	No. of Respondents	% of 10 Respondents
20 to 50	5	50%
51 to 75	1	10%
76 to 100	4	40%
Total	10	100%

Note: For 3 of the 10 respondents, 100 percent of their irrigation water is reclaimed water.

For the Recreation / Aesthetic respondents, reclaimed water comprises from 20 to 100 percent of the irrigation water use. Six of these respondents use reclaimed water for all of their irrigation needs. The distribution of these percentages among the Recreation / Aesthetic respondents is provided in Table 2.1.12.

Table 2.1.12
Percent of Recreation / Aesthetic Respondents' Total Irrigation Water Use That is Reclaimed Water

% of Total Water Use	No. of Respondents	% of 17 Respondents
20 to 50	2	11%
51 to 75	4	24%
76 to 100	11	65%
Total	17	100%

Note: For 6 of the 17 respondents, 100 percent of their irrigation water is reclaimed water.

O:\44302-000\wpdocs\R3

Nutrients and Chemicals in Reclaimed Water

Of the 10 Agricultural respondents, five know the nutrient contents and chemical constituents in their reclaimed water. All respondents know how to obtain this information. Of the 17 Recreation / Aesthetic respondents, eight know the nutrient contents and chemical constituents in their reclaimed water. All but one of the respondents knows how to obtain this information.

Reasons for Connecting to Reclaimed Water System

The primary reasons that the Agricultural respondents connected to the reclaimed water system are varied. Three respondents connected because the reclaimed water was free, two connected to reduce ground water pumping and two connected to reduce irrigation or fuel cost. Another respondent said it was offered to the farm and, after research, the farm concluded that it would be beneficial to diversify its water sources. Another farm is part of the University of Florida IFAS and needed the reclaimed water for research purposes. The distribution of respondent answers is provided in Table 2.1.13.

Table 2.1.13
Primary Reasons the Agricultural Respondents Connected to the Reclaimed Water System

Primary Reasons	No. of Respondents	% of 10 Respondents
It was free water	3	30%
To reduce ground water pumping	2	20%
Utility needed us to take it	1	10%
It was offered to us and provides benefits as part of our conjunctive water plan	1	10%
To reduce irrigation or fuel cost	2	20%
Used to research effects of reclaimed water on citrus	1	10%
Total	10	100%

The most common primary reason that Recreation / Aesthetic respondents connected to the reclaimed water system was to obtain an available water supply either as a supplement to their other sources or to have any water supply at all. This was the primary reason for 11 of the 17 respondents. Three respondents use reclaimed water because it is a drought proof supply and three others use reclaimed water because it is a cost-effective water supply or to reduce electricity cost. The distribution of respondent primary reasons is provided in Table 2.1.14.

Table 2.1.14
Primary Reasons the Recreation / Aesthetic Respondents Connected to the Reclaimed Water System

Primary Reasons	No. of Respondents	% of 17 Respondents
It was an available water supply	3	18%
Drought proof water supply	3	18%
To reduce ground water pumping	3	18%
To supplement surface water supply	3	18%
Ground water was not sufficient	2	11%
It was a cost-effective water supply	2	11%
To reduce electricity cost	1	6%
Total	17	100%

Nine of the 10 Agricultural respondents and 11 of the 17 Recreation / Aesthetic respondents would have been able to use the Floridan aquifer if they had not connected to the reclaimed water system. One Agricultural respondent would have used the Intermediate aquifer. Three Recreation / Aesthetic respondents would have used a ground water source other than the Floridan aquifer, one would have used a surface water source and two had no other water source available.

Payments to Utility for Reclaimed Water

Nine of the 10 Agricultural respondents do not pay their utility for their reclaimed water use. The one who does pays a reclaimed water rate of $0.15 per 1,000 gallons resulting in an annual payment of about $3,000 per year.

Of the 17 Recreation / Aesthetic respondents, 14 pay their utility for their reclaimed water use. Two of these respondents pay a monthly fixed charge and no variable rate charge. The monthly charges are $1,000 and $12,775. Three respondents pay a nominal monthly charge ranging from $2.65 to $2.90 and a variable rate charge of $0.08 per 1,000 gallons for two of these respondents and $0.50 per 1,000 gallons for the third respondent. The nine other respondents pay only a variable rate that ranges from $0.04 per 1,000 gallons to $0.72 per 1,000 gallons. The median rate of these nine respondents is $0.25 per 1,000 gallons.

Timing of Reclaimed Water Connection

Seven of the 10 Agricultural respondents connected to the reclaimed water system after their irrigation system was installed. Another connected before and one other connected

O:\44302-000\wpdocs\R3

after the system was installed. The tenth respondent connected to the reclaimed water system before, during, and after the irrigation system was installed.

Nine of the 17 Recreation / Aesthetic respondents connected to the reclaimed water system after their irrigation system was installed. Four connected before and four connected during installation.

On-Site Reclaimed Water Storage

Nine of the 10 Agricultural respondents do not have any on-site reclaimed water storage. The one who does stores the reclaimed water in an open lake or pond. Of the 17 Recreation / Aesthetic respondents, 14 store their reclaimed water in open lakes or ponds, two store their reclaimed water in tanks, and one does not store reclaimed water on-site.

Changes to Irrigation, Pumping and Storage Systems and Costs

Four of the 10 Agricultural respondents and five of the 17 Recreation / Aesthetic respondents made changes to their irrigation, pumping and/or storage systems in order to accept and use the reclaimed water. The types of changes made by these respondents are summarized in Table 2.1.15. The changes included installing a pipeline to connect to the reclaimed water system, disconnecting the existing water supply source, adding water storage, adding one or more pumps or adding a pump station, adding additional acreage to accept excess reclaimed water, and adding a filtration system to improve the water quality prior to it entering the irrigation system.

Four of the Agricultural respondents need to filter the reclaimed water. However, only one respondent said that a filtration system was installed specifically to treat the reclaimed water. A filtration system is common when using drip or micro-sprinkler irrigation. However, when reclaimed water is used, the frequency of filter replacement and the use of chemicals may increase.

Table 2.1.15
Summary of On-Site Improvements Made By Respondents
To Connect To and Use Reclaimed Water

Item Installed	Agricultural		Recreation / Aesthetic	
	Number of Respondents	Percent of 10 Respondents	Number of Respondents	Percent of 17 Respondents
Pipeline to Connect	2	20%	2	11%
Disconnect Existing Water Supply	0	0%	2	11%
Water Storage	1	10%	4	24%
Pump(s) / Pump Station	0	0%	4	24%
Added Irrigated Acres to Accept Excess Reclaimed Water	1	10%	1	6%
Filtration System	1	10%	0	0%

Of the four Agricultural respondents who made on-site improvements, one did not know the cost because they were made a long time ago. Another did not know the cost because the County installed the pipeline connection. Another farm irrigating 80 acres with reclaimed water paid $3,000 to move the reclaimed water to a sinkhole in the grove when not using it. The fourth farm, irrigating about 6,000 acres with reclaimed water, paid $55,000 for a filtration system, on-site storage, and ditches to take the excess reclaimed water to a pasture for an average cost of $9.17 per acre irrigated with reclaimed water. One of these four respondents received compensation from the District or other government agency for these investments but did not know the monetary amount because the transaction took place a long time ago.

Of the five Recreation / Aesthetic respondents who made on-site improvements, the costs ranged from $27,000 for a 50-acre irrigated area to $855,000 for a 314-acre irrigated area. The cost per irrigated acre ranges from $540 to $2,700 for those respondents who made on-site improvements. Two of these respondents received monetary compensation from the District or other government agency. One received $75,000 and the other received free reclaimed water for nine years valued at about $115,000.

Annual Cost Associated with Reclaimed Water Use

Of the 10 Agricultural respondents, six said they pay annual costs associated with their reclaimed water use other than payments made to the utility. Of these six respondents, the total annual cost associated with reclaimed water use ranged from $500 to $18,500 per respondent with a median cost of $4,725 per respondent. The median annual cost per acre per respondent was $7.00.

O:\44302-000\wpdocs\R3

Three of these six respondents said they incur annual reporting and administrative costs related to reclaimed water ranging from $1,200 to $8,000 per year per respondent for an average of $3,600 per year per respondent. Given the acreages irrigated with reclaimed water, reporting and administrative costs ranged from $1.66 to $5.50 per acre per year.

Two respondents said they incur costs associated with irrigation management of $5,000 and $2,800 per year or $0.83 to $9.33 per acre per year. One respondent says that repairing tubing and cleaning jets costs his farm about $5,000 per year or about $62 per acre irrigated with reclaimed water.

Another respondent said that his farm spent $10,500 last year, or about $1.75 per acre, to change the material in the sand media filters because of the reclaimed water use. However, this is done on an as-needed basis and not every year. The respondent said the material is changed every few years. One respondent said his farm's only annual cost associated with reclaimed water was $500 per year, or $5 per acre, to manage pests and/or algae.

Of the 17 Recreation / Aesthetic respondents, nine said that they incur annual costs associated with their reclaimed water use other than payment to the utility. The total annual cost reported by these nine respondents ranged from $2,500 to $140,000 per respondent with a median of $9,224. The total annual cost per acre ranged from $20 to $538 with a median annual cost of $94 per acre per year.

Salinity and pH management was the most common issue associated with reclaimed water use, with seven of the respondents spending from $2,500 to $110,000 annually. This cost amounts to $20 to $423 per acre irrigated with reclaimed water with a median of $84 per acre. These costs include chemical applications such as calcium, gypsum and dolomite, changing plant material, and mechanical means.

The next most common annual expense was for pest and algae management, with five of the respondents spending from $1,224 to $14,400 per year or from $12 to $46 per acre irrigated with reclaimed water. Reporting and administrative costs for three respondents ranged from $500 to $1,500 per year or from $5 to $7 per acre. One respondent said his firm spent $5,000 to repair tubing and cleaning jets or $19 per acre. Another respondent said his firm spent $15,000 changing the media in the sand filters or $58 per acre and a third respondent said his firm spent $5,000 or $56 per acre in additional irrigation management costs.

Changes in Fertilizer and Chemical Applications

Of the 10 Agricultural respondents, five, or 50 percent, said they adjust their applied fertilizer to account for nutrients in the reclaimed water. Of these five, two said that they

have reduced the amount of nitrogen applied to their citrus – one respondent said by 10 percent and the other said by 20 percent. Another respondent said that the reclaimed water provides plenty of boron and a fourth said that adjustments are made based on soil samples and tissue samples. The fifth respondent said that his fertilizer cost is lower by about $1,400 per year because of the reclaimed water.

Of the 17 Recreation / Aesthetic respondents, 11 respondents, or 65 percent, said that their firm adjusts the fertilizer to account for nutrients, soil pH and/or salinity in the reclaimed water. Of these 11 respondents, seven said they conduct soil and water sampling to adjust for nutrients, soil pH and salinity. The other four may also conduct these tests but they did not mention testing in their survey response even though they mentioned taking action to correct for nutrients, soil pH and salinity. Five respondents apply calcium and three apply gypsum or dolomite to manage soil salinity. Three respondents said they have reduced nitrogen applications. Two respondents apply lime, presumably to increase soil pH. A summary of their responses is provided in Table 2.1.16.

Table 2.1.16
Adjustments Made to Account for Effects of Reclaimed Water on Nutrients, Soil pH and Soil Salinity by Recreation / Aesthetic Respondents

Fertilizer or Chemical Adjustment	Number of Respondents	% of 17 Respondents
Soil and water sampling to adjust for nutrients, soil pH, and salinity	7	41%
Apply calcium to manage soil salinity	5	29%
Apply gypsum or dolomite to soil / ponds to manage soil salinity	3	18%
Reduce nitrogen application	3	18%
Apply lime	2	12%
Adjust for pH levels and nutrients	1	6%
Increased foliar applications to get more nutrients directly to the plant	1	6%
Periodically use the acid injection system to flush salts, bicarbonates, etc. through our greens on the golf course.	1	6%
Use of flushing agents, light frequent fertilizer applications	1	6%

Cost Reductions Associated with Reclaimed Water

Of the 10 Agricultural respondents, nine said that their farm experienced cost reductions associated with reclaimed water use. A summary of these responses is provided in Ta-

O:\44302-000\wpdocs\R3

ble 2.1.17. Four of these respondents provided an estimate of their annual cost savings which ranged from $2,000 to $11,000 per year or from $5 to $71 per acre irrigated with reclaimed water. Of the nine respondents, seven said that their fuel costs are lower due to their reclaimed water use. A fifth farm said its fuel costs are about 25 percent lower as a result of its reclaimed water use.

Five of the Agricultural respondents said that they save money on fertilizer because of their reclaimed water use. Only two of these respondents provided an estimate of the amount of money saved: one said $38,000 per year or $32 per acre per year from reducing the amount of nitrogen applied and the other said $1,400 per year or $37 per acre per year for reducing the amount of nutrients applied. These respondents were not asked to provide records that would demonstrate this cost savings.

Two respondents said that their irrigation or pumping system maintenance cost is lower: one said they save $10,000 per year or $5 per acre per year and the other did not know the dollar value of savings.

Table 2.1.17
Cost Reductions Due to Reclaimed Water Use
By Agricultural Respondents

Cost Reductions?	No. of Respondents	% of 10 Respondents
Yes	9	90%
No	1	10%
Total	10	100%
Type of Cost Reduction	**No. of Respondents**	**% of 10 Respondents**
Fuel Cost	7	70%
Fertilizer Cost	5	50%
Maintenance Cost	2	20%

While 90 percent of the 10 Agricultural respondents said their farm experienced cost reductions associated with reclaimed water use, only two of the 17 Recreation / Aesthetic respondents reported any cost reductions. One respondent reported a savings in electricity cost because the firm now has one primary pump station to irrigate golf courses and common grounds instead of using several different well pump stations. However, no cost savings estimate was provided. Another respondent reported a cost savings of $4,800 per year in reduced pumping system fuel costs and $850 per year in reduced pumping system cost, other than fuel.

The three Recreation / Aesthetic respondents who said they reduced their nitrogen application said they did not experience any cost savings associated with reclaimed water use. Based on their survey responses, it appears that their cost associated with salinity management was higher than their reduced cost associated with reduced nitrogen use so they answered "No" to the annual cost reduction question.

Table 2.1.18
Cost Reductions Due to Reclaimed Water Use
By Recreation / Aesthetic Respondents

Cost Reductions?	No. of Respondents	% of 10 Respondents
Yes (a), (b)	2	12%
No	15	88%
Total	17	100%

(a) One respondent reported a savings in electricity cost due to the fact the firm now has 1 primary pump station to irrigate golf courses and common grounds instead of using several different well pump stations. However, no cost savings estimate was provided.

(b) Another respondent reported a savings of $4,800 per year in reduced pumping system fuel costs and $850 per year in reduced pumping system cost, other than fuel.

Impacts of Reclaimed Water on Crop Productivity and Plant Quality

Only one of the ten Agricultural respondents reported a change in crop productivity as a result of reclaimed water use. This respondent said that the citrus crop's productivity and pounds of juice increased but was unsure of the amount of this increase.

Of the 17 Recreation / Aesthetic respondents, eight, or 47 percent, reported a change in the quality of lawns and/or landscaping after they began using reclaimed water. Only two of these eight reported an increase in quality. One of these respondents said reclaimed water provided a greener lush lawn because it is not limited to a watering schedule. The other respondent did not elaborate. Six respondents reported a decrease in grass and/or landscape quality primarily due to the impact of reclaimed water on soil salinity. However these respondents say that this impact can be managed by controlling soil salinity as was described in their responses reported above. A summary of the impact of reclaimed water on the quality of grass and landscaping, as reported by the respondents, is provided in Table 2.1.19.

Table 2.1.19
Impact of Reclaimed Water on Quality of Grass and Landscaping
As Reported by Eight of 17 Recreation / Aesthetic Respondents
Individual Responses to the Survey

Grass or Landscape Type	Quality	Change	Understanding
Grass	Increased	Greener lush lawn	Not limited to watering schedule
Bermuda Grass	Decreased	Significant over time period	Bicarbs and high pH
Bermuda Grass	After long periods of dry weather and thus prolonged irrigation use on the greens, pore space becomes clogged with salts, etc. This increases wilt and yellowing of the turf.		
Fairways & Greens	Decreased	Moderate	Increased treatment of algae on turf
Golf course greens and landscaping	All of it decreases unless you treat the soil and apply additional material to counteract the sodium and bicarbonates in the water, more cultural practices such as aerification.		
Lawns, turf in general	Decreased	Moderate	Turf wilts faster - salts in soil build up making plants unable to use water.
Landscape	Decreased	Moderate	Some plants have not done well and are eventually eliminated over time
Golf course trees	Decreased	Moderate	Lower tree branches struck by irrigation system water have scorched leaves.
Pine and Oak trees	Decreased	Significant over time period	Bicarbs and high pH cause problems
Trees	Decreased	Significant	Water oaks have weakened and become diseased

Benefits of Reclaimed Water to Users

The Agricultural respondents were asked to indicate which of 14 potential benefits were they receiving from their use of reclaimed water and to list any other benefits. The number and percentage of respondents who indicated that they were receiving each benefit are provided in Table 2.1.20. All but one of the 10 Agricultural respondents said that because their farm uses reclaimed water, irrigation costs are lower. This was the most common benefit.

Six of the 10 Agricultural respondents said that they were able to conserve fresh water for their other uses, they have a guaranteed and reliable water source, and their net income was higher than if they used a traditional water source. Five of the 10 respondents said they were better able to supply water to their crops during drought conditions.

The Recreation / Aesthetic respondents were asked to indicate which of 11 potential benefits were they receiving from their use of reclaimed water and to list any other benefits. The number and percentage of respondents who indicated that they were receiving each benefit are provided in Table 2.1.21. The most common benefit is that they have a guaranteed and reliable water source with 14 of the 17 respondents, or 82 percent, writing "Yes" to this benefit. The second most common benefit as indicated by 13 respondents, or 76 percent, is that they have been able to irrigate more frequently than if they used a traditional water source. The third most common benefit is that they are able to conserve fresh water for their other uses with 12 respondents, or 71 percent, indicating this benefit. The fourth most common benefit, as reported by 11 respondents, or 65 percent, is that they have been able to apply more water to their lawns and landscaping than with a traditional water source.

Despite these benefits, only five of the 17 Recreation / Aesthetic respondents said that their net income is higher than if they had used a traditional water source. This could be due to the increased soil salinity and pH management costs associated with reclaimed water use on golf courses and landscaping that most respondents reported on the survey. However, five of the respondents said that their revenue is higher than with a traditional water source and three of these five respondents plus another respondent said that business increased during fresh water shortage restrictions due to their use of reclaimed water.

Reclaimed Water Restrictions and Availability

Seven of the 10 Agricultural respondents said that, from time-to-time, their reclaimed water is restricted or is not available. One of these seven respondents says it happens frequently but there was never an impact on the farm's crop. The other six respondents said that reclaimed water was not available one to four times in the past ten to twenty years for a period of 30 to 60 days. All but one of these respondents said that there was no impact on the crop. One respondent said there was some crop loss where back up wells were not available.

Table 2.1.20
Benefits of Reclaimed Water to 10 Agricultural Respondents by Ranking

Reclaimed Water Benefits	No. of Respondents			
	Yes	No	DK	Total
Irrigation costs are lower	9	1	0	10
Able to conserve fresh water for their other uses	6	4	0	10
Have a guaranteed and reliable water source	6	4	0	10
Net income is higher than with traditional water source	6	2	2	10
Better able to supply water to crops during drought conditions	5	4	1	10
Able to irrigate more frequently than if used traditional source	4	6	0	10
Revenue is higher than with traditional water source	4	4	2	10
Able to apply more water to the crop than with traditional source	3	7	0	10
Fertilization costs are lower (a)	3	7	0	10
Better able to protect crops from freezing	2	8	0	10
Water storage costs are lower	2	8	0	10
Crop yield has been higher than with a traditional source	1	6	3	10
Pounds of juice per acre is higher than with traditional source	1	6	3	10
Quality of crop is higher than with traditional source	0	7	3	10
Reclaimed Water Benefits	**Percent of 10 Respondents**			
	Yes	**No**	**DK**	**Total**
Irrigation costs are lower	90%	10%	0%	100%
Able to conserve fresh water	60%	40%	0%	100%
Have a guaranteed and reliable water source	60%	40%	0%	100%
Net income is higher than with traditional water source	60%	20%	20%	100%
Better able to supply water to crops during drought conditions	50%	40%	10%	100%
Able to irrigate more frequently than if used traditional source	40%	60%	0%	100%
Revenue is higher than with traditional water source	40%	40%	20%	100%
Able to apply more water to the crop than with traditional source	30%	70%	0%	100%
Fertilization costs are lower	30%	70%	0%	100%
Better able to protect crops from freezing	20%	80%	0%	100%
Water storage costs are lower	20%	80%	0%	100%
Crop yield has been higher than with a traditional source	10%	60%	30%	100%
Pounds of juice per acre is higher than with traditional source	10%	60%	30%	100%
Quality of crop is higher than with traditional source	0%	70%	30%	100%

DK means Don't Know.

(a) Five agricultural respondents reported fertilization cost savings in another part of the survey.

O:\44302-(

Table 2.1.21
Benefits of Reclaimed Water to 17 Recreation / Aesthetic Respondents (16 Golf Courses and 1 HOA)

Reclaimed Water Benefits	No. of Respondents					
	Yes	No	DK	DNA	N/A	Total
Have a guaranteed and reliable water source	14	2	0	1	0	17
Able to irrigate more frequently than if used traditional source	13	3	0	1	0	17
Able to conserve fresh water for their other uses	12	4	0	1	0	17
Able to apply more water to the lawn/landscape than with traditional source	12	4	0	1	0	17
Revenue is higher than with traditional water source	5	3	5	4	0	17
Net income is higher than with traditional water source	5	4	4	4	0	17
Irrigation costs are lower (a)	4	11	0	2	0	17
Business has increased during fresh water shortage re-strictions	4	4	6	2	1	17
Fertilization costs are lower (a)	4	10	1	2	0	17
Quality of lawn/landscape higher than with traditional source	2	12	1	2	0	17
Water storage costs are lower	1	11	3	2	0	17
Reclaimed Water Benefits	**Percent of 17 Respondents**					
	Yes	**No**	**DK**	**DNA**	**N/A**	**Total**
Have a guaranteed and reliable water source	82%	12%	0%	6%	0%	100%
Able to irrigate more frequently than if used traditional source	76%	18%	0%	6%	0%	100%
Able to conserve fresh water	71%	24%	0%	6%	0%	100%
Able to apply more water to the lawn/landscape than with traditional source	71%	24%	0%	6%	0%	100%
Revenue is higher than with traditional water source	29%	18%	29%	24%	0%	100%
Net income is higher than with traditional water source	29%	24%	24%	24%	0%	100%
Irrigation costs are lower	24%	65%	0%	12%	0%	100%
Business increased during water shortage restrictions	24%	24%	35%	12%	6%	100%
Fertilization costs are lower	24%	58%	6%	12%	0%	100%
Quality of lawn/landscape higher than with traditional source	12%	71%	6%	12%	0%	100%
Water storage costs are lower	6%	65%	18%	12%	0%	100%

Note: DK means Don't Know. DNA means Did Not Answer. N/A means Not Applicable.

(a) In another section of the survey, only two of these four respondents said they experienced a cost reduction associated with reclaimed water use.

O:\44:

Of the 17 Recreation / Aesthetic respondents, 10 reported that there have been times when their reclaimed water was restricted or unavailable. Of these 10 respondents, only one experienced a loss of turf and this occurred during the month of April of each year. The others indicated that the reclaimed water plant shuts down from time to time and they are usually able to avoid impacts to their grass and landscape by using their backup water supplies.

Impact of Reclaimed Water Use on Crop Marketing

All of the 10 Agricultural respondents said that they have not experienced any issues associated with marketing their crops. One respondent said that, at this time, the water quality standards of reclaimed water are consistent with food safety issues.

Reclaimed Water Potential Problems and Solutions

The Agricultural respondents were asked to indicate which of 21 potential problems they have experienced from their use of reclaimed water and to list any other problems they have experienced. The number and percentage of respondents who indicated that they experienced these problems and their solutions to these problems, if any, are provided in Table 2.1.22. The most common problem as indicated by seven of the 10 respondents, is that the farm has problems with clogged irrigation heads. Only three of the seven said they were able to correct the problem via reclaimed water filtration and cleaning the irrigation heads, as needed. However, it is likely that all seven farms clean their irrigation heads as needed. Four of the respondents said their farm needed to filter the reclaimed water before use.

Six respondents said they sometimes do not have enough reclaimed water when needed. Of these six respondents, three said they use ground water when reclaimed water is not available. Five of the respondents said they are limited to certain days and/or times when they may use reclaimed water. Of these, one said the farm was able to correct the problem by using well water.

Only one or two respondents indicated that their farm had problems with: reclaimed water pressures (1 respondent), reclaimed water blending (1 respondent), algae growth (1 respondent), lower net income (1 respondent), or having to take more water than needed (2 respondents). None of the respondents indicated a problem with initial investment cost, record keeping or reporting, crop sales, crop toxic reactions, soil salinity, employee concerns, soil pH, reductions in crop quality, rust problems, or revenue reductions.

The 17 Recreation / Aesthetic respondents seemed to have more problems with reclaimed water than did the 10 Agricultural respondents. The number and percentage of Recreation / Aesthetic respondents who indicated that they experienced these problems

O:\44302-000\wpdocs\R3

and their solutions to these problems, if any, are provided in Table 2.1.23. The most common problem as indicated by eight of the 17 respondents, or 45 percent, is that the firms have problems with algae growth on the lawn/landscape, irrigation lines/heads and/or storage ponds. Four of these eight respondents said they were able to correct the problem by cleaning irrigation heads and treating storage ponds.

The second most common problem, as indicated by seven of the 17 respondents, or 41 percent, is that the chloride or salt content of the reclaimed water water is higher than if a traditional water source was used and has negatively affected plant and/or grass quality. Four of these respondents were able to correct the problem by flushing the soil when needed and applying gypsum or calcium.

Five respondents said they had problems with clogged irrigation heads resulting in three of these respondents treating the well room or irrigation lake and cleaning the sprinkler heads. Five of the respondents said that sometimes they do not have enough irrigation water for their needs. When this happens, two respondents said they use a backup water supply, when available.

Four respondents said that they need to use and do use more pesticides or fungicides than if a traditional water source was used. Four respondents said that their equipment has had rust problems and one recommended washing the equipment with fresh water and replacing metal power boxes with plastic. None of the respondents said that their initial investment costs were too high or that their revenue is lower than if a traditional water source had been used. One respondent said that his firm's net income was lower than if a traditional water source had been used because the cost of reclaimed water is higher than ground water.

Table 2.1.22
Problems and Solutions Associated with Reclaimed Water Use By 10 Agricultural Respondents

Problem: Because we use reclaimed water…	No. of Respondents	% of 10 Respondents	No. Able to Correct	% Able to Correct	Method to Correct
We have had problems with clogged irrigation heads.	7	70%	3	43%	Have to clean heads - bugs come in from outside jets; we use sand media filters.
Sometimes we do not have enough reclaimed water for our needs.	6	60%	3	50%	Use groundwater when reclaimed water not available.
The water pressure fluctuates and causes irrigation management or other problems.	5	50%	2	40%	Better management
We are limited to certain days and/or times when we may obtain reclaimed water.	5	50%	1	20%	Use well water.
Our irrigation water must be filtered before use	4	40%	3	75%	Filter the reclaimed water
We are forced to take more reclaimed water than needed.	2	20%	2	100%	Apply water where won't do any harm.
We need to blend it with water from another source to improve water quality.	1	10%	0	0%	The blending was not sufficient because not enough water.
The irrigation water tends to be supplied at pressures greater than desired which causes problems with pipes, valves or application (i.e. drippers, microjet sprinklers) devices.	1	10%	1	100%	Air relief valves/ Pipe repairs.
We need to use more pesticides or fungicides than we would with a traditional water source.	1	10%	0	0%	N/A
We have problems with algae growth on the lawn/landscape, irrigation lines/heads or storage ponds.	1	10%	0	0%	N/A
Our net income is lower than if we used a traditional water source.	1	10%	0	0%	N/A
Other - Overwatering of pastures at times	1	10%	0	0%	N/A
Initial investment cost was high and made it difficult to connect	0	0%	N/A	N/A	N/A
Our record keeping and/or reporting has increased significantly.	0	0%	N/A	N/A	N/A

O:\44

Table 2.1.22
Problems and Solutions Associated with Reclaimed Water Use By 10 Agricultural Respondents

Problem: Because we use reclaimed water…	No. of Respondents	% of 10 Respondents	No. Able to Correct	% Able to Correct	Method to Correct
Our crop sales have fallen due to concerns regarding food safety.	0	0%	N/A	N/A	N/A
Our lawn and/or plants experience a toxic reaction when fertilizer or chemicals applied.	0	0%	N/A	N/A	N/A
The chloride or salt content of our irrigation water is higher than if we used a traditional water source and has negatively affected plant/grass quality.	0	0%	N/A	N/A	N/A
We have had to address employee health or safety concerns.	0	0%	N/A	N/A	N/A
We need to change the pH of the reclaimed water before use.	0	0%	N/A	N/A	N/A
The quality of our crop is lower than if we used a traditional water source	0	0%	N/A	N/A	N/A
Our equipment has had rust or other problems.	0	0%	N/A	N/A	N/A
Our revenue is lower than if we used a traditional water source.	0	0%	N/A	N/A	N/A

Note: DNA means that the respondent did not answer the question. N/A means "not applicable".

O:\4302-000\wpdocs\R3

Table 2.1.23
Problems and Solutions Associated with Reclaimed Water Use By 17 Recreation / Aesthetic Respondents
(16 Golf Courses and 1 HOA)

Problem: Because we use reclaimed water…	No. of Respondents	% of 17 Respondents	No. Able to Correct	% Able to Correct	Method to Correct
We have problems with algae growth on the lawn/landscape, irrigation lines/heads or storage ponds.	8	47%	4	50%	Storage ponds treated monthly. Heads - bottom of screens cleaned out.
The chloride or salt content of our irrigation water is higher than if we used a traditional water source and has negatively affected plant/grass quality.	7	41%	4	57%	Monitor the problem and flush when needed. Apply gypsum or calcium.
We have had problems with clogged irrigation heads.	5	29%	3	60%	Treat well room or irrigation lake. Labor for cleaning has increased. Sprinklers are dug up and cleaned.
Sometimes we do not have enough reclaimed water for our needs.	5	29%	2	40%	Backup water supplies are used where available.
We need to use more pesticides or fungicides than we would with a traditional water source.	4	24%	4	100%	Need to budget for it.
Our equipment has had rust or other problems.	4	24%	1	25%	Wash equipment with potable water. Change metal power boxes to plastic.
Our irrigation water must be filtered before use	3	18%	3	100%	Filter water
Our record keeping and/or reporting has increased significantly.	3	18%	0	0%	Utilized additional staff and consultant time to meet regulatory requirement
Our customers are concerned about potential contact with the reclaimed water.	3	18%	1	33%	With customer education
We are limited to certain days and/or times when we may obtain reclaimed water.	3	18%	2	67%	Other water sources used.
We have had to address employee health or safety concerns.	3	18%	3	100%	Post signs.
We need to change the pH of the reclaimed water before use.	3	18%	1	33%	DNA

Table 2.1.23
Problems and Solutions Associated with Reclaimed Water Use By 17 Recreation / Aesthetic Respondents
(16 Golf Courses and 1 HOA)

Problem: Because we use reclaimed water…	No. of Respondents	% of 17 Respondents	No. Able to Correct	% Able to Correct	Method to Correct
We need to blend it with water from another source to improve quality.	2	12%	1	50%	Blend with groundwater or surface runoff (a)
The irrigation water tends to be supplied at pressures greater than desired and causes problems with pipes, valves or application (i.e. drippers, microjet sprinklers) devices.	1	6%	DNA	DNA	DNA
The water pressure fluctuates and causes irrigation management or other problems.	1	6%	DNA	DNA	DNA
We are forced to take more reclaimed water than needed.	1	6%	1	100%	During wet weather, excess reclaimed water is irrigated for disposal.
Our lawn and/or plants experience a toxic reaction when fertilizer or chemicals are applied.	1	6%	1	100%	You have to know when your soil was last flushed and what you are doing.
Our net income is lower than if we used a traditional water source.	1	6%	0	0%	Cost of reclaimed water higher than ground water
Initial investment cost was high and made it difficult to connect	0	0	N/A	N/A	N/A
Our revenue is lower than if we used a traditional water source.	0	0%	0	0%	N/A

(a) Not enough ground water available to change quality.

Note: DNA means that the respondent did not answer the question. N/A means "not applicable".

O:\4302-000\wpdocs\R3

Reclaimed Water User Ratings

The 10 Agricultural respondents were asked to rate the supply reliability, quantity and quality of reclaimed water as they used it on their farm. The ratings are summarized in Table 2.1.24. For the most part, the respondents gave favorable ratings to their reclaimed water. Six of the 10 respondents were satisfied with their water supply reliability and water quality and five were satisfied with their water quantity. Three were very satisfied with their reclaimed water quantity and quality and four were very satisfied with their water supply reliability.

The 17 Recreation / Aesthetic respondents also gave favorable ratings for their reclaimed water. The ratings are summarized in Table 2.1.25. Nine respondents are very satisfied with the supply reliability of their reclaimed water while 11 respondents are satisfied with their reclaimed water quantity and 10 are satisfied with its quality.

Table 2.1.24
Overall Satisfaction with Reclaimed Water Supplied by a Utility
Agricultural Respondents

	No. of Agricultural Respondents		
Satisfaction Level	**Water Supply Reliability**	**Water Quantity**	**Water Quality**
Very Satisfied	4	3	3
Satisfied	6	5	6
Somewhat Satisfied	0	2	0
Not Satisfied (a)	0	0	1
Total	10	10	10
	% of 10 Agricultural Respondents		
Satisfaction Level	**Water Supply Reliability**	**Water Quantity**	**Water Quality**
Very Satisfied	40%	30%	30%
Satisfied	60%	50%	60%
Somewhat Satisfied	0%	20%	0%
Not Satisfied	0%	0%	10%
Total	100%	100%	100%

(a) The respondent said that the reclaimed water quality is fine for open ditch irrigation systems but it is terrible for microjet irrigation systems.

O:\4302-000\wpdocs\R3

Table 2.1.25
Overall Satisfaction with Reclaimed Water Supplied by a Utility
Recreation / Aesthetic Respondents

Satisfaction Level	No. of Recreation / Aesthetic Respondents		
	Water Supply Reliability	Water Quantity	Water Quality
Very Satisfied	9	5	3
Satisfied	7	11	10
Somewhat Satisfied	1	1	2
Not Satisfied	0	0	2
Total	17	17	17
Satisfaction Level	**% of 17 Recreation / Aesthetic Respondents**		
	Water Supply Reliability	**Water Quantity**	**Water Quality**
Very Satisfied	53%	29%	18%
Satisfied	41%	65%	59%
Somewhat Satisfied	6%	6%	12%
Not Satisfied	0%	0%	12%
Total	100%	100%	100%

Net Benefits of Reclaimed Water

All respondents were asked the following question regarding the net benefits of reclaimed water to their firm: "Do you believe that the total benefit your firm is receiving from using reclaimed water is greater than the total cost your firm is paying for reclaimed water (after subtracting any money received from government agencies)?" Of the 10 Agricultural respondents, six answered yes, one answered no, one did not know and two did not answer the question. Of the 17 Recreation / Aesthetic respondents, 15 said yes, one said no and one did not know. A summary of these responses is provided in Table 2.1.26 and Table 2.1.27.

Table 2.1.26
Benefit of Reclaimed Water Greater than Cost of
Reclaimed Water to Agricultural Respondents

Answer	No. of Respondents	% of 10 Respondents
Yes	6	60%
No	1	10%
Don't Know	1	10%
Did Not Answer	2	20%
Total	10	100%

O:\44302-000\wpdocs\R3

Table 2.1.27
Benefit of Reclaimed Water Greater than Cost of Reclaimed Water to Recreation / Aesthetic Respondents

Answer	No. of Respondents	% of 17 Respondents
Yes	15	88%
No	1	6%
Don't Know	1	6%
Total	17	100%

All of the respondents were asked the following question: "If your firm could do it all over again, would your firm agree to connect to the reclaimed water system? If you cannot speak for your firm, would you agree to connect this facility if the choice was yours alone?" Of the 10 Agricultural respondents, nine would connect again because the reclaimed water saves the farm money and one would not connect, citing the added cost of grove maintenance associated with using the reclaimed water.

All of the Recreation / Aesthetic respondents said they would connect to reclaimed water if they had to do it all over again. The reasons for agreeing to connect are summarized in Table 2.1.28. The most common answers were that the reclaimed water is needed as a supplemental water source and is it available during fresh water shortage restrictions. Four said that irrigation is a good use of reclaimed water and three said that reclaimed water is affordable or saves money.

Table 2.1.28
Reasons Given by Recreation / Aesthetic Respondents for Agreeing to Connect to Reclaimed Water if Firm Could Do it All Over Again

Reason	No. of Responses	% of 17 Respondents
It is a needed supplemental water source.	6	35%
Reclaimed water is available during water shortage restrictions.	6	35%
Good use of reclaimed water – turf grass filters out remaining pollutants and it returns back to aquifer for use as potable source.	4	24%
Cost savings or cost is affordable	3	18%

Note: More than one answer could be provided by the respondent. These answers represent 16 of the 17 respondents. The 17th respondent did not answer the question.

O:\44302-000\wpdocs\R3

These survey responses were used to develop the evaluation criteria to assess the economic feasibility of reclaimed water to Agricultural and Recreation / Aesthetic water use permittees and applicants.

2.2 Costs of Reclaimed Water

The actual costs associated with connecting to a reclaimed water system and using the reclaimed water for irrigation will vary depending on factors specific to the farm, golf course, or landscaped area. There are potentially three types of costs associated with using reclaimed water: (1) installation costs; (2) annual costs; and (3) periodic recurring costs. Each is discussed below.

Installation costs are the one-time costs associated with connecting the irrigation system to the reclaimed water supply and any changes that may need to be made to the irrigation, pumping or storage system to manage the reclaimed water. Installation costs include materials, labor and management costs. A list of the potential installation costs is provided in Table 2.2.1.

A reclaimed water user will not necessarily need to spend money on all of the cost items listed in Table 2.2.1. In some cases, the reclaimed water utility will pay for the piping system needed to connect the irrigation system to the reclaimed water system. If the reclaimed water pressure is compatible with the irrigation system, then pressure regulating valves would not be needed. If the reclaimed water is provided continuously in the amounts needed for irrigation, then storage may not be necessary.

Table 2.2.1
Potential Installation Cost Items Associated with Using Reclaimed Water for Irrigation

(1) Install pipe system to connect irrigation system to reclaimed water pipeline
(2) Install pressure regulating valves to control pressure of water flowing into irrigation system
(3) Install water meter to monitor amount of reclaimed water used
(4) Create storage pond or install storage tank and pump station to match reclaimed water supply with timing of water needs
(5) Disconnect existing water source from irrigation system
(6) For micro-sprinkler and drip irrigation systems - To reduce clogging, install or upgrade filtration and/or chemical injector system
(7) Create reclaimed water disposal area such as ditch connection to pasture area during times when reclaimed water flows are higher than crop water needs
(8) For turf and landscape, change plant material to more salt tolerant species
(9) Other costs, if any, specific to the individual reclaimed water user associated with the provision of water for other uses from the existing fresh water source.

To prevent clogging, a method to filter the reclaimed water prior to entering the irrigation system is usually needed if the system is micro-jet, drip or fully enclosed seepage. Filtration systems are oftentimes already a part of these systems. If the existing irrigation filtration system is sufficient to clean the reclaimed water, then no additional filtration expenses would be incurred.

If there is no existing water source attached to the irrigation system, then there would be no cost to disconnect it. Also, a reclaimed water disposal area may not be necessary if the utility does not need to dispose of excess reclaimed water. If the existing turf or landscape species are tolerant to the salt concentrations of the reclaimed water, then changing the plant material will not be necessary. The magnitude of the installation costs will depend on these factors as well as the size and configuration of the irrigation system.

If the well or surface water source is connected to other potable uses, in addition to the irrigation system, the firm may need to make modifications to the water delivery system of these other potable uses. This may be necessary in order to comply with reclaimed water regulations or to maintain a water source connection with these other water uses.

The water user may incur annual costs associated with reclaimed water use. These costs are related to utility charges for reclaimed water use; maintenance of reclaimed water conveyance and storage; fertilizer, salinity, pH, pest and/or algae management; and data recording and reporting that may be required of government agencies. A list of the potential annual and periodically recurring costs associated with using reclaimed water is provided in Table 2.2.2.

Some of these costs may be annual costs and others may be periodic recurring costs where the cost for an item, such as replacing a filter cartridge, is not expended every year but every 2 to 5 years.

A reclaimed water user will not necessarily need to spend money on all of the cost items listed in Table 2.2.2. Some utilities do not charge irrigators to use reclaimed water because such use is considered to be a wastewater effluent disposal method and the cost is paid by wastewater customers. In addition, some water utilities consider reclaimed water to be an alternative water supply that reduces the demand for potable water and so water customers pay for part of the reclaimed water system.

Table 2.2.2
Potential Annual or Periodically Recurring Cost Items
Associated with Using Reclaimed Water for Irrigation

1. Reclaimed water payment to the utility.
2. Irrigation-related management associated with maintaining reclaimed water meter, pipeline, pump and storage pond; repairing pipeline due to fluctuating water pressure; and repairing or replacing rusty controllers, power boxes and equipment.
3. Fertilizer management including water quality and plant tissue testing and nutrient evaluations.
4. Salinity and pH management including chemical applications, water blending, soil leaching and mechanical means.
5. Pest or algae management including cleaning or repairing microjets or drip nozzles, water chlorination, pesticides, and filter replacement.
6. Recording water data and providing reports to the water management district and the FDEP

As discussed under installation costs, a reclaimed water user may not need to install a pump or storage to manage the reclaimed water and thus no annual costs for these items would be incurred. Fungus and algae management may be an issue when reclaimed water is used for irrigation. The reclaimed water survey found that eight of 16 golf courses and one of ten farms had to manage problems with algae growth that was believed to be tied to reclaimed water use.

While it is possible that pest problems could occur, pests were not mentioned as a problem associated with reclaimed water use in the available literature and in this study's reclaimed water user survey. Rust was reported to be an issue for four golf courses surveyed. Two recommended that equipment be cleaned with fresh water and metal controllers and other affected items be replaced with plastic versions, where possible.

Salinity and pH management may be necessary when reclaimed water is used for irrigation. Reclaimed water use for irrigation may affect the pH of the soil solution which is very important to determining the ability of plants to absorb nutrients. Plants grow best when the soil pH is 5.5 to 7.5, depending on the plant type. For example, the soil pH for citrus should be between 5.5 and 6.5.[1] The addition of irrigation water will affect the soil

[1] Zekri, Mongi, Thomas Obreza and Arnold Schumann, "Increasing Efficiency and Reducing Costs of Citrus Nutritional Programs", University of Florida IFAS Extension, SL222, January 2005, EDIS Web Site at http://edis.ifas.ufl.edu.

pH. The survey found that 3 of the 16 golf courses needed to manage soil pH while none of the ten agricultural users needed to change the pH in the reclaimed water prior to use.

Sometimes, the salinity content of reclaimed water is significantly higher than is found in traditional water sources. Plants do not use salt in significant quantities nor is salt evaporated from the soil.[2] As salt accumulates in the soil, plant growth and quality can be negatively affected. Salinity management was found to be a more common issue than pH management in the survey responses and in the literature review. While none of the 10 agricultural reclaimed water users reported a problem with salinity, seven of the 16 golf courses did. These golf courses monitor for salinity and flush the soil when needed. Others apply gypsum or calcium to the soil. It should be noted here that golf courses can also have salinity management issues associated with potable water sources, such as the Floridan aquifer.

Because reclaimed water may contain significant quantities of nutrients, it is necessary to test the water, soil, and plant tissue to monitor how the nutrient content changes once reclaimed water is used. It is possible that the addition of nutrients in the water will reduce the amount of fertilizer needed and thus reduce costs.

It is also possible that the content of certain nutrients in the reclaimed water is so high that it has a detrimental effect on plant growth, aesthetics, crop yield and/or ground and surface water resources. In this case, blending reclaimed water with fresh water or changing the water source during critical growth periods may be necessary. In the case of nitrogen, water reclamation plants that incorporate nitrification and denitrification to comply with waste discharge permits (i.e. NPDES) typically produce AWT[3] reclaimed water with less than 3 mg/L of nitrogen. Advanced secondary treated reclaimed water facilities typically provide reclaimed water with about 8 mg/l of nitrogen. Both nitrogen levels are acceptable for plant health.[4]

Because of the potential impact of reclaimed water on soil pH, salinity, and nutrient content of the irrigation water that affects plant health, it is necessary to obtain the water

---

[2] Metcalf & Eddy | AECOM, "Water Reuse Issues, Technologies, and Applications", Written by Takashi Asano, Franklin L. Burton, Harold L. Leverenz, Ryujiro Tsuchihashi and George Tchobanoglous, McGrall Hill, 2007. (available from AWWA Bookstore)

[3] AWT stands for advanced wastewater treatment.

[4] Metcalf & Eddy | AECOM, "Water Reuse Issues, Technologies, and Applications", Written by Takashi Asano, Franklin L. Burton, Harold L. Leverenz, Ryujiro Tsuchihashi and George Tchobanoglous, McGrall Hill, 2007. (available from AWWA Bookstore)

quality test results from the reclaimed water provider before accepting reclaimed water and on an annual basis and monitor for any needed changes in reclaimed water management. Of the 17 recreation / aesthetic reclaimed water users surveyed, only eight knew the nutrient content and chemical constituents of their reclaimed water. Only one of these 17 did not know how to obtain this information. Five of the 10 agricultural reclaimed water users surveyed knew the nutrient content and chemical constituents of their reclaimed water and all of them knew how to obtain this information.

Of the 10 agricultural and 17 recreation / aesthetic reclaimed water users (16 golf courses, 1 HOA), only three farmers and three golf courses reported annual costs associated with reclaimed water record keeping and reporting. It may be that such activities are a part of everyday operations and/or the time required is not significant making it difficult to isolate the cost impact of using reclaimed water.

The costs associated with reclaimed water compared to the cost of water from traditional water sources are described further in Chapter 3.0 of this report.

2.3 Benefits of Reclaimed Water

The survey responses demonstrated that there are benefits of reclaimed water use relative to using traditional water sources such as ground or surface water. These benefits include cost savings and value-added. The benefits are listed in Table 2.3.1 in order of importance to the 27 Agricultural and Recreation / Aesthetic reclaimed water users surveyed.

The top five benefits are related to having more water available when needed relative to traditional water sources. The top three benefits are: (1) having a guaranteed and reliable water source, (2) able to conserve fresh water for their other uses and (3) able to irrigate more frequently than if a traditional water source was used. At least 2 of every 3 respondents said they were receiving at least one of these three benefits.

Table 2.3.1
Benefits of Reclaimed Water for Irrigation

Reclaimed Water Benefits	Survey Respondents Who Said Yes to Benefit		
	Number	% of Responses	Total No. of Respondents (a)
1. Have a guaranteed and reliable water source	20	74%	27
2. Able to conserve fresh water for their other uses	18	67%	27
3. Able to irrigate more frequently than if used traditional source	17	63%	27
4. Able to apply more water to the crop/ lawn/ landscape than with traditional source	15	56%	27
5. Better able to supply water to crops during drought conditions	5	50%	10
6. Irrigation costs are lower	13	48%	27
7. Net income is higher than with traditional water source	11	41%	27
8. Revenue is higher than with traditional water source	9	33%	27
9. Fertilization costs are lower	7	26%	27
10. Business has increased during fresh water shortage restrictions	4	24%	17
11. Better able to protect crops from freezing	2	20%	10
12. Water storage costs are lower	3	11%	27
13. Crop yield has been higher than with a traditional source	1	10%	10
14. Pounds of juice per acre is higher than with traditional source	1	10%	10
15. Quality of crop/lawn/ landscape is higher than with traditional source	2	7%	27

(a) The total number of respondents is 27 where the statement was presented to both agricultural and recreation / aesthetic respondents. The total number of respondents is 10 where the statement was presented to only the agricultural respondents.

The fourth and fifth benefits are also related to having more water and are: (4) Able to apply more water to the crop/ lawn/ landscape than with a traditional source and (5) Better able to supply water to crops during drought conditions. At least 50 percent of the 27 respondents stated that they received at least one of these two benefits from using reclaimed water.

The sixth to ninth ranked benefits have to do with cost savings, higher revenue and higher net income. Almost 50 percent of the reclaimed water users said that their irrigation costs are lower and their net income is higher because they use reclaimed water for irrigation. The lower irrigation costs are primarily due to reduced energy use for pumping relative to the respondent's ground or surface water source. The higher revenue is due to the availability of needed water supply, increased business during drought conditions, and the improved ability to protect the crop during freezing temperatures. The higher net income is due to all of the benefits listed in Table 2.3-1, including lower fertilization costs, lower pumping costs, more water available, lower storage costs, and more business during drought restrictions, among other benefits.

Only two of the 27 respondents (1 agricultural and 1 golf course respondent) said that their net income is lower due to their use of reclaimed water. None of the 27 respondents said that their revenue is lower from using reclaimed water.

Of the 27 agricultural and recreation / aesthetic respondents, 12, or 44 percent do not pay their reclaimed water supplier while 15, or 56 percent, do pay their reclaimed water supplier. Many of these 15 respondents probably pay their reclaimed water supplier less money than they would pay if they obtained their water from a potable water source such as the Floridan aquifer.

The consideration and estimation of these benefits are discussed in Chapter 3.0 of this report.

Chapter 3.0
Reclaimed Water Benefit-Cost Evaluation For Irrigation Uses

3.1 Background

This Chapter describes the Reclaimed Water Benefit-Cost Calculator for irrigation uses, the evaluation criteria for irrigation, and recommendations for additional research.

The Reclaimed Water Benefit-Cost Calculator for Irrigation is to be used to provide guidance as to the economic feasibility of using reclaimed water for a specific purpose. The values that the user will input into the model are estimates and the model results should not be the only factor in determining economic feasibility. Instead, the model results should be viewed in the proper context of all other information submitted and relevant to the water use permit application or renewal.

The example values used in the models and referenced in this report are purely illustrative for purposes of this study presentation only. Readers are advised to develop proper estimates of costs and benefits that would be appropriate for their individual site(s). Except where explicitly directed (*e.g.*, to obtain the proper values of nitrogen fertilizer and fuel costs from specific websites), the example values provided in the model and in this report are NOT "default" values.

3.2 Reclaimed Water Benefit-Cost Calculator for Irrigation

The evaluation criteria attempt to measure and compare the benefits of reclaimed water to the costs of reclaimed water. In an ideal world, the total and marginal value[1] of reclaimed water to each water user would be known and would simply be compared, respectively, to the total and marginal costs of using reclaimed water. If the value of reclaimed water to the user is greater than the costs of reclaimed water, then it is economically feasible to use.

Unfortunately, the total and marginal values of fresh water and reclaimed water are not known for even groups of water users, particularly in Florida. This is primarily because water values will vary depending on the value of the product produced with the water and the dependence of the product on water. For example, high valued crops would

[1] Marginal water value is the additional value of water received from an additional unit of water.

have higher water values than lower valued crops and, due to differences in crop growing seasons, ET and rainfall, a certain crop grown in one part of the United States may have a different water value than the same crop grown in Florida. The water users themselves may not even know the value of water to their operations.

An Awwa Research Foundation report[2] titled, "The Value of Water: Concepts, Estimates and Applications for Water Managers" provides a literature review of water values that have been estimated as of around 2003. None of these values can be used directly by Florida water users. However, the estimated values might be used as a range of possible values. The marginal water values documented in The Value of Water report range from $0.09 to $2.47 per 1,000 gallons for commercial, institutional and industrial customers and from $0.08 to $2.59 per 1,000 gallons for agricultural water users. A useful research project would be to estimate these values for the types of industrial, recreational, and agricultural water users in Florida. This information could be used to help water users and the District assess the economic value of reclaimed water to their operations.

Because water values in particular uses are not known, the value of reclaimed water needs to be inferred from the available information. Economists know that the value of the last unit of water used, also called marginal water value, is the price or cost paid for that last unit of water. The marginal water values of all water used up to that last unit are higher than the price or cost paid for the last unit due to diminishing returns as more water is used. The average cost or payment for the water used is the minimum value of that amount of water in that particular use. So, for example, if a farmer spends $2,000 annually to pump 13.3 million gallons per year from the ground for irrigation, we know that the average value of the water to that farmer is at least $0.15 per 1,000 gallons ($0.15 = ($2,000/13,333,333)X1,000). Otherwise, the farmer would not have spent that much money to obtain the irrigation water.

Ground water and surface water are the primary water sources in Florida, including for agricultural, golf course and landscape irrigation. Florida water users, particularly in the southwest and the south, experience water restrictions on a regular basis. If the cost of reclaimed water can be offset by the avoided cost of the irrigator's next best water source plus provide other benefits including a reliable water supply and reduced fertilizer costs, then reclaimed water is economically feasible to the water user. This presumes

[2] For a good summary of estimated values for water by agricultural, residential and industrial water uses, see Raucher, Robert S., David Chapman, James Henderson, Marca L. Hagenstad and John Rice, "The Value of Water: Concepts, Estimates and Applications for Water Managers, Prepared by Stratus Consulting and associated firms for the Awwa Research Foundation, #2855, 2005.

that the quality of the reclaimed water is suitable for use. If the reclaimed water must be further treated by the irrigator, then those costs would be added to the cost of reclaimed water. This is the approach that is used to develop reclaimed water economic evaluation criteria for irrigation.

The evaluation criteria are comprised of the information required of the District and the reclaimed water user in order to estimate the values of the benefits and costs associated with reclaimed water use for irrigation. The spreadsheet model called "RW Benefit-Cost Comparison for Irrigation" was developed during this study. It incorporates the evaluation criteria into an estimate of the net benefits (benefits minus costs) of reclaimed water use as compared to using water from the next best available water source. The model allows the user to enter all available information regarding factors that determine benefits and costs in order to obtain an estimate of the economic feasibility of reclaimed water to the user. Because the data values entered into the model are likely to be estimates, the model allows the user to easily conduct sensitivity analyses to see how the economic feasibility changes as the input data is changed.

3.2.1 Worksheet Instructions

The first spreadsheet in the Excel file is called "RW Comparison Worksheet Instruc". It contains initial questions and worksheet instructions. This spreadsheet is reproduced as Table 3.2.1. This is where the District and the water user begin the economic evaluation. The "RW Benefit-Cost Comparison for Irrigation" model is used if the answer is YES to Question 1, "Is reclaimed water service available to your operation?" and NO to Question 2, "Is reclaimed water the only water source available to your operation?" The answer to Question 2 would be YES only if the water user cannot access any other water source. It is up to the District and the water user to decide if reclaimed water is the only viable water source. In this case, it would be up to the water user to decide if reclaimed water is economically feasible by making an assessment of the value of water to the particular operation. It is expected that, in most cases, the answer to Question 2 will be NO.

The third and fourth questions ask the District and the user to identify the water source they will compare to reclaimed water. The third question asks the user to identify one or more available water sources and the fourth question asks: "which is the water source that would be replaced, in whole or in part, by reclaimed water?" This water source is then called the "Next Available Water Source" or NAWS for short.

The next part of the Spreadsheet instructs the user to enter the data in the Spreadsheet titled "RW Comparison Worksheet". The other spreadsheets in this file calculate values referred to by the "RW Comparison Worksheet" spreadsheet.

Then there is a color code that identifies spreadsheet cells that are calculated numbers; entered by the user; drop down menus; parameters of equations (assumed values); or blank cells. For the convenience of the reader, all tables in this Chapter are in black and white and are not color-coded and the table cells that are entered by the user are in **Comic Sans MS** Font.

The remainder of this spreadsheet provides instructions regarding where on the Internet to find current electricity, diesel, gasoline and nitrogen fertilizer prices that will be used in the model.

Table 3.2.1
Reclaimed Water Benefit-Cost Calculator For Irrigation - Worksheet Instructions

1. Is reclaimed water service available to your operation?	*YES, CONTINUE TO QUESTION 2.*		*NO, Stop Here*
2. Is reclaimed water the only water source available to your operation?	*YES, Stop Here*		***NO,*** continue to Question 3 *and* complete the **RW Comparison Worksheet**.
3. What other water source(s) are available to your operation for irrigation? (Circle all that apply.)	*FLORIDAN AQUIFER*		
	INTERMEDIATE AQUIFER		
	SURFACE WATER		
	OTHER, PLEASE SPECIFY:		
4. Of these water sources, which is the water source that would be replaced, in whole or in part, by reclaimed water? For the purposes of the RW Comparison Worksheet, this water source will be called the "Next Available Water Source" or NAWS.			
5. Has the applicant obtained, from the reclaimed water provider, the nutrient contents and chemical constituents in the reclaimed water, including nitrogen, phosphorus, potassium, trace elements including boron, and the electrical conductivity and sodium absorption ratio (sodium, chloride and magnesium) of the water? This information should be used to assist in estimating the benefits and costs of using reclaimed water for irrigation.			*YES*
			NO

Enter the information in the Spreadsheet titled "RW Comparison Worksheet".
The other spreadsheets calculate values referred to by the "RW Comparison Worksheet" spreadsheet.

Color Code of RW Comparison Worksheet	
	means calculated numbers
	means entered by user
	means this is a drop down menu
	means parameters of equations (assumed values)
	means keep as blank cell

Use the following sources to determine prevailing energy costs:

Gasoline and Diesel Fuel: U.S. Government: **http://tonto.eia.doe.gov/oog/info/gdu/gasdiesel.asp**

AAA: **http://www.fuelgaugereport.com/FLmetro.asp**

Electricity: U.S. Government: http://www.neo.ne.gov/statshtml/115.htm

http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_a.html

For fertilizer prices go to:
http://www.ers.usda.gov/Data/FertilizerUse/ Use Table 7 (Excel Spreadsheet) to determine the current price of fertilizer. Scroll down to the most recent year and use the cost of "Urea 45-46% Nitrogen.

3.2.2 RW Comparison Worksheet

The user enters all of the required information into the spreadsheet called "RW Comparison Worksheet". This worksheet has five columns that comprise the benefit-cost table. The first column identifies the Row number of the worksheet. The second column identifies the benefit or cost item or the information needed to estimate benefits or costs. The third column is the data and calculations that correspond to the "Next Available Water Source" or "NAWS". The fourth column contains the data and calculations that correspond to reclaimed water or, in the case of a partial offset, to be described below, the term "RW/Other" is used to characterize the combination reclaimed water / other water source scenario. The model uses the term "RW/Other" in the heading of Column (4) to represent either an evaluation of reclaimed water only or an evaluation of a combination of reclaimed water and another water source.

The fifth column calculates the difference between "NAWS" and "RW/Other". If the value in this fifth column is positive, then it means that the value for "NAWS" is greater than the value for "RW/Other". If it is negative, then the value for "NAWS" is less than the value for "RW/Other". The model is designed so that if the value is positive, then it is a benefit of RW/Other and if it is negative, then it is a cost of RW/Other.

All data and resulting calculations are displayed in these five columns. The order of benefits and costs as one moves down this spreadsheet and the evaluation criteria are provided in Table 3.2.2. Each row of this table is described in turn as follows.

3.2.3 Installation Costs and Water Available

The first 26 rows of the RW Comparison Worksheet identify the water sources, address the amount of water needed and available from both sources (NAWS and RW/Other), and itemize the estimated installation costs associated with these two water sources. These 26 Rows are depicted in Table 3.2.3. These rows estimate the potential reclaimed water cost savings associated with installing water storage and pumping, and the potential reclaimed water cost increase from installing additional filtration, among other installation cost differences.

The user enters the data and information into the green cells. In this Chapter these cells are in black and white and are not color-coded. Instead, in this Chapter's tables that reproduce the spreadsheet, all green cells are in ***Comic Sans MS*** Font so that the reader may identify them easily.

The calculated numbers and repeated information are in the blue cells. In this table and in the tables of the spreadsheet that follow, hypothetical numbers and data are entered in order to assist the reader in understanding how the model works. They are not meant to represent any particular water user and are not to be used as "default" values.

Table 3.2.2
Order of Benefits and Costs Presented in the Reclaimed Water Benefit-Cost Calculator And Evaluation Criterion

Benefit or Cost Item	Measure of Benefit Or Cost Item	Evaluation Criterion (a)
A. Amount of water needed and available in million gallons – annual	Amount of water needed and available in million gallons – annual	Negative of Difference in amount of water needed and available (RW/Other minus NAWS)
B. Installation costs	Total annualized installation cost and Per 1,000 gallons	Difference in annualized installation cost (NAWS minus RW/Other)
C. Annual O&M costs	Total annual O&M cost and Per 1,000 gallons of water	Difference in annual O&M cost (NAWS minus RW/Other)
D. Recurring O&M costs	Total annualized recurring O&M cost and Per 1,000 gallons of water	Difference in annualized recurring cost (NAWS minus RW/Other)
E. Nitrogen fertilizer cost savings – annual	Total annual nitrogen fertilizer cost savings and Per 1,000 gallons of water	Nitrogen fertilizer cost savings
A. through E.	Total annualized cost and cost savings and Per 1,000 gallons of water	
F. Change in value of crop production – annual	Net value of change in crop production – annual	
G. Change in quality of crop, lawn and/or landscape – annual	Change in net revenue (market value minus variable cost) – annual	
H. Value of additional water available from reclaimed water source – annual	Value of additional water – annual	
I. Value of additional water “freed up” by the reclaimed water use (that can be used by the reclaimed water user)	Value of “freed up” NAWS water – annual	
J. Value of water available during NAWS water shortage restrictions - annual	Value of water available during NAWS water shortage restrictions – annual	
F. through J.	Total benefit value of reclaimed water (other than cost savings) and Per 1,000 gallons	
A. through J.	Net benefit of reclaimed water use relative to next available water source and Per 1,000 gallons	

(a) Positive values are benefits of reclaimed water and negative values are costs of reclaimed water.

O:\443(

Table 3.2.3
RW Comparison Worksheet For Irrigation – Rows 1 through 26
Economic Comparison of Reclaimed Water and Next Available Water Source

Row No.	Benefit or Cost Item	Next Available Water Source (NAWS)	Reclaimed Water Used Instead & Other Sources if Applicable (RW/Other)	NAWS Minus RW/Other (Except A. which is RW/Other minus NAWS)
(1)	(2)	(3)	(4)	(5)
1	**Name of NAWS / Name of RW Provider**	***Floridan***	***Utility***	
2	**A. Amount of Water Needed and Available in million gallons (mg) – Annual**	***74.00***	***84.00***	10.00
3	***B. Installation Costs (if not already installed or replaced) (a)***			
4	(a) The replacement cost of existing items within five years of the end of their useful lives should be included in this list as if purchased new. The current remaining or "salvage" value of these existing items may be entered as indicated below. Do not forget to consider the cost of the backup water supply in Column (4) should reclaimed water be temporarily unavailable. The user may enter all appropriate names of cost items in Column (2), Rows 5 to 12.			
5	***Pipes and Pumps***	***$1,000***	***$2,000***	
6	***Storage***	***$2,000***	***$3,000***	
7	***Filtration system (if needed for drip/ microjet irrigation system)***	***$3,000***	***$4,000***	
8	***Land Development not included in items above***	***$4,000***	***$5,000***	
9	***Item 1:***	***$0***	***$0***	
10	***Item 2:***	***$6,000***	***$7,000***	
11	***Item 3:***	***$7,000***	***$8,000***	
12	***Item 4:***	***$8,000***	***$9,000***	
13	**Current Salvage Value of Items that are replaced and included above (enter value as a negative number). It is included as 1/5th of this value in Total Annualized Installation Cost.**	***-$2,000***	***$0***	
14	**Total Installation Cost**	$29,000	$38,000	
15	**Annual Interest Rate (i.e. 6%)**	6.00%	***6.00%***	
16	**Useful Life of Item in Years**			
17	Pipes and Pumps:	***10***	***10***	
18	Water Storage:	***20***	***20***	
19	Filtration system (if needed for drip/microjet irrigation system):	***7***	***7***	
20	Land Development not included in items above:	***20***	***20***	
21	Item 1:	***10***	***10***	
22	Item 2:	***10***	***10***	
23	Item 3:	***10***	***10***	
24	Item 4:	***10***	***10***	
25	**Total Annualized Installation Cost**	**$3,650**	**$4,947**	**-$1,297**
26	***Total Annualized Installation Cost per 1,000 Gallons of Water (a)***	***$0.05***	***$0.06***	***-$0.02***

(a) The cost per 1,000 gallons of water was calculated using 74.00 mg for NAWS and using 84.00 mg for RW/Other and for NAWS Minus RW/Other. This is why Column (5) is not equal to Column (3) minus Column (4) in Row 26).

In Row 1, the user enters the name of the "Next Available Water Source" (NAWS) in Column (3) and the name of the utility that will supply the reclaimed water (RW) in Column (4). In Row 2, Column (3), the user enters the annual amount of water available from the NAWS in million gallons (mg) that will be needed for irrigation of a particular area, be it a golf course or 200 acres of citrus. In Row 2, Column (4), the user enters the annual amount of water available in mg from the reclaimed water source that will be used for the same purpose. In Column (5), the difference between the amount of reclaimed water and the amount of water from the NAWS is calculated. If more water is available for needed use from the reclaimed water supplier than from the NAWS, then this additional water has value to the water user which will be discussed later in this Chapter. In the example, 74 million gallons (mg) per year is available from the NAWS and 84 mg per year is available from the reclaimed water supplier. Row 2, Column (5) calculates that 10 mg per year is the additional amount of reclaimed water needed and available relative to the NAWS.

Partial Offset. In this document and model, a partial offset means that the reclaimed water is replacing only a portion of the NAWS water supply. When this is the case, in Row 1, Column (4), the user should enter the name of the reclaimed water provider, the percent of water from this source, the name of the water source that will provide the remainder of the water needed for reasonable/beneficial use (NAWS or other source), and the percent of water from this source. For example, Manatee County (10%) and Floridan Aquifer (90%) would be entered if 10 percent of the water supply would be reclaimed water provided by Manatee County and 90 percent of the water supply would be from the Floridan Aquifer.

The total amount of water available from the NAWS source if reclaimed water is not used is entered in Row 2, Column (3). The sum of the amount of water available from the reclaimed water source and the amount of additional water that would be provided from the other water source (which could be NAWS or a different source) should be provided in Row 2, Column (4). In most cases it is expected that the amount provided in Row 2, Column (3) should be equal to the amount provided in Row 2, Column (4).

From this point on, the user will be comparing the costs and benefits of NAWS only to the costs and benefits of the combination of reclaimed water and the other water source. This other water source will typically be the NAWS that was selected by the user and entered into Column (3) but it does not need to be the NAWS. The RW/Other Water Source combination represented in Column (4) of this model is the water source package needed to obtain the water supply necessary to continue operations that would take place if all of the water was supplied by the NAWS as indicated in Rows 1 and 2, Column (3).

Instructions regarding how to enter information into the model when a partial offset is being considered will be provided as this discussion flows from row to row of this model's spreadsheet.

O:\44302-000\wpdocs\R3

The 3rd Row in Table 3.2.3 begins the estimation of installation costs. Each item that needs to be installed is included in Rows 5 through 12 for both water source alternatives. In Column (3), all items needed to deliver water from the NAWS to the user's irrigation system should be included in these rows and their costs estimated. Likewise, in Column (4), all items needed to deliver water from the utility's reclaimed water system to the user's irrigation system are included in these rows and their costs estimated. If a partial offset is being considered, all items needed to obtain the additional water from the other water source are also included in Column (4) and their costs estimated. The cost items for each water source do not need to be the same. For example, if using the NAWS only (Column (3)) requires the installation of water storage and using reclaimed water does not require storage, then in the row for storage (Row 6 in this example), the value would be greater than zero for NAWS (Column (3)) and equal to zero for reclaimed water (Column (4)).

The user may change the names of the items listed in Column (2), Rows 5 through 12 as needed. The model will repeat the names of the items entered in Rows (17) through (24). The user may only aggregate the cost of components into one item if they all have the same useful life (as measured in years).

If the NAWS will be a backup or standby water supply in the event that the reclaimed water is temporarily unavailable, then the installation costs associated with this backup supply source should also be included in Column (4). These costs may be different from those entered in Column (3) (NAWS only alternative). For example, the original backup water supply used when NAWS only is the alternative might not be needed if reclaimed water is used and so the costs associated with this infrastructure (pumps, pipes, etc.) would be zero.

If the components of any of these water sources have already been installed, then under B. Installation Costs, include the replacement cost of components that will be at the end of their useful lives within the next five years. In Row 13, the current Salvage Value of these existing components would be entered. This value represents the value of the existing items to the operation because they will be used until they are replaced at the end of their useful lives. The model subtracts one-fifth of the Salvage Value from the Total Installation Costs. If the entire NAWS system has already been installed and does not need to be replaced within the next five years, then the costs associated with all installation items and the Salvage Value under the NAWS column (Column (3)) would be zero.

The total installation cost is summed in Row 14. In Row 15, the user enters the annual interest rate that will be used to amortize or annualize the installation costs. This value

will typically represent either the user's interest paid on loans or the interest earned on savings. In this example, the interest rate is 6 percent per year.

In Rows 17 to 24, the useful life in years of each component listed in Rows 5 through 12 is entered. The useful lives of the components must be entered in the order that the components are listed in Rows 5 through 12. In Rows 17 to 24 the model automatically enters the cost item name that was entered by the user in Rows 5 through 12.

If under the RW/Other alternative, all or a portion of the NAWS is needed as a backup system, then its components, such as the pumps, storage and/or pipes, will not be used as often and may have a longer useful life. To account for this, the user should enter the relevant NAWS installation costs and the longer useful lives in the RW/Other column (Column (4)). However, the cost of each component should only be included if it will need to be replaced sometime during the next five years and the current salvage value of the existing component should be included in Row 13, Column (4).

Row 25 presents the calculated Total Annualized Installation Cost and Row 26 presents the calculated Total Annualized Installation Cost per 1,000 gallons of water using the costs, interest rate and years of useful life reported in the previous rows. Column (3) of Row 26 uses the million gallons of NAWS provided by the user in Column (3), Row 2 of the model. Column (4) of Row 26 uses the million gallons of RW/Other Source provided by the user in Column (4), Row 2 of the model.

Column (5), Row 25 is the difference in the Total Annualized Installation Cost between the NAWS and the RW/Other and is calculated as the Total Annualized Installation Cost of the NAWS minus the Total Annualized Installation Cost of RW/Other. Column (5), Row 26 is the difference in the Total Annualized Installation Cost per 1,000 gallons, as defined in the previous sentence, divided by the quantity of RW/Other that was entered in Row (2), Column (4). In this example, the difference is -$1,297 or -$0.02 per 1,000 gallons. A negative value means that the installation cost of RW/Other is higher than the installation cost of the NAWS. This is just one component of estimating the net benefits of reclaimed water to the user.

3.2.4 Annual O&M Costs

Rows 27 through 55 of the RW Comparison Worksheet estimate the annual O&M costs associated with the NAWS and RW/Other. These rows are depicted in Table 3.2.4. The information provided by the user in these rows are used to estimate the potential annual O&M cost savings and cost increases associated with reclaimed water. These rows do not include the nitrogen fertilizer cost saving which is addressed later in the model and in this Chapter. The cells where the user enters data are in ***Comic Sans MS*** Font.

O:\44302-000\wpdocs\R3

Table 3.2.4
RW Comparison Worksheet For Irrigation – Rows 27 through 55
Economic Comparison of Reclaimed Water and Next Available Water Source

Row No.	Benefit or Cost Item	Next Available Water Source (NAWS)	Reclaimed Water Used Instead & Other Sources if Applicable (RW/Other)	NAWS Minus RW/Other (Except A. which is RW/Other minus NAWS)
(1)	(2)	(3)	(4)	(5)
27	***C. Annual O&M Costs***			
28	**1.0 Payments to Reclaimed Water Utility and, if applicable, to NAWS Water Utility**			
29	Annual Fixed Payment	***$0.00***	***$144.00***	
30	Price per 1,000 gallons	***$0.00***	***$0.05***	
31	***Total Utility Payment – Annual***	$0	$4,344	**-$4,344.00**
32	**2.0 Irrigation Pumping Energy Cost – Annual**			
33	Energy Source:	***Electricity***	***Electricity***	
34	Total Dynamic Head in Feet:	***300***	***30***	
35				
36	Cost of energy source, Dollars per KWH or gallon (obtain from appropriate web site):	***$0.11***	***$0.11***	
37	Energy cost to pump 1 Kgal:	$0.16	$0.02	**$0.15**
38	**Total irrigation pumping energy cost – Annual**	**$12,069**	**$1,370**	**$10,699**
39	**3.0 Irrigation Maintenance Labor Cost – Annual**			
40	Labor Cost per Hour:	***$10.00***	***$10.00***	
41	Pumping System Labor Hours:	***52***	***26***	
42	Irrigation System Labor Hours (include relevant issues such as fungus and algae management that involve repairing tubes and cleaning jets, maintaining storage pond):	***156***	***208***	
43	Salinity or pH management Labor Hours:	***20***	***52***	
44	**Total Maintenance Labor Cost – Annual**	**$2,280**	**$2,860**	**-$580**
45	**4.0 Annual Cost of Chemicals To Manage Irrigation Water or Soil, other than Nitrogen, specify chemical**			
46	***Gypsum***	***$2,000***	***$5,000***	**-$3,000**
47	***Chemical Name:***	***$0***	***$0***	**$0**
48	***Chemical Name:***	***$0***	***$0***	**$0**
49	**5.0 Reporting or Record Keeping Costs - Annual**	***$500***	***$1,500***	**-$1,000**
50	**6.0 Other Annual Costs, specify below**			
51	***Item A:***	***$0***	***$0***	**$0**
52	***Item B:***	***$0***	***$0***	**$0**
53	***Item C***	***$0***	***$0***	**$0**
54	**Total Annual O&M Cost**	**$16,849**	**$15,074**	**$1,775**
55	***Total Annual O&M Cost per 1,000 Gallons of Water (a)***	***$0.23***	***$0.18***	***$0.02***

(a) The cost per 1,000 gallons of water was calculated using 74.00 mg for NAWS and using 84.00 mg for RW/Other and for NAWS Minus RW/Other. This is why Column (5) is not equal to Column (3) minus Column (4) in Row 55).

In Rows 29 and 30, the user enters the annual fixed payment and the price per 1,000 gallons charged in the NAWS column and in the RW/Other Column. If the NAWS is purchased from a water provider, then the fixed and variable charges should be entered in Column (3). The reclaimed water rates charged by the reclaimed water provider are entered in Column (4). If the rate structure has more than one variable rate because it is a declining or inclining block rate structure or if a partial offset is being considered in Column (4), then the user may just calculate the annual water bill offline and enter it in Row 29 under Annual Fixed Payment and entering a zero ($0) in Row 30 for the price per 1,000 gallons. Row 31 calculates the annual water bill using the values in Rows 29 and 30 and the water quantities provided in Row 2 (See Table 3.2.3). The utility water payment under the NAWS minus the utility water payment under RW/Other is provided in Column (5) of Row 31. In this example, the water payment is $0 per year for the NAWS and $4,344 per year for RW/Other. Thus, the difference in Column (5) is -$4,344 per year which is a cost increase associated with RW/Other.

The annual irrigation pumping energy cost using the NAWS and RW/Other is estimated in Rows 32 to 38. In Row 33, the user is asked to choose the energy source used for water pumping. The cells in Columns (3) and (4) of Row 33 are drop down menus where the user chooses Electricity, Diesel or Gasoline. The Total Dynamic Head (TDH) is entered in Row 34. A discussion of TDH is provided in Appendix B of this report. The current cost of the energy source in dollars per KWH or dollars per gallon of diesel or gasoline is entered in Row 36.

If a partial offset is being considered under RW/Other (Column (4)) and the energy source is the same for reclaimed water and for the other source, then enter the weighted average TDH based on the proportion of the water supply that is reclaimed water and the proportion that is from the other source. So using the 10% reclaimed water / 90% Floridan Aquifer example with TDHs of 30 and 300, respectively, the weighted average TDH would be 273 which was calculated as (0.10 x 30) + (0.90 x 300). The calculation of the energy cost to pump 1,000 gallons of water using this weighted average is the same as if the calculation was done separately for each water source. If the energy source is different for reclaimed water and for the other source, then the user should calculate the Total Irrigation Pumping Energy Cost – Annual offline and enter it in Row 38, Column (4). The user may use Rows 33 to 38 to calculate the annual cost associated with each of the two energy sources, add the results together, and enter the total in Row 38. Because the model calculation in this cell will be deleted once the value is entered into Row 38, the user is encouraged to maintain a separate copy of this model that is unchanged. This situation is not expected to be common.

The energy cost to pump 1,000 gallons of water is calculated and reported in Row 37. This calculation is made using the following equations.[3]

(1) Energy needed to pump 1,000 gallons of water=

(Motor HP x Hours to Pump 1,000 Gallons) / HP-Hours per Gallon (of fuel or per kWh)

Where,

Energy needed is in kilowatt hours of electricity (kWh), gallons of diesel fuel, or gallons of gasoline;

Motor HP = (TDH x GPM x 1) / (3,956 x Pump Efficiency);

Pump Efficiency is assumed to be 0.75;

Hours to Pump 1,000 Gallons = (1,000 gallons / GPM) / 60 minutes per hour;

For electricity, HP-Hours per kWh = 1.18;

For diesel, HP-Hours per Gallon of diesel = 14.75; and,

For gasoline, HP-Hours per Gallon of gasoline = 11.50.

When calculating the energy needed to pump 1,000 gallons of water, the GPM variable cancels out so it does not affect the value.

The energy cost to pump 1,000 gallons of water is equal to the energy needed per 1,000 gallons of water pumped as described in Equation (1) above times the cost per kilowatt hour or per gallon of diesel or gasoline. This value is provided in Row 37. The total annual irrigation pumping energy cost is provided in Row 38 and is the energy cost to pump 1,000 gallons (Row 37) times the amount of water pumped in year (Row 2 times 1,000).

In the numerical example provided in Table 3.2.4, The Total Irrigation Pumping Energy Cost per year in Row 38 is $12,069 under the NAWS requiring 300 feet of TDH to pump water from a deep aquifer using electricity and $1,370 per year under the reclaimed wa-

[3] Sources: Equation derived from Boman, Brian J., "Water and Florida Citrus", University of Florida, IFAS, July 2002, pages 271 to 273. HP-Hours per Gallon and kWh from Smajstrla, A.G. and F.S. Zazueta, "Loading Effects on Irrigation Power Unit Performance", University of Florida, IFAS, AE242, June 2003.

See also: Smajstrla, A.G., D.S. Harrison, and J.C. Good, "Performance of Irrigation Pumping Systems in Florida", University of Florida, IFAS, Circular 653, 1985 and Florida Energy Extension Service and Helen H. Whiffen, "Energy Efficiency & Environmental News: Energy Use in Irrigation", University of Florida, IFAS, November 1991.

ter alternative requiring 30 feet of TDH using electricity. Column (5) reports that reclaimed water saves $10,699 per year in fuel using this example.

Rows 39 through 48 address any anticipated differences in labor and chemical costs, other than fertilizer, associated with using reclaimed water. Pretreatment of reclaimed water and/or soil management to address salinity problems were necessary for 7 of the 16 golf course survey respondents but for none of the 10 Agricultural respondents and the HOA respondent. Given this result, it appears that turf grass on golf courses is negatively impacted by the salinity of reclaimed water given the quality of turf desired by golf course operators. There is a good deal of golf course operations literature devoted to the management of salinity issues associated with reclaimed water.[4]

Problems with algae growth and clogged irrigation heads were issues for seven of the 10 Agricultural respondents and eight of the 17 Recreation / Aesthetic respondents. Chemical treatment (herbicides), filtration, and/or manual cleaning were used to address these problems. These issues should be considered by the user when completing the Annual O&M Costs associated with this evaluation model.

Rows 39 through 44 estimate the Irrigation Maintenance Labor cost associated with the NAWS and RW/Other. The user enters the Labor Cost per Hour in Row 40 and the estimated pumping system labor hours in Row 41. The estimated Irrigation System Labor Hours are entered into Row 42 and the estimated Salinity and pH Management Hours are entered into Row 43. The estimated data entered into these rows provide the user an opportunity to evaluate whether reclaimed water use will increase or reduce the labor costs.

Under the RW/Other alternative, all or a portion of the NAWS may be needed as a backup system that would be used only when reclaimed water is temporarily unavailable. In Row 41, Pumping System Labor Hours, the user should include only those labor hours associated with maintaining the backup system so that it will operate when needed in addition to any other relevant costs not associated with the backup system.

O:\44302-000\wpdocs\R3

[4] See Section 6.0 References for the following citations associated with golf course management of salinity in reclaimed water: Metcalf & Eddy | AECOM, 2007 (see also for other uses); Dixon, 2008; Grinnell, 2003; Harivandi, 2004; Huck, 2000; King, 2000; Martinez, no date; Stowell, 2008; and WateReuse Foundation, 2006.

The annual Total Maintenance Labor Cost is calculated and presented in Row 44. Column (5) of this row indicates whether RW/Other increases or reduces labor costs. In the example provided in Table 3.2.4, RW/Other increases labor costs by $580 per year.

Rows 45 through 53 allow the user to enter any additional annual O&M cost items, other than fertilizer, that would be impacted by using reclaimed water instead of the NAWS. Rows 46 through 48 allow the user to enter the costs to use certain chemicals that "pretreat" the irrigation water or manage the soil to control for pH, salinity, and algae including gypsum, calcium, and dolomite. The user may enter the names of these cost items in Column (2), Rows 46 through 48.

Row 49 allows the user to enter the estimated cost of reporting and record keeping associated with the NAWS and with reclaimed water. Other annual costs items may be entered in Rows 51 through 53. Only those cost items that would be affected by the use of RW/Other should be included in these rows. However, if a cost item is entered, then the cost must be entered for both NAWS and RW/Other, even if the cost would be $0 for one of these alternatives.

The Total Annual O&M Cost and the Annual O&M Cost per 1,000 gallons of irrigation water are calculated and provided in Rows 54 and 55. Column (5) indicates whether or not RW/Other increases or reduces annual O&M costs associated with the irrigation system and the irrigation water (not including fertilizer). In this numerical example, the Total Annual O&M cost is $16,849 for the NAWS and $15,074 for RW/Other. The cost per 1,000 gallons of water was calculated using 74.00 mg for the "NAWS" column and using 84.00 mg for both the "RW/Other" column and the column called "NAWS Minus RW/Other". This is why Column (5) is not equal to Column (3) minus Column (4) in Row 55. Column (5) for Rows 54 and 55 indicate that reclaimed water reduces these annual costs by $1,775 or $0.02 per 1,000 gallons of reclaimed water. In this example, this cost savings is due to the reduced pumping energy costs.

3.2.5 Recurring O&M Costs, Other Than Annual

In the event that switching from the NAWS to RW/Other affects recurring O&M costs that are not annual, the user should fill out Rows 56 through 69 as depicted in Table 3.2.5. The cells where the user enters data are in ***Comic Sans MS*** Font. An example of a recurring O&M cost would be filter media replacement. Such items should be entered in Rows 57 through 61 along with the cost estimates under the NAWS and the RW/Other columns (Columns (3) and (4)). As with the installation cost section, the frequency of replacement in number of years (i.e., Five years means the filter media is replaced once every five years.) should be entered in Rows 63 through 67 in the order of the cost items listed in Rows 57 through 61. In Rows 63 through 67 the model automatically enters the

O:\44302-000\wpdocs\R3

cost item name that was entered by the user in Rows 57 through 61. Row 68 then calculates the Total Annualized Recurring O&M Cost using the interest rate that was entered in Row 15. The user may only aggregate the cost of components into one item if they all have the same useful life (as measured in years).

In the case of filter media replacement, if the media is changed more frequently when reclaimed water is used relative to the NAWS, then the replacement frequency value should be lower for reclaimed water than for the NAWS. In this example, the filter media is replaced every five years when the NAWS is used and every three years when reclaimed water is used. Other costs have been entered for other unspecified items in this example to demonstrate how the replacement frequency is to be entered.

In Rows 57 through 61, the user may enter relevant item names for which costs are to be entered. In Row 57, the user may change the item name from “Filter Media Replacement” to any other relevant item name for which costs are to be entered.

Overall, in this example, the Total Annualized Recurring O&M Cost is $3,060 for the NAWS and $5,540 for RW/Other. The difference in cost is -$2,479 per year meaning that RW/Other increases the recurring O&M cost to the user. The difference in cost per 1,000 gallons of RW/Other is -$0.03 per 1,000 gallons of RW/Other.

Under the RW/Other alternative, all or a portion of the NAWS may be needed as a backup system that would be used only when reclaimed water is temporarily unavailable. In Rows 57 to 61, the user should include only those costs associated with maintaining the backup system so that it will operate when needed in addition to any other relevant costs. In addition, if some cost items need to be replaced less frequently because they will not be used as often, then include the cost of these items in Rows 57 through 61 of Columns (3) and (4) and enter the appropriate useful lives in Rows 63 through 67 of Columns (3) and (4).

O:\44302-000\wpdocs\R3

Table 3.2.5
RW Comparison Worksheet For Irrigation – Rows 56 through 69
Economic Comparison of Reclaimed Water and Next Available Water Source

Row No.	Benefit or Cost Item	Next Available Water Source (NAWS)	Reclaimed Water Used Instead & Other Sources if Applicable (RW/Other)	NAWS Minus RW/Other (Except A. which is RW/Other minus NAWS)
(1)	(2)	(3)	(4)	(5)
56	**D. Recurring O&M Costs, Other than Annual**			
57	***Filter Media Replacement***	***$11,000***	***$11,000***	
58	***Item a replaced:***	**$0**	**$0**	
59	***Item b replaced:***	***$500***	***$3,000***	
60	***Item c replaced:***	***$400***	***$2,000***	
61	***Item d replaced:***	***$300***	***$1,000***	
62	**Replacement Frequency - No. of Years**			
63	Filter Media Replacement	***5***	***3***	
64	Item a replaced:			
65	Item b replaced:	***3***	***5***	
66	Item c replaced:	***3***	***5***	
67	Item d replaced:	***3***	***5***	
68	**Total Annualized Recurring O&M Cost**	**$3,060**	**$5,540**	**-$2,479**
69	***Total Annualized Recurring O&M Cost per 1,000 Gallons of Irrigation Water***	***$0.04***	***$0.07***	***-$0.03***

3.2.6 Nitrogen Fertilizer Cost Savings

Nitrogen and phosphorus are macronutrients and boron is a trace element beneficial for plant growth. Significant quantities of these three nutrients are usually present in reclaimed water.[5] Depending on the timing and length of the irrigation cycles, the soil type, and the water drainage features, some portion of these nutrients in the reclaimed water will enter the plant through the root zone. If the uptake of these nutrients is great enough, the irrigator may be able to reduce the application of these nutrients, thus saving money. A visible negative impact to the plant may occur from excessive quantities of

[5] See Metcalf & Eddy | AECOM, 2007, page 968 for nitrogen, phosphorus and boron and the University of Florida IFAS survey response for boron.

these nutrients. Based on the literature review[6] and the survey responses, the amount of these nutrients applied to the soil should be and is reduced, respectively, based on the results of regular water and soil testing.

Of the 27 Agricultural and Recreation / Aesthetic survey respondents, eight said that they have reduced the amount of nitrogen applied to the soil as a result of using reclaimed water for irrigation. These eight respondents said they made changes based on the results of soil, leaf and water samples.

Other trace elements, such as cadmium, chromium, iron, and zinc, may also be present in reclaimed water but the impact of their concentrations on plant health have not, at this time, been identified as an issue for reclaimed water users. Quantities of potassium, the third macronutrient needed for plant growth, are not usually present in reclaimed water in concentrations considered to affect plant growth.[7] However, research by the University of Florida IFAS for Orlando's Water Conserv II found that the reclaimed water contained a considerable amount of potassium.[8] Therefore, the water quality testing results obtained from the reclaimed water supplier should be used to evaluate whether modifications to the amount of applied nutrients are warranted when considering and using reclaimed water.

Of the three nutrients, nitrogen, phosphorus, and boron, only nitrogen is considered to provide a cost savings that is large enough to consider in this model at this time. In southwest Florida, phosphorus typically is not applied at all or in quantities too small to justify more than a negligible cost savings. Some irrigators may be able to eliminate all boron applications as a result of using reclaimed water but the cost savings would be very small. However, even though boron and phosphorus cost savings may be very

---

[6] See, for example, University of Florida, Institute of Food and Agricultural Sciences, "Water and Florida Citrus: Use. Regulation, Irrigation, Systems, and Management, Edited by Brian J. Boman, Gainesville, Florida, July 2002, pages 415-416. Also, see the survey results of container grown nurseries where nitrogen applications were decreased and boron applications were eliminated in Yeager, T.H., University of Florida, IFAS, "Reclaimed Water for Irrigation of Container Grown Plants, Final Report, Deliverable 10", Prepared for the Southwest Florida Water Management District, Contract No. 38213, No date, page 5 of 29.

[7] Metcalf & Eddy | AECOM, "Water Reuse Issues, Technologies, and Applications", Written by Takashi Asano, Franklin L. Burton, Harold L. Leverenz, Ryujiro Tsuchihashi and George Tchobanoglous, McGrall Hill, 2007. (available from AWWA Bookstore), page 968.

[8] University of Florida, Institute of Food and Agricultural Sciences, "Water and Florida Citrus: Use. Regulation, Irrigation, Systems, and Management, Edited by Brian J. Boman, Gainesville, Florida, July 2002, page 72.

small, the irrigator should make adjustments to their application in response to the results of regular water and soil tests in order to prevent negative environmental impacts.

An estimate of the annual cost savings from reducing the amount of nitrogen applied to the soil when reclaimed water is used is calculated in Rows 70 through 77 of the RW Comparison Worksheet which is reproduced in black and white in Table 3.2.6. The cells where the user enters data are in **Comic Sans MS** Font.

The nitrogen fertilizer cost per ton is entered by the user in Row 71. The cost is obtained from the internet at http://www.ers.usda.gov/Data/FertilizerUse/ which will take you to the USDA Economic Research Service web page that lists data files for U.S. Fertilizer and Price. Scroll down to *Table 7-Average U.S. farm prices of selected fertilizers*, *1960-2008* and click on the link that will allow the user to download an Excel file of this data. Use the price of "Urea 45-46% Nitrogen" fertilizer for the most recent year. In 2008, the price was $552 per ton.

The nitrogen concentration of water from the NAWS and reclaimed water in parts per million (ppm) or milligrams per liter (mg/l) is entered in Row 72. The value of these concentrations would come from water test results. For reclaimed water, this information is available from the reclaimed water provider. For the NAWS, use the available information from water test results or assume that the concentration is zero.

In Row 73, the user enters the percent of nitrogen in the water that is taken up by the plant. There is no standard value for this percent because it will vary depending on the timing and length of the irrigation cycles, the water use efficiency of the irrigation system, the soil type, and the water drainage features. The value is not likely to be 100 percent due to the loss of nitrogen from the soil profile as it percolates through the ground and runs off the land.

For a partial offset, the user should multiply the proportion of Nitrogen taken up by the plant by the proportion of total water use in Row (2) that is Reclaimed Water and enter the result as a percent. For example, 50% nitrogen uptake and 10% reclaimed water use would be 0.50 x 0.10 = 0.05, so 5 would be entered in Row 73, Column (4).

Table 3.2.6
RW Comparison Worksheet For Irrigation – Rows 70 through 77
Economic Comparison of Reclaimed Water and Next Available Water Source

Row No.	Benefit or Cost Item	Next Available Water Source (NAWS)	Reclaimed Water Used Instead & Other Sources if Applicable (RW/Other)	NAWS Minus RW/Other (Except A. which is RW/Other minus NAWS)
(1)	(2)	(3)	(4)	(5)
70	**E. Nitrogen Fertilizer Cost Savings - Annual:**			
71	N Fertilizer Cost per Ton:	$552	***$552***	
72	Nitrogen concentration in ppm or mg/l of Irrigation Water (for reclaimed water, obtain from utility. For NAWS, use available info or assume 0):	***0***	***6***	
73	Percent of Nitrogen in water that is taken up by the plant:	***50%***	***50%***	
74	**Nitrogen Fertilizer Cost Savings Per 1,000 gallons of irrigation water:**	**$0.00**	**-$0.015**	**$0.015**
75	**Nitrogen Fertilizer Cost Savings due to N in applied water - Annual**	**$0**	**-$1,258**	**$1,258**
76	**Total Annualized Cost, including Cost Savings (Negative cost means cost increase associated with reclaimed water)**	**$23,559**	**$24,302**	**-$743**
77	**Total Annualized Cost, including Cost Savings Per 1,000 Gallons of Irrigation Water (Negative cost means cost increase associated with reclaimed water) (a)**	**$0.32**	**$0.29**	***-$0.01***

(a) The cost per 1,000 gallons of water was calculated using 74.00 mg for NAWS and using 84.00 mg for RW/Other and for NAWS Minus RW/Other. This is why Column (5) is not equal to Column (3) minus Column (4) in Row 77).

Some issues that may affect nitrogen uptake are as follows.

(1) Different types of plant material (*e.g.*, citrus, turf, herbaceous landscape) will have different nitrogen uptake rates.

(2) Intuitively, it would seem that the rate of nitrogen uptake by any plant material would not be likely to be a straight linear function. Plants may not be able to utilize nitrogen in

the diluted concentrations present in reclaimed water as efficiently as they can process nitrogen in the greater quantities associated with “normal recommended” applications.

(3) Climatic variables affect the rate of nitrogen uptake by plants. For example, even in central Florida, certain plant species are dormant during the winter and might not absorb any nitrogen from the root zone.

(4) One researcher[9] found that even at high irrigation application rates (100 inches per year of reclaimed water – which contained an equivalent volume of nitrogen as what would be contained in normal recommended applications) citrus trees could not take up sufficient nitrogen from reclaimed water to maintain good yields. Full applications of nitrogen were needed to maintain good fruit production.

In an IFAS presentation titled “Effect of Nitrogen Rate on Yield of Tomatoes Grown with Seepage Irrigation and Reclaimed Water”,[10] a 50 percent nitrogen uptake value was assumed. This is a reasonable assumption if one assumes that any value between 0 and 100 could be the correct number with equal probability. In this case the expected value is 50 percent.

The user and the District may be able to come up with a representative estimate given the on-site factors listed above. Otherwise, the user should enter 50 percent in Row 73 for both water sources, NAWS and reclaimed water, unless a different value can be justified with the available information.

[9] Parsons, Lawrence R. "Reclaiming a Resource", Florida Grower, May 2007.

[10] Ozores-Hampton, Monica, Eric Simonne, Phyllis Gilreath, Steven Sargent, et.al. "Effect of Nitrogen Rate on Yield of Tomato Grown With Seepage Irrigation and Reclaimed Water", Presentation, University of Florida, IFAS Extension, no date.

The annual nitrogen fertilizer cost savings per 1,000 gallons of applied water is calculated and presented in Row 74.[11] This calculation is made using the following equations.

(2) Nitrogen Cost Savings per 1,000 gallons of water = **-1** x % **N Uptake by Plant** x **Pounds of N per 1,000 gallons of water** x **Cost per Pound of N**

Where,

N stands for nitrogen;

-1 converts the number so that the difference between NAWS and Reclaimed Water has the correct sign in Column (5) of Rows (74) and (75);

% N Uptake by Plant is provided by the user as discussed above;

Pounds of N per 1,000 gallons of water = (0.226 x 1 x ppm of N) / (27,154 / 1,000); and,

Cost per Pound of N = Price of "Urea 45-46% Nitrogen" fertilizer per Ton / (2,000 x 0.46).

In the example provided in Table 3.2.6, the nitrogen fertilizer cost savings from using reclaimed water with 6 ppm of Nitrogen is $1,258 per year or 0.015 per 1,000 gallons of reclaimed water. These two values are positive because the applied nitrogen cost savings is a benefit of reclaimed water.

3.2.7 Total Annualized Cost, Including Cost Savings

The Total Annualized Cost, Including the Cost Savings, of each water source alternative is provided in Row 76. This is a calculated value and is the sum of all of the costs estimated in Items A through E as listed in Table 3.2.2. The difference in these costs between NAWS and RW/Other is provided in Row 76, Column (5). The Total Annualized Cost, Including the Cost Savings per 1,000 gallons of water, is provided in Row 77. In this example, RW/Other increases the Total Annualized Cost, including the Cost Savings, by $743 or 0.01 per 1,000 gallons of RW/Other. These two values are negative because they are the cost of RW/Other.

[11] Equation based on University of Florida, Institute of Food and Agricultural Sciences, "Water and Florida Citrus: Use. Regulation, Irrigation, Systems, and Management, Edited by Brian J. Boman, Gainesville, Florida, July 2002, page 416.

3.2.8 Change in Value of Crop Production

If the irrigator is a farmer, then the change in the value of crop production due to the use of reclaimed water should be considered. Otherwise, the user may move on to Section G of the model. The literature collected during this study that focused on the yield and plant quality effects from using reclaimed water for irrigation, focused on whether the crop is negatively affected when reclaimed water is used. The conclusion was that plants were not negatively affected as long as the nutrients and chemical constituents in the reclaimed water and soil were monitored and corrective actions taken where needed.[12] The increases in crop productivity noted, other than the beneficial effect of nutrients, were due to increased quantities of water applied to the plants relative to what would be used from traditional water sources.

In the event that the user or the District believe that the reclaimed water will increase the amount of a crop produced, then this additional value to the farm should be noted. Such increases could be due to the increased availability of reclaimed water relative to what would be available from the NAWS or for other reasons identified by the District or the user. One of the 10 Agricultural respondents to this study's survey believes that the productivity of his crop increased due to the use of reclaimed water. Rows 78 through 85 of the RW Comparison Worksheet are used to estimate this value as presented in Table 3.2.7. The cells where the user enters data are in **Comic Sans MS** Font.

In Row 79, the user enters an estimate of the average crop production in number of units per acre when irrigating with reclaimed water instead of the NAWS. In Row 80, the user enters the average crop production in number of units per acre when irrigating with the NAWS. The name of the unit is provided in Row 81. From this information, the estimated change in crop production in units per acre due to the reclaimed water is calculated in Row 82 as Row 79 minus Row 80.

---

[12] Yeager, T.H., University of Florida, IFAS, "Reclaimed Water for Irrigation of Container Grown Plants, Final Report, Deliverable 10", Prepared for the Southwest Florida Water Management District, Contract No. 38213, No date.

Morgan, Kelly T., T. Adair Wheaton, Larry R. Parsons, and William S. Castle, "Effects of Reclaimed Municipal Waste Water on Horticultural Characteristics, Fruit Quality, and Soil and Leaf Mineral Concentration of Citrus", HortScience, Volume 43(2), April 2008.

Von Merveldt, Joseph K., "Reclaimed Municipal Water for Irrigatoin of Container-Grown Nursery Crops", Masters Thesis, University of Florida, 2008.

In Row 83, the user enters the market value of the crop minus the cost of harvesting and selling the crop per unit. This is the additional income the grower would receive if reclaimed water increases yield per acre.

In Row 84, the user enters the number of acres affected by this change in crop production. From this information, the calculation of the net value of the annual change in crop production is provided in Row 85. This calculation is Row 82 times Row 83 times Row 84.

This change in the value of crop production is an estimate and can be positive or negative and could be due to increased reliability of reclaimed water, differences in water quality, increased availability of water for frost/freeze protection and/or more water available to meet crop water requirements when compared to next available water source (NAWS).

For a partial offset, the user would also consider how the reclaimed water may affect crop production. The user would focus on how many acres would be affected and by how much relative to using the NAWS. For example, if the reclaimed water will be applied to all 100 acres of a farm's crop 10% of the time, then the user should consider how the availability of reclaimed water will affect all 100 acres. For example, it may increase crop productivity from 500 boxes to 505 boxes over all 100 acres. In this case the user would enter 505 in Row 79, 500 in Row 80 and 100 in Row 84. Alternatively, if the reclaimed water will only increase crop production on 10 acres of land and if this production with reclaimed water is 525 boxes, then the user would enter 525 in Row 79, 500 in Row 80 and 10 in Row 84.

3.2.9 Change in Quality of Nursery Plants, Lawn and/or Landscape

The use of reclaimed water may increase the quality of nursery plants, the lawn and/or landscape and thereby increase nursery plant prices, the number of golfers or the golf course fee. While none of the Agricultural respondents to this study's survey said that the quality of their crops improved, one golf course and one HOA said that the quality of their turf and landscaping improved. While no definitive studies regarding this benefit were found during the literature review, this benefit is included in the model if the user or the District believes that improved plant quality would likely increase net revenue to the irrigator.

Table 3.2.7
RW Comparison Worksheet For Irrigation – Rows 78 through 93
Economic Comparison of Reclaimed Water and Next Available Water Source

Row No.	Benefit or Cost Item	Next Available Water Source (NAWS)	Reclaimed Water Used Instead & Other Sources if Applicable (RW/Other)	NAWS Minus RW/Other (Except A. which is RW/Other minus NAWS)
(1)	(2)	(3)	(4)	(5)
78	**F. Change in Value of Crop Production - Annual**			
79	Average crop production in number of units per acre when irrigating w/ reclaimed water (b):			***525.00***
80	Average crop production in number of units per acre when irrigating with the next available water source:			***500.00***
81	Name of Unit:			***Boxes of Oranges***
82	Change in Crop Production in Units per Acre Due to Reclaimed Water (b)			25.00
83	Market Value Less Harvest and Marketing Costs Per Unit			***$2.56***
84	Number of Acres of production affected			***100***
85	**Net Value of Change in Crop Production – Annual**			**$6,400**
86	(b) The average crop production is an estimate and could be due to increased reliability of reclaimed water, differences in water quality, increased availability of water for frost/freeze protection and/or more water available to meet crop water requirements **when compared to next available water source (NAWS).**			
87	**G. Change in Quality of Nursery Plant, Lawn and/or Landscape – Annual**			
88	**Change in Net Revenue (Market Value minus Variable Cost) - Annual (c)**			***$5,000***
89	(c) This change in net revenue is an estimate and can be positive or negative. This value would be positive if more water is available to meet the plant's water requirements **when compared to the next available water source (NAWS)** which results in improved plant quality and, thus, increases landscape plant prices or revenue. For golf courses, improved quality of lawn and landscape during drought could increase golf course use and, thus, sales. The net revenue during a drought year would be the change in revenue minus the change in cost due to having reclaimed water during a drought year. This net revenue during a drought year would be multiplied by the proportion of years that a drought occurs. For example, a proportion of 0.10 means that drought restrictions occur once every ten years. Variable cost includes the costs that increase with increasing production or sales, and decrease with decreasing production or sales. The change in net revenue would be negative if the use of reclaimed water reduces plant quality which reduces revenue through lower plant sales or number of golfers.			
90	**H. Value of Additional Water Available from Reclaimed Water Source**			
91	Additional Water Available from Reclaimed Water Source in million gallons per year compared to amount needed and available from NAWS- Annual:			10.00
92	Enter the cost per 1,000 gallons to obtain this fresh water, including any pumping costs. This is a lower bound estimate of the value of water to the operation. The actual value is likely much higher than this value.			***$0.30***
93	**Value of Additional Water Available from Reclaimed Water Source – Annual**			**$3,000**

This change in net revenue is an estimate provided by the user in Row 88 as presented in Table 3.2.7. It is the value of the increased sales minus all variable costs. Variable cost includes the costs that increase with increasing production or sales, and decrease with decreasing production or sales. This change in net revenue can be positive or negative. This value would be positive if more water is available to meet the plant's water requirements when compared to the NAWS which results in improved plant quality and increases landscape plant prices or plant revenue.

For golf courses, the improved quality of lawn and landscape during drought could increase golf course use and, thus, sales. The net revenue during a drought year would be the change in revenue minus the change in cost due to having reclaimed water during a drought year. This net revenue during a drought year would be multiplied by the proportion of years that a drought occurs. For example, a proportion of 0.10 means that drought restrictions occur once every ten years. The change in net revenue would be negative if the use of reclaimed water reduces plant quality which reduces revenue through lower plant nursery sales or number of golfers.

3.2.10 Value of Additional Water Available from the Reclaimed Water Source

Two of the most common benefits noted by the 27 Agricultural and Recreation / Aesthetic survey respondents were that 63 percent of these irrigators were able to irrigate more frequently and 56 percent were able to apply more water to the crop / lawn / landscape than with a traditional water source. In addition, 20 percent of the 10 agricultural respondents were better able to protect their crops from freezing because they had water available for freeze protection.

The value of this benefit is estimated using Rows 90 through 93 of the RW Comparison Worksheet as presented in Table 3.2.7. This benefit should be considered if it was not fully accounted for when estimating the benefits from increased crop production or improved plant quality as discussed in the previous two sections. The additional amount of water available from the reclaimed water provider relative to the amount needed and available from the NAWS is entered by the model into Row 91. The model inputs into Row 91 the value from Column (5) of Row (2) (See Table 3.2.3) which is the additional amount of water available from the reclaimed water provider relative to the NAWS. If no additional water is provided by the reclaimed water supplier, then this value is zero and the benefit is zero.

In the example provided in these tables, the reclaimed water supplier is expected to provide 10 million gallons annually in additional needed water to the irrigator than is available from the NAWS. This additional water has value to the irrigator. The actual value of

O:\4302-000\wpdocs\R3

this water to the irrigator for irrigating the types of plants contemplated in this economic evaluation is not known. However, the cost per 1,000 gallons that the irrigator is currently paying for water from the irrigator's existing supply, be it the NAWS or other source, would either be known or can be estimated.

If the irrigator is already using water from the NAWS or other source to irrigate the plant types or plant market values similar to those being contemplated in this economic evaluation, then the cost per 1,000 gallons from this water source is an estimate of the value of additional water to the irrigator. It is likely to be the minimum value of water to the irrigator if it will be used to add additional crop acreage or additional golf course capacity.

This water cost per 1,000 gallons is entered by the user into Row 92 as shown in Table 3.2.7. It can be estimated in a manner similar to that used in this model to estimate the total annualized cost per 1,000 gallons and using a recollection of how much the water source cost to develop, its useful life in years, the annual O&M costs, and the average annual amount of water obtained from this source. In this example, $0.30 per 1,000 gallons water is used as presented in Row 92 of Table 3.2.7.

The $0.30 per 1,000 gallons is based on the estimated costs to pump ground water from the Floridan aquifer in Manatee County and the water table, Lower Tamiami or Sandstone aquifers in Collier County as summarized and documented in a memorandum to Carl Woehlcke, Ph.D., South Florida Water Management District from Grace Johns, Ph.D., Hazen and Sawyer dated February 12, 2009. The values reflect well drilling, pumping and controls including annual O&M costs. These values were converted to 2009 dollars. These costs per 1,000 gallons in 2009 dollars range from $0.25 to $0.46 per 1,000 gallons. The $0.30 was chosen from this range and is less than the mid-point of these numbers to reflect that the water source development costs would have been made in a year prior to 2009. This value should be estimated to reflect the cost to the irrigator.

If the irrigator is not or has not been irrigating similar plants in terms of types or value, then the District could use an estimated water cost per 1,000 gallons that represents the water source of existing irrigators raising similar plants. The same cost estimation method described above would be used. Remember that the goal is to find a reasonable estimate of the value of additional water supply to the irrigator. The cost estimate described here represents either the marginal value of water or the minimum value of water depending on whether the water will be used to enhance plant growth and quality (marginal value) or to add crop acreage or golf course capacity (minimum value).

The annual value of the additional water available from the reclaimed water supplier is calculated and provided in Row 93 of Table 3.2.7 and is Row 91 times Row 92. In the example, this value is $3,000 per year. This means that reclaimed water provides an additional $3,000 per year in value to the irrigator because it allows for the production of additional crops or the irrigation of additional golf course grounds.

3.2.11 Value of Additional Water "Freed Up" by Reclaimed Water Use

The second most common benefit noted by the 27 Agricultural and Recreation / Aesthetic survey respondents was that 67 percent of the irrigators were able to conserve freshwater for their other uses. This benefit is different from the benefit described in the previous section where a value was placed on the additional amount of water available from the reclaimed water supplier relative to the NAWS.

If the irrigator is able to use all or a portion of the water from the NAWS that is "freed up" when reclaimed water is used, then this water has a benefit to the irrigator that should be considered in the economic feasibility analysis. The value of this benefit is estimated in Rows 94 through 98 of the RW Comparison Worksheet, as presented in Table 3.2.8. In Row 95, the user enters the percent of water that was entered in Row 2, Column (3) (Amount of Water Needed and Available in Million Gallons from NAWS) that will be "freed up" by the reclaimed water use. In this example, 20 percent is used. The model then calculates and presents in Row 96 the million gallons per year of additional fresh water that is now available to the irrigator which is the amount of water from the NAWS that was entered in Row 2, Column (3) times the percent freed up in Row 95, or in this example, 20 percent. If none of the "freed up" water will be available to the irrigator, then the user enters a zero in Row 95 and the value of the benefit is zero.

The model also enters the marginal or minimum value of this water using the value that the user entered in Row 92 (See Table 3.2.7). In this example, a value of $0.30 per 1,000 gallons is used as discussed above. The model then calculates and presents in Row 98 the estimated annual value of the "freed up" NAWS water. This value is Row 96 times Row 97. In this example, the annual value of water that is "freed up" due to reclaimed water use is $4,440.

3.2.12 Value of Water Available During NAWS Water Shortage Restrictions

The most common benefit noted by the 27 Agricultural and Recreation / Aesthetic survey respondents was that 74 percent of the irrigators had a guaranteed and reliable water source and 50 percent of the 10 Agricultural respondents were better able to supply water to crops during drought conditions. This benefit is not captured by the other two water supply benefits discussed in the previous two sections.

Table 3.2.8
RW Comparison Worksheet For Irrigation – Rows 94 through 105
Economic Comparison of Reclaimed Water and Next Available Water Source

Row No.	Benefit or Cost Item	Next Available Water Source (NAWS)	Reclaimed Water Used Instead & Other Sources if Applicable (RW/Other)	NAWS Minus RW/Other (Except A. which is RW/Other minus NAWS)
(1)	(2)	(3)	(4)	(5)
94	**I. Value of the Additional Water "Freed Up" by the Reclaimed Water Use**			
95	Percent of water needed and available from NAWS that will be "freed up" and used for other purposes when reclaimed water used (% of water amount entered in Row 2, Column (3)):			***20.00%***
96	Amount of fresh water that would be "freed up" due to the reclaimed water use and would be used for other reasonable / beneficial uses, including other irrigation needs, by the applicant during a year **in million gallons** (on average)?			15
97	Cost per 1,000 gallons of fresh water, including any pumping costs. This is a lower bound estimate of the value of water to the operation. The actual value is likely much higher than this value. (From H. above)			$0.30
98	**Value of "freed up" NAWS water - Annual**			**$4,440**
99	**J. Value of Water Available During NAWS Water Shortage Restrictions**			
100	Number of years every ten years when NAWS Water Shortage Restriction in Place			***1.0***
101	Percent of total annual water use that is used during the months when NAWS Water Shortage Restriction in Place			***30.00%***
102	Cutback percent or percent of NAWS water use that is cut back during water restriction period:			***20.00%***
103	Annualized amount of water available during NAWS Water Shortage Restriction Due to Reclaimed Water Use in million gallons per year			0.44
104	Cost per 1,000 gallons of fresh water, including any pumping costs. This is a lower bound estimate of the value of water to the operation. The actual value is likely much higher than this value. (From H. above)			$0.30
105	**Value of Water Available During NAWS Water Shortage Restrictions – Annual**			**$133**

O:\4302-000\wpdocs\R3

The value of this benefit is estimated in Rows 99 through 105 of the RW Comparison Worksheet as presented in Table 3.2.8. This benefit should be considered if it was not fully accounted for when estimating the benefits from increased crop production or improved plant quality as discussed in the previous sections. In Row 100, the user enters the number of years every ten years when a water shortage restriction associated with

the NAWS that would affect the irrigator is in place. It is a projected value. In the example, the value is 1 which means that a NAWS water shortage restriction that would affect the irrigator occurs once every ten years.

In Row 101, the user enters the percent of the irrigator's total annual water use that is used during the months when the NAWS water shortage restriction is in place. In the example, 30 percent is entered which means that the irrigator uses 30 percent of his annual water use during the months when the water shortage restriction is in place.

In Row 102, the user enters the percent of the cutback that would be imposed on the irrigator during the water shortage restriction. In the example, 20 percent is entered which means that during the water shortage restriction period, the irrigator must reduce his water use by 20 percent.

The model then calculates the annualized amount of water available to the irrigator during the NAWS water shortage restriction because he is using the reclaimed water which is not restricted. This value is calculated and presented in Row 103. It is equal to Row 2 which is the NAWS water quantity in million gallons times (Row 100 divided by 10 years) times Row 101 times Row 102. In the example, the result is 0.44 million gallons per year.

The model then enters the estimated value of water per 1,000 gallons that the user had entered in Row 92 as discussed in the previous sections. In this example, the value is $0.30 per 1,000 gallons. In Row 105, the model calculates the estimated value of water available during NAWS Water Shortage Restrictions as Row 103 times 1,000 gallons times Row 104. In this example, the result is $133 which means that the annualized value to the irrigator of avoiding water shortage restrictions to the NAWS is $133 per year.

3.2.13 Total Benefit Value of the Reclaimed Water

The Total Benefit Value of the RW/Other, other than the cost savings, is calculated and presented in Row 106 of the "RW Comparison Worksheet" as presented in Table 3.2.9. This is a calculated value and is the sum of all of the benefits estimated in Items F through J as listed in Table 3.2.2. The Total Benefit, other than the cost savings per 1,000 gallons of RW/Other, is provided in Row 107. In this example, the benefits, other than cost savings, provided by RW/Other increases the irrigator's net income, by $18,973 per year or $0.23 per 1,000 gallons of RW/Other. These two values are positive because they are benefits of RW/Other.

For a partial offset, if all of these benefits are attributable to reclaimed water, and not the other source, then the user could calculate the benefits per 1,000 gallons of reclaimed water offline by dividing the benefit value estimate in Row 106 by the amount of reclaimed water being considered in the RW/Other combination. If RW/Other is all reclaimed water, then the benefits and costs per 1,000 gallons calculated in Column (5) of the "RW Comparison Worksheet" are per 1,000 gallons of reclaimed water.

3.2.14 Net Benefit of Reclaimed Water Use Relative to NAWS

The Net Benefit of RW/Other relative to the NAWS is calculated and presented in Row 108 as presented in Table 3.2.9. It is equal to Row 76 (Total Annualized Cost and Cost Savings) plus the benefits estimated in Items F through J as listed in Table 3.2.2 (Row 85 plus Row 88 plus Row 93 plus Row 98 plus Row 105). The Net Benefit of RW/Other per 1,000 gallons of RW/Other is provided in Row 109. In the example, the net benefit of RW/Other is $18,230 per year or $0.22 per 1,000 gallons of RW/Other. A positive net benefit means that RW/Other is economically feasible. The RW Comparison Worksheet can be used to conduct sensitivity analysis to evaluate uncertainties in the input data.

For a partial offset, the user could calculate the net benefit per 1,000 gallons of reclaimed water offline by dividing the net benefit value estimate in Row 108 by the amount of reclaimed water being considered in the RW/Other combination. If RW/Other is all reclaimed water, then the benefits and costs per 1,000 gallons calculated in Column (5) of the "RW Comparison Worksheet" are per 1,000 gallons of reclaimed water.

O:\44302-000\wpdocs\R3

Table 3.2.9
RW Comparison Worksheet For Irrigation – Rows 106 through 110
Economic Comparison of Reclaimed Water and Next Available Water Source

Row No.	Benefit or Cost Item	Next Available Water Source (NAWS)	Reclaimed Water Used Instead & Other Sources if Applicable (RW/Other)	NAWS Minus RW/Other (Except A. which is RW/Other minus NAWS)
(1)	(2)	(3)	(4)	(5)
106	**Total Benefit Value of Reclaimed Water (Other Than Cost Savings) – Annual**			**$18,973**
107	**Total Benefit Value of Reclaimed Water per 1,000 Gallons (Other Than Cost Savings)**			**$0.23**
108	**Net Benefit of Reclaimed Water Use Relative to Next Available Water Source - Annual (d)**			**$18,230**
109	**Net Benefit of Reclaimed Water Use Relative to Next Available Water Source Per 1,000 Gallons of Irrigation Water (d)**			**$0.22**
110	(d) Net Benefit is the sum of the benefits minus the sum of the costs of RW/Other. These are benefits and costs when compared to the Next Available Water Source (NAWS). A positive number means the estimated value of the total benefit of RW/Other is greater than the estimated value of the total cost of RW/Other. A negative number means the estimated value of the total benefit of RW/Other is less than the estimated value of the total cost of RW/Other.			

3.3 Evaluation Criteria and Recommendations for Further Research

This study used survey research and the available literature to develop evaluation criteria that may be used to assess the economic feasibility of reclaimed water for irrigation of crops, turf and landscape. Farmers, golf course owners, homeowner and condominium associations, and any entity with a beneficial need for irrigation water would complete the estimation model called "RW Benefit-Cost Comparison for Irrigation" as described in this Chapter. The evaluation criteria attempt to measure and compare the benefits of reclaimed water to the costs of reclaimed water. If the value of reclaimed water to the user is greater than the costs of reclaimed water, then it is economically feasible to use.

The evaluation model compares the costs associated with accessing and using reclaimed water with the costs to access and use water from the next available water source (NAWS). The model also provides guidance in estimating the benefits of reclaimed water to the user. These benefits include:

- Change in value of crop production – annual

- Change in quality of crop, lawn and/or landscape – annual
- Value of additional water available from reclaimed water source – annual
- Value of additional water "freed up" by the reclaimed water use (that can be used by the reclaimed water user)
- Value of water available during NAWS water shortage restrictions - annual

In the course of this study several areas of further research to address information gaps were identified. These study areas are as follows.

- Develop a method to estimate the influence of reclaimed water on the amount of macro and micro nutrients taken up by plants, including citrus, tomato, turf, etc. This information would be useful to estimating the cost savings associated with reduced fertilizer requirements.
- Conduct scientific field trials to determine the impact of reclaimed water features on crop productivity per acre for crops commonly produced in Florida that would have access to reclaimed water. Reclaimed water features include differences in water quality and water availability relative to traditional water sources. This information would be useful to estimating the change in the value of crop production associated with reclaimed water use.
- Conduct scientific field trials to determine the impact of reclaimed water features on turf and landscape plant quality. Given these results, conduct research to document the impact of these quality changes on net revenue to the reclaimed water user. This research should be conducted at the nursery production and sales level and at the plant end user level such as golf course and homeowner associations. Reclaimed water features include differences in water quality and water availability relative to traditional water sources. This information would be useful to estimating the change in net revenue from changes in plant quality associated with reclaimed water use.
- Conduct research to estimate representative values of water used for irrigation by type of plant irrigated. The plant types would include those commonly produced and/ or irrigated in Florida that would have access to reclaimed water, such as citrus, tomatoes, St. Augustine grass, and Bermuda grass. These estimated values would be used in estimating the benefits of reclaimed water as well as the benefits of all other alternative water supplies.

O:\44302-000\wpdocs\R3

Chapter 4.0
Industrial / Commercial Reclaimed Water Users

4.1 Background

The focus of this Chapter is to develop evaluation criteria and identify the types of information that would assist Industrial and Commercial water use permittees and applicants in determining the economic feasibility of using reclaimed water. Relevant information was compiled through a literature review, consultation with industry experts, a formal survey, and interviews with a representative sample of existing industrial reclaimed water users. This Chapter summarizes the literature review and survey results and presents the Reclaimed Water Benefit-Cost Calculator for industrial uses to aid the District and potential reclaimed water users in evaluating the feasibility of utilizing reclaimed water for industrial operations.

4.2 Literature Review

A literature search and review was conducted to identify documents that address the benefits and costs of industrial reclaimed water usage. The use of reclaimed water for industrial processes is not prevalent in the United States and as a result, information regarding benefits and costs to industrial reclaimed water users was very limited..

A variety of general information was retrieved on water use, industrial water use, industrial processes and consumptive water use within Florida. This information was obtained from several sources including the United States Geological Survey (USGS) which compiles information on water usage in Florida for the USGS National Water-Use Information Program.[1] This program collects water-use data from each state every five years. The data were collected from the Florida Department of Environmental Protection (FDEP), Florida's water management districts, and various utilities, industries and power companies. Other organizational sources reviewed for industrial reclaimed water usage information were:

- FDEP Water Reuse Program
- Florida Institute of Phosphate Research
- Minnesota Metropolitan Council

[1] Marella, R.L. "Water Withdrawals, Use, Discharge, and Trends in Florida, 1985", Florida Department of Environmental Protection, Tallahassee, Florida, 1999.

- Metropolitan Council Environmental Services
- North Carolina Division of Water Quality
- Orange Water and Sewer Authority, North Carolina
- University of Florida Institute of Food and Agricultural Sciences

The literature review identified the types of operations likely to utilize reclaimed water in their industrial processes and two survey research efforts. The two survey instruments provided useful industrial operation criteria, survey question examples, and insight into survey structure for best respondent completion. Additionally, prior work completed for the District on reuse potential for reclaimed water in industrial uses was evaluated.

One Industrial Reclaimed Water Survey prepared by the URS Corporation for the Texas Water Development Board[2] is useful as an example survey instrument. This survey instrument helped identify the types of information that water use permittees or applicants would need to provide the District and the biases that exist among survey respondents. Survey respondents showed some lack of interest in completing the reclaimed water survey for a variety of reasons including: (1) management did not recognize the value of survey participation; (2) management did not consider reclaimed water as an alternative water supply; and (3) the survey respondent did not have sufficient choices to choose from in answering some of the questions. However, some of the survey respondents welcomed additional education focused on the needs and benefits of using reclaimed water.

The other useful survey instrument[3] focused more on industrial "reuse" of wastewater generated in production as opposed to using reclaimed water from a utility for industrial processes. However, the survey instrument provided additional useful options that assisted in developing the content and format of the survey instrument used in this study.

In Japan, more than 40 percent of reclaimed water is used by industry. In California, only 6 percent is used by industry.[4] In other U.S. states reclaimed water is used for in-

[2] URS Corporation, "Developing a Baseline GIS Database and Tools to Identify Water Reuse Potential In Texas", Prepared for the Texas Water Development Board, Austin, Texas, 2008.

[3] Bryck, Jack, Rajesh Prasad, Trevor Lindley, Steve Davis and Guy Carpenter , "National Database of Water Reuse Facilities Summary Report", WateReuse Foundation, Alexandria, Virginia, 2008.

[4] Water Encyclopedia Website (WEW), "Science and Issues, Reclamation and Reuse" accessed on January 6, 2010 on website: http://www.waterencyclopedia.com/Po-Re/Reclamation-and-Reuse.html.

dustrial irrigation, irrigation of golf courses, parks, schools and right-of-ways, fire protection, dust suppression, impoundment maintenance, and irrigation of non-food and some food crops.[5] Under North Carolina rules, reclaimed water can be used for a variety of activities such as concrete cutting; fire fighting; industrial and commercial cooling water; make-up water for road brine slurry and chemical solutions preparation (pesticides); street sweeping; soil compaction; subsurface directional boring; and vehicle washing.[6]

Industries within the District that are associated with high total and consumptive water use and potential for using reclaimed water are power plants, phosphate and mining plants, chemical manufacturing, and metal plating[7]. The estimated distribution of water use by Industrial/Commercial water use permittees in the District (which excludes the Mining/Dewatering category) from 83 reporting permits is provided in Table 4.2.1.

Table 4.2.1
Distribution of Industrial / Commercial Water Use
In the Southwest Florida Water Management District, 2008 (a)

Type of Industry	Percent of 68 MGD
Power generation	48%
Product manufacturing including chemicals, cement, asphalt	36%
Other self-supplied water use permittees including equipment cleaning, retail, car washes, laundries, schools, etc.	9%
Food processing	5%
General commercial	2%
Total	100%

(a) Southwest Florida Water Management District, "2008 Estimated Water Use In the Southwest Florida Water Management District", Brooksville, Florida, 2009.

[5] See for example, Texas Natural Resource Conservation Commission (TNRCC), "Chapter 210 – Use of Reclaimed Water", Rule Log No. 96156-210-WT, Texas Office of Policy and Regulatory Development, Austin, Texas, 2009.

[6] North Carolina Division of Water Quality (NCDWQ), "Land Application Unit: Reclaimed Utilization Systems", 2009, accessed on August 20, 2009 on website: http://h2o.enr.state.nc.us/lau/reclaimed.html, and Orange Water and Sewer Authority (OWASA - North Carolina), Draft Long-Range Water Supply Plan", 2009, Update accessed on August 20, 2009 on website: http://www.owasa.org/home/index.aspx.

[7] Stone, Dennis, Teleconferences, emails and documentation on 8/24/09, 8/26/09, 12/11/09, 12/14/09, and 1/4/10.

The mining industry primarily uses water for dewatering of the mine sites, material washing and material conveyance.[8] Some of the highest freshwater withdrawals were in Polk County for a variety of mining operations.[9] In 2005, the USGS reported that mining accounted for 40 percent of commercial, industrial, and mining water use in Florida and was the largest water use in this category[10]

Power generation plants use water for boiler make-up water; non-contact cooling water such as once-through cooling and cooling tower blow-down; and air conditioning and scrubber make-up water. Manufacturing typically uses water for boiler make-up and vehicle wash downs.[11]

In phosphate mining, beneficiation and the chemical processing require significant quantities of water, some of which could be provided by reclaimed water. Potential improvements, innovations, or revised procedures may exist that could increase water reuse, utilize reclaimed water, and / or reduce overall water requirements in this complex integrated process. An evaluation of source water activities that could use reclaimed water is provided in Table 4.2.2. This matrix illustrates the complexity of the industrial process for this individual facility and the depth of analysis performed to determine reclaimed water use potential.

[8] Marella, R.L. "Water Withdrawals, Use, Discharge, and Trends in Florida, 1985", Florida Department of Environmental Protection, Tallahassee, Florida, 1999.

[9] Borisova, Tatiana and Roy R. Carriker, "Water Use in Florida", University of Florida, IFAS Extension, Document FE797, 2009.

[10] United States Geological Survey, FDEP, and the Florida Water Management Districts, "Water Use in Florida, 2005 and Trends 1950-2005", 2008, http://pubs.usgs.gov/fs/2008/3080/.

[11] Ibid and Dennis Stone telephone conversations.

Table 4.2.2

Phosphate Mining, Beneficiation, and Chemical Processing Water Use – Source Matrix (a)

Uses: E=existing use P=potential use	**Deep Potable Ground-water**	**Shallow Ground-water**	**Direct Rainfall**	**Deep Brackish Ground-Water[1]**	**Storm Water Runoff[1]**	**Clay Settling Area Decant Water**	**Non-Contact Process Water**	**Treated Municipal Effluent (b)**	**Treated Process Water (b)**	**Process (Gypsum Stack/ Pond) Water**
Mining:										
Matrix Slurry/ Trans-port	E	E	E	P	E	E		P		
Slurry Pump Seal Water	E	P	P	P	P	P		P		
Recirculation Sys-tem Makeup	E	P	P	P	P	P		P		
Other (c)										
Beneficiation:										
Trommel Wash and Flotation Process Water Makeup	E	P	E	P	E	E		P		
Flotation Process Reagent Production	E	P	P	P	P	P		P		
Slurry Pump Seal Water	E	P	P	P	P	P		P		
Other (c)										
Chemical Processing:										
Ball Mill Slurry	E	P	E (d)	P	P		P			E
Phosphoric Acid Vacuum Pump Seal Water	E	P	P	P	P		P	P (f)	P	P (e)
Heated Non-Contact Water Cooling	E	P	P	P (f)	P		P (f)	P	P (f)	
Cooling Tower Ma-keup	E	P	P	P	P		P	P	P (g)	
Boiler Feed Water Treatment Makeup	E	P	P		P		P (h)			
Granular Plant Scrubber	E							P		E
Contact Waste Wa-ter Dilution	E	P	P							
Sulfuric Acid Pro-duction Makeup	E	P	P		P		P (h)	P		
Gypsum Transport										E
Other (c)										
Potable Supply	E	P	P							

Table 4.2.2
Phosphate Mining, Beneficiation, and Chemical Processing Water Use – Source Matrix (a)

NOTES:

(a) From HSW Engineering, Inc., "Reuse and Alternative Best Management Practices For Ensuring Lowest Water Quality Is Used During Mining, Beneficiation, and Chemical Processing of Phosphate", Prepared for Southwest Florida Water Management District, Brooksville, Florida, 2008.

(b) Pre-treatment may be required and resulting waste stream managed and disposed of accordingly.

(c) Other uses as determined by the Permittee.

(d) Direct rainfall that falls onto cooling water ponds.

(e) May need to upgrade to alloy phosphoric acid vacuum pump materials

(f) May require additional treatment due to corrosion & scaling buildup

(g) May require treatment due to high dissolved solids content

(h) May require treatment to de-mineralize water

The industrial process for power generation is just as complex as for mining operations and also requires in-depth analysis to determine reclaimed water use potential. Most of the water used for thermoelectric power generation is for cooling purposes.[12] The circulation water can be once-through non-contact water, recirculating non-contact water or direct contact water. Important considerations for cooling tower systems are the number of cycles of concentration in the recirculated water before disposal and replacement with makeup water. The cycles of concentration in recirculated water are determined based on the makeup water quality to the cooling system (reclaimed water) and the allowable dissolved solids concentrations.[13] Reclaimed water quality issues present in cooling systems consist of corrosion, scaling and biofouling. These were some of the problems highlighted by survey respondents.

A study by the Minnesota Metropolitan Council evaluated the economic feasibility of reclaimed water for industrial use in Minnesota and identified implementation issues associated with reclaimed water use. One typical application is the use of reclaimed water in cooling towers by the energy industry, which, in Minnesota, accounts for 63 percent of

[12] Borisova, Tatiana and Roy R. Carriker, "Water Use in Florida", University of Florida, IFAS Extension, Document FE797, 2009.

[13] Cheremisinoff, N.P. and P.N. Cheremisinoff, "Cooling Towers: Selection, Design and Practice", Ann Arbor Science Publishers, Ann Arbor, MI, 1981.

daily water use or 2.4 billion gallons per day.[14] Implementation issues identified by the study were:

1. Upholding a positive image by touting reclaimed water as the "right thing to do",
2. Unknown regulations,
3. Financial incentives to compete with traditional low cost source water, and
4. Need for further studies to gather technical information.

Costs issues identified in this study for reclaimed water use were:

1. Reclaimed water can be competitive with traditional water sources,
2. Hardness removal and high salt levels significantly add to the cost, and
3. Cost efficiency improves as usage volume increases which favors systems delivering more than 1 mgd.[15]

Some of these same costs and benefits were given by our survey respondents.

4.3 Industrial Reclaimed Water Survey

Potential survey respondents were identified through a search of the District's e-permitting website and a list of utilities that provide reclaimed water for cooling towers in Florida provided by District staff.[16] In 2007, there were 23 water reclamation facilities providing reclaimed water to 52 cooling towers in Florida. From that list, reclaimed water suppliers were contacted to identify industrial reclaimed water customers.

Power companies were contacted to participate in the survey using a list of power companies participating in the Florida Department of Environmental Protection's (FDEP) Water Reuse Program.[17] The FDEP 2007 Reuse Inventory was also used to identify addi-

[14] Minnesota Metropolitan Council (MMC), "Recycled Wastewater Could Provide Water for Industry", 2010, http://www.metrocouncil.org/directions/water/water2007/wastewaterRptAug07.htm.

[15] Metropolitan Council Environmental Services, "Recycling Treated Municipal Wastewater for Industrial Water Use", 2007, Publication No. LCMR 05-07d, MCES, Project Number 070186: http://www.metrocouncil.org/directions/ water/water2007/wastewaterRptAug07.htm.

[16] Rome, Don. Forwarded email from Gregory Brown with Information on Reclaimed Water For Cooling Processes in Florida. SWFWMD email correspondence dated July 3, 2009.

[17] Florida Department of Environmental Protection ,Water Reuse Program, Industrial Uses of Reclaimed Water, accessed on October 7, 2009 through website: http://www.dep.state.fl.us/water/reuse/industry.htm.

tional contacts. The City of St. Petersburg distributed a list of cooling towers they supply with reclaimed water, including contact information. In addition, the cities of Clearwater, Dunedin, Cocoa, and Plant City were very helpful in supplying reclaimed water user contacts. Lee, Orange, Pinellas and Hillsborough Counties produced additional contacts to survey.

A variety of industries in the District use reclaimed water in their operations, primarily for cooling towers. Over 70 of these facilities were contacted requesting survey participation. The types of facilities contacted included hospitals, colleges, industrial parks, sports complexes, landfills, manufacturing plants, mining and fertilizer operations, and power plants. Survey participation was also requested from similar industries outside of the District.

Industrial Reclaimed Water Use Surveys were emailed, mailed or fax'd to 25 industrial reclaimed water users. Completed surveys were returned by respondents representing the following 10 facilities.

Electric Power Plant

- Lakeland Electric, C.D. McIntosh Power Plant
- Curtis Stanton Energy Center
- Vero Beach Municipal Power Plant
- Osprey Energy Center
- Hines Energy Complex
- Covanta Energy-Pinellas County Resource Recovery
- City of Tampa, McKay Bay Refuse to Energy Facility

Landfill Irrigation

- Waste Management, Inc.

Phosphate Mining

- CF Industries Plant City Phosphate Complex

Fertilizer Production

- Mosaic Fertilizer Riverview Plant

Of these ten plants, nine use most of the reclaimed water for industrial cooling. The tenth uses reclaimed water for on-site irrigation. Other uses include process water, boi-

ler make-up water, and scrubber & evaporator seal water. The Industrial Reclaimed Water Survey instrument is provided in Appendix A.

Industrial Facility Location

The locations of these 10 facilities are provided in Table 4.3.1. These facilities are located in four District counties and two outside the District. Annual reclaimed water use at these facilities ranges from 6,000 gallons to 3 billion gallons.

Table 4.3.1
Location of Industrial Reclaimed Water User Respondents

County	No. of Respondents	% of 10 Respondents
Charlotte	1	10%
Hillsborough	3	30%
Orange (a)	1	10%
Pinellas	1	10%
Polk	3	30%
Indian River (a)	1	10%
Total	10	100%

(a) This county is not in the Southwest Florida Water Management District.

Of these 10 survey respondents, 7 are power plant facilities. Of these 10, four facilities were interviewed via telephone following receipt of their survey responses. Two of these interviews were with the two power plants in Polk County, one was with a power plant in Orange County, and one was with a City of Tampa solid waste refuse-to-energy facility.

Utility Providers of Reclaimed Water

The distribution of utilities that provides reclaimed water to the surveyed industries is provided in Table 4.3.2. Each respondent receives reclaimed water from a different supplier for a total of 10 reclaimed water suppliers providing reclaimed water to 10 facilities.

O:\4302-000\wpdocs\R3

Table 4.3.2
Utility Providing Reclaimed Water To Industrial Respondents

Name of Utility	No. of Respondents	% of 10 Respondents
City of Auburndale	1	10%
City of Bartow	1	10%
Charlotte County Utilities	1	10%
Hillsborough County	1	10%
Lakeland Water Utilities	1	10%
City of Largo/City of St. Petersburg	1	10%
Orange County-East	1	10%
City of Plant City	1	10%
City of Tampa	1	10%
City of Vero Beach	1	10%
Total	10	100%

Reasons for Connecting to Reclaimed Water System

The industrial respondents had a variety of reasons for connecting to reclaimed water. These reasons are summarized in Table 4.3.3. Three of the facilities have an education program that highlights the benefits of using reclaimed water to their operations.

Table 4.3.3
Primary Reasons the Industrial Respondents Connected to the Reclaimed Water System

Primary Reasons	No. of Respondents	% of 10 Respondents
To conserve groundwater or reduce water well usage	3	30%
To utilize tertiary treated (reclaimed) water	1	10%
To conserve potable water &/or save money	2	20%
To have consistent water quality & no limits on use	1	10%
To be part of the water supply solution for the Central Florida Region	1	10%
Construction plans/design called for using reclaimed water	1	10%
To have a reliable source of water for boiler/cooling tower	1	10%
Total	10	100%

O:\44302-000\wpdocs\R3

Next Available Water Source

If the survey respondents had not connected to the reclaimed water system, other sources would have been used. These sources included Floridan or surficial aquifer wells, surface waters or other alternatives. Alternatives included using the Indian River Lagoon, Lithia and Buckhorn Springs, onsite storage ponds, or potable water. A summary of this information is presented in Table 4.3.4.

Table 4.3.4
Source Water Used if Industrial Respondents Did Not Connect to the Reclaimed Water System

Source Water	No. of Respondents	% of 10 Respondents
Floridan Aquifer Well	4	40%
Other Groundwater Source (i.e. shallow irrigation well)	1	10%
Surface Water Source (i.e. Indian River Lagoon, onsite storage pond)	2	20%
Other Water Source (i.e. potable water, spring water)	2	20%
No Other Water Source Available	1	10%
Total	10	100%

Percent of Total Water Use that is Reclaimed Water

The 10 industrial respondents use reclaimed water for one percent to 90 percent of their total water use. The distribution of respondents in terms of the percent of their total water use that is reclaimed water is provided in Table 4.3.5. One-half of the 10 respondents use reclaimed water for more than 75 percent of their total water usage.

Table 4.3.5
Percent of Total Water Use that is Reclaimed Water Industrial Respondents

Percent of Reclaimed Water Use	No. of Respondents	% of 10 Respondents
75% - 90%	5	50%
50% - 74%	1	10%
25% - 49%	1	10%
1% - 24%	2	20%
Did not answer	1	10%
Total	10	100%

O:\44302-000\wpdocs\R3

The major costs for reclaimed water systems serving industrial operations include: (1) payments to reclaimed water provider, (2) capital cost for facility construction and installation, (3) operation and maintenance (O & M) costs, and (4) financing and administration costs.[18]

Cost of On-Site Improvements

The majority of reclaimed water user costs identified by the survey respondents are the reclaimed water distribution piping and pumping installation and chemical treatment or pre-treatment equipment as summarized in Table 4.3.6. Two respondents incurred reclaimed water connection costs of approximately $900,000 each for piping and valve installation. In one case, the costs included over one mile of pipeline to connect to the reclaimed system. Of the three respondents who installed water treatment equipment, one power plant paid for upgrades to the city-owned water treatment facility to improve the quality of the reclaimed water. Two respondents incurred additional permitting costs where one power plant facility reported a one-time cost of $20,000 for modifying the Site Certification Permit.

Table 4.3.6
Summary of On-Site Improvements Made By Industrial Respondents To Connect To and Use Reclaimed Water

Improvements	Number of Respondents	Associated Costs	Percent of 10 Respondents
Changes to Pipeline/Connection Equipment	2	~$900,000 each respondent	20%
Additional Water Pre-treatment Equipment	3	NS (a)	30%
Additional permitting costs (i.e. MSSW, Site Certification)	2	$20,000 Site Certification	20%

(a) NS means "not specified".

Cost of Water Treatment Chemicals

Five of the respondents cited water treatment chemicals as a cost item associated with reclaimed water use as summarized in Table 4.3.7. The treatment chemical costs for

[18] Treweek, G.P., "Industrial Reuse of Wastewater: Quantity, Quality and Cost", Ch. 23, 521-548 in E.J. Middlebrooks (ed.). Water Reuse. Ann Arbor Science Publishers, Ann Arbor, MI, 1982.

the respondents ranged from $1,000 to $300,000 per year depending on usage volume and water quality, with two spending in the range of $30,000 per year.

Table 4.3.7
Summary of Reclaimed Water Treatment Chemicals and Costs
Reported by Industrial Respondents

Treatment Chemicals	Number of Respondents	Associated Annual Costs	Percent of 10 Respondents
pH control, chlorine addition, & scale inhibitor	1	$300,000	10%
pH control with H2SO4 for hard-ness	2	$30,000 & $1,000	20%
Biocide to prevent biofouling	1	NS (a)	10%
Other chemicals (not specified)	1	$38,000	10%

(a) NS means "not specified".

None of the survey respondents were required to add specialized personnel when they connected to the reclaimed water system.

Reclaimed Water Use Challenges

Nine out of 10 survey respondents cited at least one challenge in using reclaimed water. These challenges are summarized in Table 4.3.8. Three respondents noted lower water quality, pipe scaling, pressure fluctuation, and operational issues associated with using reclaimed water. Two respondents noted concerns about reliability, necessity to segregate reclaimed water in their production process, and increased permit reporting requirements as a result of using reclaimed water. One had minimal restrictions, rationing, or availability issues annually lasting for less than 8 hours. Reliability of reclaimed water was noted by another respondent as possibly affecting power generation output at their power plant facility.

Follow-up telephone interviews with four survey respondents were conducted. For the City of Tampa, pipe scaling is a problem in the dry season due to increased levels of calcium in the reclaimed water supply. They are able to accommodate this change in water quality by blending with potable water and increasing chemical treatment to lower the pH. The City's supply of reclaimed water is interrupted on occasion due to pumps taken offline for servicing or chlorine levels in the water being too high.

The McIntosh Power Plant in Lakeland detailed some of their costs of using reclaimed water. At the start of using reclaimed water, employees complained of a bad smell. When reclaimed service started, the facility used an evaporator along with biocide to re-

O:\44302-000\wpdocs\R3

duce biofouling. The smell resulted from the overfeeding of the biocide. The process has now been modified to use bleach and less biocide, thereby eliminating the smell.

Table 4.3.8
Reclaimed Water Use Challenges for
Industrial Reclaimed Water Users

Challenges	No. of Respondents	% of 10 Respondents
Lower water quality than traditional water source	3	30%
Smell/color complaints of reclaimed water	1	10%
The amount of reclaimed water available is less than traditional source water	1	10%
Reclaimed water costs are higher than traditional source water	1	10%
Permit recording/reporting requirements increased	2	20%
Operation & Maintenance costs increased	1	10%
Increased pipe scaling issues	3	30%
Needed to segregate potable & food processing water from reclaimed water	2	20%
Reclaimed water pressure fluctuates	3	30%
Reclaimed water pressure is lower than traditional source water	1	10%
Reclaimed water supply is unreliable	2	20%
The challenges above cause production/operational problems	3	30%

Another problem at the McIntosh Power Plant is the requirement for additional permit reporting. Since reclaimed water use began, additional power units have converted to using sewage effluent water or reclaimed water which requires additional reporting to the regulatory agencies. Pipe scaling due to increased calcium was also a problem for them. This has been addressed by using a crystalline modifier to soften the scale allowing it to be blasted away for cleaning. The McIntosh Power Plant was the only survey respondent that reported an annual interruption in reclaimed water service during wastewater treatment plant maintenance. They deal with this by using two storage tanks and well water as back up supplies.

Calpine Construction Finance Company paid to upgrade the City-owned (Auburndale) reclaimed water treatment facility and distribution piping system for delivery to the Osprey Energy Center. One of the issues for this facility is that the permitted well water usage limit decreases over time based on the assumption that increased reclaimed wa-

O:\44302-000\wpdocs\R3

ter would be provided over time. However, their utility reclaimed supplier is unable to provide this increased amount of reclaimed water to the Energy Center.

The Curtis Stanton Energy Center near Orlando has had problems with microbiological corrosion within its extensive lengths of carbon steel pipeline ranging in diameter from 0.25-inch to 12-inches, particularly the lateral piping that has limited circulation. This microbiological corrosion took approximately 2.5 years to become evident and its location is unpredictable. Biocide is now added to eliminate additional corrosion issues. If this microbiological corrosion was recognized or identified as a potential issue from the beginning of reclaimed water use, preventative measures could have mitigated the increased maintenance costs.

Benefits of Reclaimed Water

A summary of reclaimed water benefits to the respondents is presented in Table 4.3.9 and the annual costs savings as reported by three respondents is provided in Table 4.3.10. The most common benefits of using reclaimed water for industrial use are:

1. To conserve fresh water and potable water for other uses (70 percent of respondents);
2. To have a guaranteed and reliable water source (50 percent of respondents);
3. To have more water available for beneficial use (40 percent of respondents); and,
4. To lower water costs (40 percent of respondents).

Reclaimed water used for industrial operations is not typically seasonal in demand as are other uses such as agricultural irrigation. As a result, industrial operations yield a consistent demand for reclaimed water quantities irrespective of the fact that reclaimed water supply can be seasonal.[19]

The majority of reclaimed water is used by the respondents for cooling water, process water and onsite irrigation. The majority of respondents felt a benefit of using reclaimed water was to conserve fresh and potable water supplies. If the respondents had not connected to reclaimed water, they would have used other source water alternatives such as potable water, onsite ponds, shallow wells, the Indian River Lagoon and Lithia/Buckhorn Springs.

[19] Metcalf & Eddy| AECOM, "Water Reuse: Issues, Technologies and Applications", Chapter 19, Published by McGraw Hill, 2007.

The respondent for the Vero Beach Municipal Power Plant cited that surface water withdrawals and associated permitting requirements were diminished considerably by connecting to a reclaimed water supply. This was extremely important in this case because additional surface water withdrawals would have been made from the Indian River Lagoon, a protected national estuary, which is the most biologically diverse in North America.[20] If they had not used reclaimed water to supply a cooling tower, the water would have been withdrawn and re-circulated back into surface waters of the Lagoon, causing both thermal and flow volume impacts. By using reclaimed water, this power facility's National Pollutant Discharge Elimination System (NPDES) effluent reporting/recording requirements were considerably less, saving the facility more than $60,000 annually.

The City of Tampa was able to install reclaimed water infrastructure at half the cost of potable infrastructure. In addition, the City saves approximately $200,000 in potable water costs annually while conserving potable water.

Five of the respondents stated that connecting to reclaimed water allowed for a guaranteed and reliable water source for their operations. One respondent is supplied by two different reclaimed water suppliers which helps to eliminate reclaimed water availability restrictions and pressure fluctuations during the dry season.

For example, the benefits of using reclaimed water highlighted by Osprey Energy Center include having additional water available for beneficial use, conserving fresh water by decreasing well-water usage, having a guaranteed and reliable water source, and creating positive relations with the City of Auburndale, which supplies their reclaimed water. This power facility would increase its use of reclaimed water if more was available from the supplier.

Other benefits cited by the respondents were reduced permitting requirements which translated into annual savings of more than $60,000 and reduced equipment corrosion with an annual savings of $5,000 at one power plant, product quality improvement, and production cost savings. Production cost savings were a result of less chemical treatment costs and fewer permitting requirements.

[20] St. Johns River Water Management District, "The Indian River Lagoon National Estuary Program" accessed on January 27, 2010 on website: http://sjr.state.fl.us/itsyourlagoon/index.html.

Table 4.3.9
Reclaimed Water Use Benefits To Industrial Survey Respondents

Benefits	No. of Respondents	% of 10 Respondents
Can conserve fresh/potable water supplies for other uses	7	70%
Have a guaranteed/reliable water source	5	50%
More water available for beneficial use	4	40%
Our water costs are lower	4	40%
Permitting requirements have been reduced	3	30%
No longer need to pre-treat our water	1	10%
Our product quality has improved	1	10%
Our product quantity has improved	1	10%
Have experienced production cost savings	1	10%

Table 4.3.10
Summary of Benefits and Associated Savings by Respondents Which Connected to Reclaimed Water

Benefits	Number of Respondents	Associated Annual Savings	Percent of 10 Respondents
Annual Water Costs	1	$200,000	10%
Reduced permitting requirements	1	> $60,000	10%
Reduced corrosion maintenance	1	$5,000	10%

Reclaimed Water Quality Benefits

Water quality characteristics of reclaimed water add value to the industrial operations of the survey respondents for a variety of reasons. Some of the reasons cited by respondents include: reduction of algae growth, less chemical usage in the cooling tower and for corrosion control, improved specific conductivity levels which increases the number of cycles for the cooling tower[21], providing a water supply with low total dissolved solids (TDS) for makeup water, and providing an available supply of water.

[21] Specific conductivity is a surrogate measure for the concentration of total dissolved solids (TDS) in water used in boilers and cooling towers. As steam is generated from a boiler or water evaporating from a cooling tower, the dissolved minerals are left behind. After a number of circulation cycles, the minerals in the original water and any makeup water eventually reach a concentration that will either cause a loss in efficiency due to

The McIntosh Power Plant originally used reclaimed source water high in phosphates for cooling which required chemical removal. This high level of phosphate in their source water allowed bacteria and algae to grow in the cooling tower. The wastewater treatment plant upgraded and the reclaimed water no longer requires pre-treatment which currently presents a cost savings.

One respondent pointed out (which others noted as a benefit) that the reclaimed pH level allows for easier water chemistry control of their cooling tower and that the trace of chlorine in the reclaimed water controls algae growth. Another benefit highlighted by two respondents is that the reclaimed water quality is consistent. A summary of those reclaimed water quality characteristics seen as valuable and contributing to the above benefits are presented in Table 4.3.11.

Table 4.3.11
Reclaimed Water Characteristics That Add Value
To the Operations of Industrial Respondents

Reclaimed Water Characteristic	No. of Respondents	% of 10 Respondents
Chlorine	4	40%
pH	4	40%
Water supply availability	3	30%
Alkalinity	1	10%
Hardness	1	10%
Nitrogen	1	10%
Phosphorus	1	10%
Specific conductivity	1	10%

Primary Purpose of Reclaimed Water

Respondents use reclaimed water at their facilities primarily for cooling water systems. Other uses include onsite irrigation and process water. A few operations use reclaimed water for boiler make-up water, air conditioning, and scrubber and evaporator seal water A summary of these uses is provided in Table 4.3.12. None of the respondents received funding to connect to their utility's reclaimed water supply.

scale or damage from corrosion. The circulation water must then either be treated to reduce concentrations, or removed (as bleedoff or blowdown) and replaced with water with lower mineral content.

The Curtis Stanton Energy Center has four generating units which utilize reclaimed water not only for the tower cooling water, but also as process water. The process water consists of the pump seal water for scrubbers and evaporators, along with the fire systems. Using reclaimed water for process water is an additional benefit that some of the other power plants did not include. This facility uses the highest volume of reclaimed water out of all of the survey respondents at approximately 3 billion gallons annually.

Table 4.3.12
Primary Purpose of Reclaimed Water Used by Industrial Respondents

Purpose	No. of Respondents	% of 10 Respondents
Cooling Water	9	90%
Onsite Irrigation	4	40%
Process Water	2	20%
Boiler Make-up Water	1	10%
Air Conditioning	1	10%
Other: Scrubber & Evaporator Seal Water	1	10%

Reclaimed Water Ratings

All of the respondents were very satisfied or satisfied with their reclaimed water reliability, quality and supply. All of the survey respondents would use reclaimed water as a supply source for their industrial operations if they had to make the decision again. Three of the 10 survey respondents are interested in increasing their reclaimed water quantities. In other areas of Florida, excess reclaimed water is deep well injected for disposal, while Vero Beach would like to receive more reclaimed water but does not have access to more supply.

4.4 Costs of Using Reclaimed Water for Industrial Applications

The evaluation criteria used for the Reclaimed Water Benefit-Cost Calculator for Industrial Applications were identified through an analysis of the reclaimed water use survey responses, a literature review, research into industrial processes, and industry expert input. The calculator contains some of the evaluation criteria applicants may utilize to determine the economic feasibility of using reclaimed water for their industrial processes. Because each facility is unique and presents a complex set of equipment configurations, a simple spreadsheet may not be an appropriate format for that determination, but is presented as a starting point.

Cost determinations for these unique systems are not linearly proportional to the magnitude of water use due to the permutations available with respect to system configurations at the facilities. Some options for components of broad industrial processes known

O:\44302-000\wpdocs\R3

to exist that could be generally quantified are condensed into drop-down menus in the calculator. Costs in this calculator are entered for fresh water usage and reclaimed water usage, to give a comparison of using one over the other. The costs provided are rule-of-thumb or industry guideline standards. The actual costs will be entered by the applicant.

The quantifiable financial items are the reclaimed water storage options, water treatment system type, and pre-treatment system type and associated general costs. No predetermined cost can be assumed for pipes, pumps, other infrastructure necessary, land, operations and maintenance, chemical costs, residual disposal, and any cost offsets or grants. The applicant will need to enter their individual costs into the calculator for that determination.

Typical unit costs are provided for the storage and water treatment cost items. These unit costs were drawn from in-house sources. Typical costs used in the spreadsheet calculator are described below.

Pipe and pump costs are not provided in the calculator because options exist which are too numerous to list. Examples of typical pipe sizes and associated costs that could be represented in the calculator spreadsheet include PVC or HDPE piping for 2-, 4-, 6-, and 8-inch diameter with associated costs of $30, $50, $100, and $200/foot, respectively, in 2009 dollars. These pipe costs include the cost of design, materials, site preparation, installation, and final grade.

Typical storage costs that are included in the calculator can be assumed to be $1.50 per gallon of capacity for a storage tank and $0.40 per gallon for a lined pond. There should be 5 days worth of storage capacity for the facility. The typical cost for a multimedia gravity filter is $400 per square foot, with a flow rate limited to 0.5 GPM/square foot. The typical cost for a multimedia pressure filter is $1000 per square foot, with a flowrate limited to 3 GPM per square foot. Other pre-treatment systems such as reverse osmosis or chemical treatments would be entered by the applicant.

Annual costs that the applicant would need to enter manually, for both fresh water and reclaimed water usage, include items such as additional water treatment or pre-treatment systems, land acquisition costs, chemical costs, residual/waste disposal, additional personnel hired to operate any pre-treatment systems, and the amount of reclaimed water the applicant desires to use. The applicant will enter the cost and use a drop-down menu for the energy source containing electricity, diesel or gasoline as energy fuel source choices for the facility.

A more in-depth set of options for piping and pump sizing along with pre-treatment/filtration, chemical treatment, and waste disposal could be incorporated into

O:\44302-000\wpdocs\R3

the Worksheet with further analysis. The costs for these items are not necessarily linearly related to system flow rates and will depend on other aspects of design specifications. The choices could contain multiple possibilities including pump curves to determine needed flow and power configurations along with associated pipe materials, pipe characteristics (surface roughness), length, diameter, and elevation or head required for their design specifications. The same would be necessary applicant input for all other variables associated with connecting to reclaimed water.

In general, some important considerations in determining the economic feasibility of using reclaimed water for industrial applications are identified as follows.

1. Additional cost for additional onsite treatment of reclaimed water,

2. Distribution system cost for pipeline construction for conveyance from treatment facility to industrial operation,

3. Onsite re-piping or retrofitting the existing system to accommodate the reclaimed water,

4. Engineering analysis of water quality issues or additional treatment alternatives,

5. Pretreatment capital and operating and maintenance (O&M) costs,

6. Internal treatment needs for the industrial operations,

7. Management of industrial processes residuals such as sludges or brines generated by the additional pre- or post-treatment,

8. Institutional, legal, and administrative activities such as regulatory agency coordination, meeting regulatory requirements, contract negotiations with water suppliers, permit acquisition, participation with any regional projects.

The goal of water reuse and/or reclaimed water use is to reduce the overall consumption of ground or surface water and the overall reduction of waste water. Information that the applicant would need to consider and potentially provide to the District when evaluating the worthiness of reclaimed water projects are as follows.

- The complete "life cycle" of costs and benefits from initial planning through operation and disposal of a facility relevant to decision making. These costs include design, engineering, permitting, procurement, construction, and operation & maintenance.

O:\4302-000\wpdocs\R3

- Specifically define the scope of the project. Based on this scope and objectives, conduct detailed design of the project. Careful planning and coordination must be performed during all phases of the project. Ensure all materials are available when needed especially if plant outages or special operations are required during the project. After the construction is completed, there is usually a brief period of start-up and checkout of the process.

- Don't over design. Stick with what is actually beneficial and required.

- Quality of work and performance are critically important to the success of a project.

The applicant and permit application reviewer would need to evaluate a variety of information to determine the costs associated with utilizing reclaimed water. Items to consider in this analysis are as follows.

- End use activity (cooling tower, boiler, process, etc.)

- Quantity of reclaimed water desired, gallons per day (GPD)

- Pressure required at the end use

- Period of time per day when utilizing reclaimed water, hours

- Limiting quality of water for feasible end use

- Reclaimed water quantity consumed in the end use, GPD

- Residual waste water materials produced in the end use

- Determine if quality of the reclaimed water affects the quality of the residual waste water materials

- Determine if the quality of the reclaimed water affects the quality of the site products

- Determine if an existing water pretreatment process is available for treating the reclaimed water

- Identify the components of the existing water pretreatment process

- Determine how are the residual waste water materials are disposed

- Identify the residual waste water disposals that have discharge limits for quantity and quality and/or percent solids
- Determine the distance and change in elevation from the reclaimed water source to the site
- Determine the distance from the reclaimed water entrance to the site to the end use and what is the change in elevation
- Determine the amount of bulk storage available for reclaimed water
- Determine the distance from the bulk storage to the end use
- Identify the type of electrical power source that is available (120,240,480 volt)
- Determine if existing pipe systems and pumping systems are available within the site to deliver the reclaimed water to the end use
- Determine if existing pipe systems and pumping systems are available from the source to deliver to the end use site
- Determine the existing on-site pump system specifications
- Determine the length of each pipe by size and material in the existing on-site pipe system
- Identify the existing source pump system specifications
- Determine the length of each pipe by size and material in the existing source pipe system to the end use site
- Determine if the site is a permitted Industrial Wastewater site
- Identify railroad tracks or canals, or other impediments, on site, that will interfere with transporting the water to the end use

A complete understanding of the facility and the answers to the above questions will aid the District in determining whether or not an applicant can economically justify connecting to reclaimed water.

The consideration of a reclaimed water project is usually a result of addressing insufficient water supply or in some cases an excess of wastewater. In most industrial

processes insufficient water and excess wastewater are significant challenges. The need for sufficient influent water is obvious. The incorporation of reclaimed water offers a solution for this need. However, wastewater produced has to be disposed of in accordance with environmental regulations. Sometimes, this may not be advantageous due to the availability of additional disposal areas or limitations of disposal methods. Disposal area availability can be limited by geographical constraints and/or environmental regulations. This is usually where there is an advantage to using reclaimed water.

Various reclaimed water alternatives may be considered in the conceptual planning stage. The technological and economic feasibility of each alternative will be assessed and compared in order to select the best possible solution. Life cycle costs of a proposed facility are necessary to estimate the operation and maintenance costs over time after the start up of the facility. And, if the project is economically driven; determine if the best possible solution is financially acceptable.

In addition to the Reclaimed Water Benefit-Cost Calculator, the Water Reuse Logic and Planning Chart presented as Figure 4-1 can be utilized. This is a tool for determining potential places within the industrial process in which reclaimed water can be substituted for higher quality water sources.

The following general suggestions and Water Reuse and Planning Chart are provided to facilitate the conceptualization of reclaimed water processes.

- Examine the processes in the facility and determine which are water consumers and/or water dischargers.
- Determine the desired quantity and water quality of each influent stream.
- Determine the quantity and water quality of each effluent stream.
- Identify quantity and water quality of potential sources of reclaimed water.
- Organize each stream data in adjacent column format.
- Identify any potential candidates for reclaimed water as influent to any process.
- Identify any potential candidates for reclaimed water with treatment and/or blending for influent to any process.

The upper portion of the Water Reuse Logic and Planning Chart illustrates how to identify water quality requirements for influent water of each process. Identifying whether the process requires low water quality versus higher quality water gives a guideline as to

O:\44302-000\wpdocs\R3

Water Reuse Logic and Planning Chart

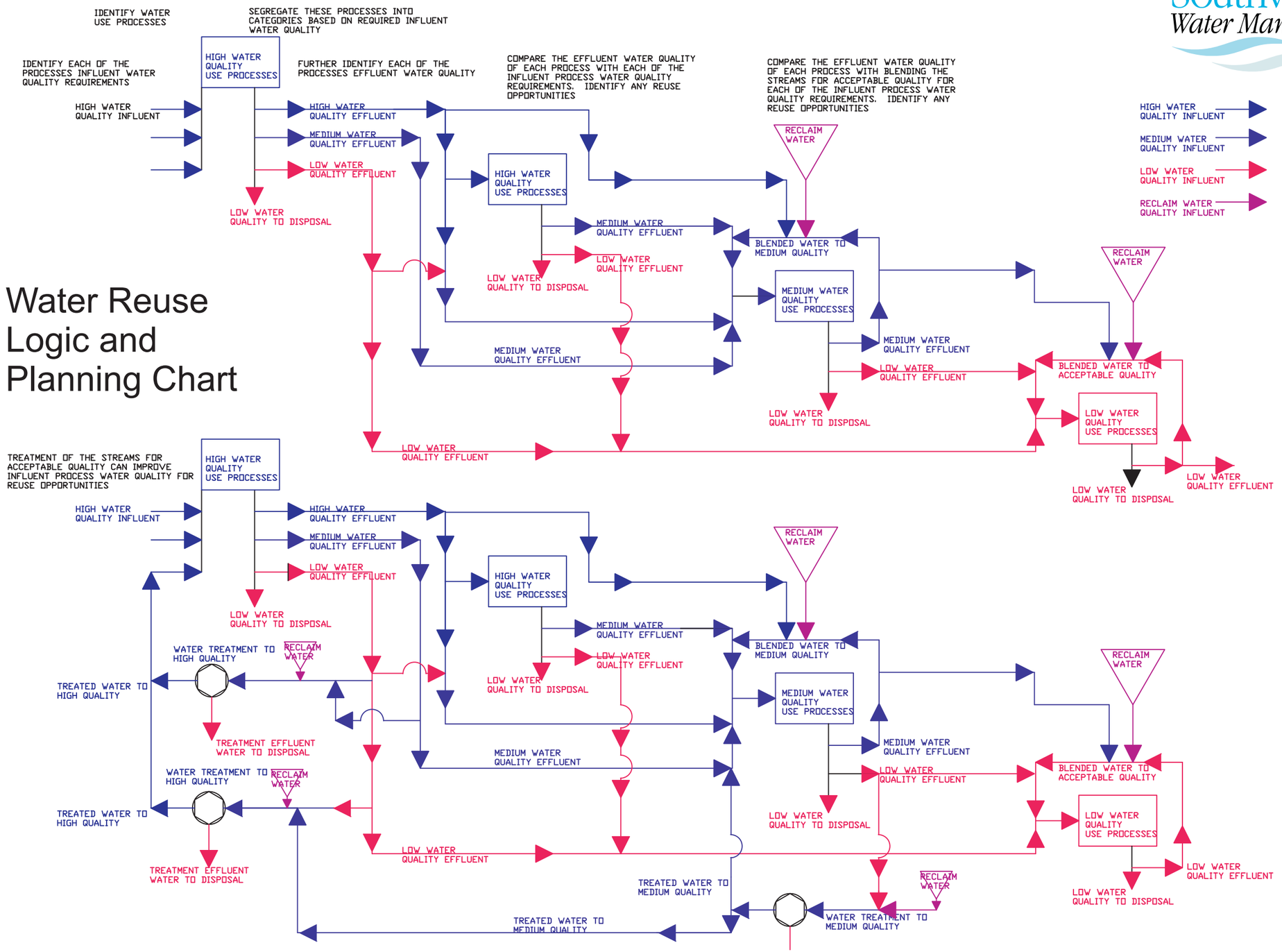

Figure 4-1
Generalized Flow Chart that Incorporates Reclaimed Water into the Industrial Process

44302-000R1

where pre-treatment may be necessary if reclaimed water is added to the process. Pre-treatment allows for a greater volume of reclaimed water to be used. The lower portion of the chart illustrates potential water treatment/pre-treatment system placement if reclaimed water is added to the process. The use of reclaimed water with pre-treatment can serve to offset other higher quality sources.

4.5 Reclaimed Water Benefit-Cost Calculator for Industrial Applications

The Reclaimed Water Benefit-Cost Calculator for Industrial Applications is very similar to the calculator for irrigation uses. Some of the same concepts described in Chapter 3.0 are also included in this section. In addition, the calculator specific to industrial applications is described.

The evaluation criteria attempt to measure and compare the benefits of reclaimed water to the costs of reclaimed water. In an ideal world, the total and marginal value[22] of reclaimed water to each water user would be known and would simply be compared, respectively, to the total and marginal costs of using reclaimed water. If the value of reclaimed water to the user is greater than the costs of reclaimed water, then it is economically feasible to use.

Unfortunately, the total and marginal values of fresh water and reclaimed water are not known for even groups of water users, particularly in Florida. This is primarily because water values will vary depending on the value of the product produced with the water and the dependence of the product on water. For example, the value of water used in phosphate mining will be different from the value of water used in power generation. The water users themselves may not even know the value of water to their operations

An Awwa Research Foundation report[23] titled, “The Value of Water: Concepts, Estimates and Applications for Water Managers” provides a literature review of water values that have been estimated as of around 2003. None of these values can be used directly by Florida water users. However, the estimated values might be used as a range of possible values. The marginal water values documented in The Value of Water report range from $0.09 to $2.47 per 1,000 gallons for commercial, institutional and industrial customers and from $0.08 to $2.59 per 1,000 gallons for agricultural water users. A use-

[22] Marginal water value is the additional value of water received from an additional unit of water.

[23] For a good summary of estimated values for water by agricultural, residential and industrial water uses, see Raucher, Robert S., David Chapman, James Henderson, Marca L. Hagenstad and John Rice, "The Value of Water: Concepts, Estimates and Applications for Water Managers, Prepared by Stratus Consulting and associated firms for the Awwa Research Foundation, #2855, 2005.

ful research project would be to estimate these values for the types of industrial, recreational, and agricultural water users in Florida. This information could be used to help water users and the District assess the economic value of reclaimed water to their operations.

Because water values in particular uses are not known, the value of reclaimed water needs to be inferred from the available information. Economists know that the value of the last unit of water used, also called marginal water value, is the price or cost paid for that last unit of water. The marginal water values of all water used up to that last unit are higher than the price or cost paid for the last unit due to diminishing returns as more water is used. The average cost or payment for the water used is the minimum value of that amount of water in that particular use. So, for example, if a phosphate mine owner spends $2,000 annually to pump 13.3 million gallons per year from the ground for irrigation, we know that the average value of the water to that mine owner is at least $0.15 per 1,000 gallons ($0.15 = ($2,000/13,333,333)X1,000). Otherwise, the mine owner would not have spent that much money to obtain the water.

Ground water and surface water are the primary water sources in Florida, including for industrial operations. Florida water users, particularly in the southwest and the south, experience water restrictions on a regular basis. If the cost of reclaimed water can be offset by the avoided cost of the water user's next best water source plus provide other benefits including a reliable water supply and reduced chemical costs, then reclaimed water is economically feasible to the water user. This presumes that the quality of the reclaimed water is suitable for use. If the reclaimed water must be further treated by the firm, then those costs would be added to the cost of reclaimed water. This is the approach that is used to develop reclaimed water economic evaluation criteria for industrial uses.

The evaluation criteria are comprised of the information required of the District and the reclaimed water user in order to estimate the values of the benefits and costs associated with the use of reclaimed water use for industrial processes. The spreadsheet model called "RW Benefit-Cost Comparison for Industrial Applications" was developed during this study. It incorporates the evaluation criteria into an estimate of the net benefits (benefits minus costs) of reclaimed water use as compared to using water from the next best available water source. The model allows the user to enter all available information regarding factors that determine benefits and costs in order to obtain an estimate of the economic feasibility of reclaimed water to the user. Because the data entered into the model is likely to be estimates, the model allows the user to easily conduct sensitivity analyses to see how the economic feasibility changes as the input data is changed.

4.5.1 Worksheet Instructions

The Reclaimed Water Benefit-Cost Calculator for Industrial is to be used to provide guidance as to the economic feasibility of using reclaimed water for a specific purpose. The values that the user will input into the model are estimates and the model results should not be the only factor in determining economic feasibility. Instead, the model results should be viewed in the proper context of all other information submitted and relevant to the water use permit application or renewal.

The example values used in the models and referenced in this report are purely illustrative for purposes of this study presentation only. Readers are advised to develop proper estimates of costs and benefits that would be appropriate for their individual site(s). Except where explicitly directed (*e.g.*, to obtain the proper values of nitrogen fertilizer and fuel costs from specific websites), the example values provided in the model and in this report are NOT "default" values.

The first spreadsheet in the Excel file is called "RW Comparison Worksheet Instruc". It contains initial questions and worksheet instructions. This spreadsheet is reproduced as Table 4.5.1. This is where the District and the water user begin the economic evaluation. The "RW Benefit-Cost Comparison for Industrial Applications" model is used if the answer is YES to Question 1, "Is reclaimed water service available to your operation?" and NO to Question 2, "Is reclaimed water the only water source available to your operation?" The answer to Question 2 would be YES only if the water user cannot access any other water source. It is up to the District and the water user to decide if reclaimed water is the only viable water source. In this case, it would be up to the water user to decide if reclaimed water is economically feasible by making an assessment of the value of water to the particular operation. It is expected that, in most cases, the answer to Question 2 will be NO.

The third and fourth questions ask the District and the user to identify the water source they will compare to reclaimed water. The third question asks the user to identify one or more available water sources and the fourth question asks: "which is the water source that would be replaced, in whole or in part, by reclaimed water?" This water source is then called the "Next Available Water Source" or NAWS for short.

The next part of the Spreadsheet instructs the user to enter the data in the Spreadsheet titled "RW Comparison Worksheet". The other spreadsheets in this file calculate values referred to by the "RW Comparison Worksheet" spreadsheet.

Then there is a color code that identifies spreadsheet cells that are calculated numbers; entered by the user; drop down menus; parameters of equations (assumed values); or blank cells. For the convenience of the reader, all tables in this Chapter are in black and

white and are not color-coded and the table cells that are entered by the user are in **Comic Sans MS** Font.

The remainder of this spreadsheet provides instructions regarding where on the Internet to find current electricity, diesel, gasoline and, if necessary, nitrogen fertilizer prices that will be used in the model.

Table 4.5.1
Reclaimed Water Benefit-Cost Calculator for Industrial Applications
Worksheet Instructions

1. Is reclaimed water service available to your operation? If Yes, continue to Question 2. If No, Stop Here.	*YES, continue to Question 2.*		*NO, Stop Here*
2. Is reclaimed water the only water source available to your operation? If Yes, Stop Here. If No, continue to Question 3 and complete the RW Comparison Worksheet.	*YES, Stop Here*		*NO, continue to Question 3 and complete the RW Comparison Worksheet.*
3. What other water source(s) are available to your operation for irrigation?	*Floridan aquifer*		
	Intermediate aquifer		
	Surface water source		
	Other, please specify:		
4. Of these water sources, which is the water source that would be replaced, in whole or in part, by reclaimed water? For the purposes of the RW Comparison Worksheet, this water source will be called the "Next Available Water Source" or NAWS.			
5. Has the applicant obtained, from the reclaimed water provider, the nutrient contents and chemical constituents in the reclaimed water, including nitrogen, phosphorus, potassium, trace elements including boron, and the electrical conductivity and sodium absorption ratio (sodium, chloride and magnesium) of the water? This information should be used to assist in estimating the benefits and costs of using reclaimed water.			*YES*
			NO

Enter the information in the Spreadsheet titled "RW Comparison Worksheet".
The other spreadsheets calculate values referred to by the "RW Comparison Worksheet" spreadsheet.

Color Code of RW Comparison Worksheet	
	means calculated numbers
	means entered by user
	means this is a drop down menu
	means parameters of equations (assumed values)
	means keep as blank cell

Use the following sources to determine prevailing energy costs:

Gasoline and Diesel Fuel: U.S. Government: **http://tonto.eia.doe.gov/oog/info/gdu/gasdiesel.asp**

AAA: **http://www.fuelgaugereport.com/FLmetro.asp**

Electricity: U.S. Government: http://www.neo.ne.gov/statshtml/115.htm

http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_a.html

If necessary, for fertilizer prices go to:
http://www.ers.usda.gov/Data/FertilizerUse/ Use Table 7 (Excel Spreadsheet) to determine the current price of fertilizer. Scroll down to the most recent year and use the cost of "Urea 45-46% Nitrogen.

4.5.2 RW Comparison Worksheet

The user enters all of the required information into the spreadsheet called "RW Comparison Worksheet". This worksheet has five columns that comprise the benefit-cost table. The first column identifies the Row number of the worksheet. The second column identifies the benefit or cost item or the information needed to estimate benefits or costs. The third column is the data and calculations that correspond to the "Next Available Water Source" or "NAWS". The fourth column is the data and calculations that correspond to reclaimed water, or, in the case of a partial offset, to be described below, the term "RW/Other" is used to characterize the combination of reclaimed water / other water source scenario. The model uses the term "RW/Other" in the heading of Column (4) to represent either an evaluation of reclaimed water only or an evaluation of a combination of reclaimed water and another water source.

The fifth column calculates the difference between "NAWS" and "RW/Other". If the value in this fifth column is positive, then it means that the value for "NAWS" is greater than the value for "RW/Other". If it is negative, then the value for "NAWS" is less than the value for "RW/Other". The model is designed so that if the value is positive, then it is a benefit of "RW/Other" and if it is negative, then it is a cost of "RW/Other".

All data and resulting calculations are displayed in these five columns. The order of benefits and costs as one moves down this table and the evaluation criteria are provided in Table 4.5.2. Each row of this table is described in turn as follows.

4.5.3 Installation Costs and Water Available

The first 26 rows of the "RW Comparison Worksheet" identify the water sources, address the amount of water needed and available from both sources (NAWS and RW/Other), and itemize the estimated installation costs associated with these two water sources. These 26 Rows are depicted in Table 4.5.3. These rows estimate the potential reclaimed water cost savings associated with installing water storage and pumping, and the potential reclaimed water cost increase from installing additional water treatment capacity, among other installation cost differences.

The user enters the data and information into the green cells. In this Chapter these cells are in black and white and are not color-coded. Instead, in this Chapter's tables that reproduce the spreadsheet, all green cells are in **Comic Sans MS** Font so that the reader may identify them easily.

The calculated numbers and repeated information are in the blue cells. In this table and in the tables of the spreadsheet that follow, hypothetical numbers and data are entered in order to assist the reader in understanding how the model works. They are not meant to represent any particular water user and are not to be used as "default" values.

Table 4.5.2
Order of Benefits and Costs Presented in the Reclaimed Water Benefit-Cost Calculator
For Industrial Applications And Evaluation Criteria

Benefit or Cost Item	Measure of Benefit Or Cost Item	Evaluation Criterion (a)
A. Amount of water needed and available in million gallons – annual	Amount of water needed and available in million gallons – annual	Negative of Difference in amount of water needed and available (RW/Other minus NAWS)
B. Installation costs	Total annualized installation cost and Per 1,000 gallons	Difference in annualized installation cost (NAWS minus RW/Other)
C. Annual O&M costs	Total annual O&M cost and Per 1,000 gallons of water	Difference in annual O&M cost (NAWS minus RW/Other)
D. Recurring O&M costs	Total annualized recurring O&M cost and Per 1,000 gallons of water	Difference in annualized recurring cost (NAWS minus RW/Other)
A. through D.	Total annualized cost and cost savings and Per 1,000 gallons of reclaimed water	
E. Value of additional water available from reclaimed water source – annual	Value of additional water – annual	
F. Value of additional water "freed up" by the reclaimed water use (that can be used by the reclaimed water user)	Value of "freed up" NAWS water – annual	
G. Value of water available during NAWS water shortage restrictions - annual	Value of water available during NAWS water shortage restrictions – annual	
E. through G.	Total benefit value of reclaimed water (other than cost savings) and Per 1,000 gallons	
A. through G.	Net benefit of reclaimed water use relative to next available water source and Per 1,000 gallons	

(a) Positive values are benefits of reclaimed water and negative values are costs of reclaimed water.

O:\44302-000\wpdocs\R3

Table 4.5.3
RW Comparison Worksheet For Industrial – Rows 1 through 26
Economic Comparison of Reclaimed Water and Next Available Water Source

Row No.	Benefit or Cost Item	Next Available Water Source (NAWS)	Reclaimed Water Used Instead & Other Sources if Applicable (RW/Other)	NAWS Minus RW/Other (Except A. which is RW/Other minus NAWS)
(1)	(2)	(3)	(4)	(5)
1	**Name of NAWS / Name of RW Provider**	***Floridan***	***Utility***	
2	**A. Amount of Water Needed & Available in MG, Annual**	***74.00***	***84.00***	10.00
3	***B. Installation Costs (if not already installed or replaced) (a)***			
4	(a) The replacement cost of existing items within five years of the end of their useful lives should be included in this list as if purchased new. The remaining or "salvage" value of these existing items should be entered as indicated below. Do not forget to consider the cost of the backup water supply in Column (4) should reclaimed water be temporarily unavailable. The user enters all appropriate cost item names in Column (2), Rows 5 to 12.			
5	**Pipes and Pumps**	***$150,000***	***$200,000***	
6	**Storage (minimum 5 days of capacity) Example cost for Tank is $1.50/gal & for Lined Pond $0.40/gal of storage.**	***$405,479***	***$460,274***	
7	**Treatment system - Example cost for Gravity filters is $400/square foot & pressure filters is $1000/square foot.**	***$8,000***	***$16,000***	
8	**Land Development not included in items above**	***$4,000***	***$5,000***	
9	**Item 1:**	***$0***	***$0***	
10	**Item 2:**	***$6,000***	***$4,000***	
11	**Item 3:**	***$7,000***	***$8,000***	
12	**Item 4:**	***$8,000***	***$9,000***	
13	**Current Salvage Value of Items that are replaced and included above (enter value as a negative number). It is included as 1/5th of this value in Total Annualized Installation Cost below.**	***-$20,000***	***$0***	
14	**Total Installation Cost**	$568,479	$702,274	
15	**Annual Interest Rate (i.e. 6%)**	6.00%	***6.00%***	
16	**Useful Life of Items in Years**			
17	Pipes and Pumps:	***10***	***10***	
18	Water Storage:	***20***	***20***	
19	Treatment System:	***7***	***7***	
20	Land Development not included in items above:	***20***	***20***	
21	**Item 1:**	***10***	***10***	
22	**Item 2:**	***10***	***10***	
23	**Item 3:**	***10***	***10***	
24	**Item 4:**	***10***	***10***	
25	**Total Annualized Installation Cost**	**$56,367**	**$73,458**	**-$17,091**
26	***Total Annualized Installation Cost per 1,000 Gallons of Water (a)***	***$0.76***	***$0.87***	***-$0.20***

(a) The cost per 1,000 gallons of water was calculated using 74.00 mg for NAWS and using 84.00 mg for reclaimed water and for NAWS Minus RW. This is why Column (5) is not equal to Column (3) minus Column (4) in Row 26).

In Row 1, the user enters the name of the "Next Available Water Source" (NAWS) in Column (3) and the name of the utility that will supply the reclaimed water (RW) in Column (4). In Row 2, Column (3), the user enters the annual amount of water available from the NAWS in million gallons (mg) that will be needed. In Row 2, Column (4), the user enters the amount of water available from the reclaimed water source that will be used for the same purpose. In Column (5), the difference between the amount of reclaimed water and the amount of water from the NAWS is calculated. If more water is available for needed use from the reclaimed water supplier than from the NAWS, then this additional water has value to the water user which will be discussed later in this Chapter. In the example, 74 mg per year is available from the NAWS and 84 mg per year is available from the reclaimed water supplier. Row 2, Column (5) calculates that 10 mg per year is the additional amount of reclaimed water needed and available relative to the NAWS.

Partial Offset. In this document and model, a partial offset means that the reclaimed water is replacing only a portion of the NAWS water supply. When this is the case, in Row 1, Column (4), the user should enter the name of the reclaimed water provider, the percent of water from this source, the name of the water source that will provide the remainder of the water needed for reasonable/beneficial use (NAWS or other source), and the percent of water from this source. For example, Manatee County (10%) and Floridan Aquifer (90%) would be entered if 10 percent of the water supply would be reclaimed water provided by Manatee County and 90 percent of the water supply would be from the Floridan Aquifer.

The total amount of water available from the NAWS source if reclaimed water is not used is entered in Row 2, Column (3). The sum of the amount of water available from the reclaimed water source and the amount of additional water that would be provided from the other water source (which could be NAWS or a different source) should be provided in Row 2, Column (4). In most cases it is expected that the amount provided in Row 2, Column (3) should be equal to the amount provided in Row 2, Column (4).

From this point on, the user will be comparing the costs and benefits of NAWS only to the costs and benefits of the combination of reclaimed water and the other water source. This other water source will typically be the NAWS that was selected by the user and entered into Column (3) but it does not need to be the NAWS. The RW/Other Water Source combination represented in Column (4) of this model is the water source package needed to obtain the water supply necessary to continue operations that would take place if all of the water was supplied by the NAWS as indicated in Rows 1 and 2, Column (3).

Instructions regarding how to enter information into the model when a partial offset is being considered will be provided as this discussion flows from row to row of this model's spreadsheet.

The 3rd Row in Table 4.5.3 begins the estimation of installation costs. Each item that needs to be installed is included in Rows 5 through 12 for both water source alternatives. In Column (3), all items needed to deliver water from the NAWS to the user's industrial process should be included in these rows and their costs estimated. Likewise, in Column (4), all items needed to deliver water from the utility's reclaimed water system to the user's industrial process are included in these rows and their costs estimated. If a partial offset is being considered, all items needed to obtain the additional water from the other water source are also included in Column (4) and their costs estimated. The cost items for each water source do not need to be the same. For example, if using the NAWS only (Column (3)) requires the installation of water storage and using reclaimed water does not require storage, then in the row for storage (Row 6 in this example), the value would be greater than zero for NAWS (Column (3)) and equal to zero for reclaimed water (Column (4)).

The user may change the names of the items listed in Column (2), Rows 5 through 12 as needed. The model will repeat the names of the items entered in Rows (17) through (24). The user may only aggregate the cost of components into one item if they all have the same useful life (as measured in years).

If the NAWS will be a backup or standby water supply in the event that the reclaimed water is temporarily unavailable, then the installation costs associated with this backup supply source should also be included in Column (4). These costs may be different from those entered in Column (3) (NAWS only alternative). For example, the original backup water supply used when NAWS only is the alternative might not be needed if reclaimed water is used and so the costs associated with this infrastructure (pumps, pipes, etc.) would be zero.

If the components of any of these water sources have already been installed, then, under B. Installation Costs, include the replacement cost of those components that will be at the end of their useful lives within the next five years. In Row 13, the current Salvage Value of these existing components would be entered. This value represents the value of the existing items to the operation because they will be used until they are replaced at the end of their useful lives. The model subtracts one-fifth of the Salvage Value from the Total Installation Costs. If the entire NAWS system has already been installed and does not need to be replaced within the next five years, then the costs associated with all installation items and the Salvage Value under the NAWS column (Column (3)) are zero.

The total installation cost is summed in Row 14. In Row 15, the user enters the annual interest rate that will be used to amortize or annualize the installation costs. This value will typically represent either the user's interest paid on loans or the interest earned on savings. In this example, the interest rate is 6 percent per year.

In Rows 17 to 24, the useful life in years of each component listed in Rows 5 through 12 is entered. The useful lives of the components must be entered in the order that the components are listed in Rows 5 through 12. In Rows 17 to 24 the model automatically enters the cost item name that was entered by the user in Rows 5 through 12.

If under the RW/Other alternative, all or a portion of the NAWS is needed as a backup system, then its components, such as the pumps, storage and/or pipes, will not be used as often and may have a longer useful life. To account for this, the user should enter the relevant NAWS installation costs and the longer useful lives in the RW/Other column (Column (4)). However, the cost of each component should only be included if it will need to be replaced sometime during the next five years and the current salvage value of the existing component should be included in Row 13, Column (4).

Row 25 presents the calculated Total Annualized Installation Cost and Row 26 presents the calculated Total Annualized Installation Cost per 1,000 gallons of water using the costs, interest rate and years of useful life reported in the previous rows. Column (3) of Row 26 uses the million gallons of NAWS provided by the user in Column (3), Row 2 of the model. Column (4) of Row 26 uses the million gallons of RW/Other Source provided by the user in Column (4), Row 2 of the model.

Column (5), Row 25 is the difference in the Total Annualized Installation Cost between the NAWS and the RW/Other and is calculated as the Total Annualized Installation Cost of the NAWS minus the Total Annualized Installation Cost of RW/Other. Column (5), Row 26 is the difference in the Total Annualized Installation Cost per 1,000 gallons, as defined in the previous sentence, divided by the quantity of RW/Other that was entered in Row (2), Column (4). The cost per 1,000 gallons of water was calculated using 74.00 million gallons (mg) for NAWS and using 84.00 mg for both RW/Other and for NAWS Minus RW. This is why Column (5) is not equal to Column (3) minus Column (4) in Row 26). In this example, the difference is -$17,091 or -$0.20 per 1,000 gallons. A negative value means that the installation cost of RW/Other is higher than the installation cost of the NAWS. This is just one component of estimating the net benefits of reclaimed water to the user.

4.5.4 Annual O&M Costs

Rows 27 through 55 of the RW Comparison Worksheet estimate the annual O&M costs associated with the NAWS and RW/Other. These rows are depicted in Table 4.5.4. The information provided by the user in these rows are used to estimate the potential annual O&M cost savings and cost increases associated with reclaimed water. The cells where the user enters data are in **Comic Sans MS** Font.

Table 4.5.4
RW Comparison Worksheet For Industrial – Rows 27 through 55
Economic Comparison of Reclaimed Water and Next Available Water Source

Row No.	Benefit or Cost Item	Next Available Water Source (NAWS)	Reclaimed Water Used Instead & Other Sources if Applicable (RW/Other)	NAWS Minus RW/Other (Except A. which is RW/Other minus NAWS)
(1)	(2)	(3)	(4)	(5)
27	***C. Annual O&M Costs***			
28	**1.0 Payments to Utility Company and, if applicable, to NAWS Water Utility**			
29	Annual Fixed Payment	***$5,000.00***	***$3,000.00***	
30	Price per 1,000 gallons	***$0.45***	***$0.15***	
31	***Total Utility Payment – Annual***	$38,300	$15,600	**$22,700.00**
32	**2.0 Pumping Energy Cost – Annual**			
33	Energy Source:	***Electricity***	***Electricity***	
34	Total Dynamic Head in Feet:	***30***	***30***	
35				
36	Cost of energy source, Dollars per KWH or gallon (obtain from appropriate web site):	***$0.11***	***$0.11***	
37	Energy cost to pump 1 Kgal:	$0.02	$0.02	**$0.00**
38	**Total pumping energy cost – Annual**	**$1,207**	**$1,370**	**-$163**
39	**3.0 Water System Maintenance Labor Cost – Annual**			
40	Labor Cost per Hour:	***$10.00***	***$10.00***	
41	Pumping System Labor Hours:	***52***	***26***	
42	Water System Labor Hours:	***156***	***208***	
43	Water Treatment Labor Hours:	***0***	***52***	
44	**Total Maintenance Labor Cost – Annual**	**$2,080**	**$2,860**	**-$780**
45	**4.0 Annual Cost of Treatment Chemicals, specify chemical**			
46	***Chemical Name: Biocide***	***$0***	***$5,000***	**-$5,000**
47	***Chemical Name:***	***$0***	***$0***	**$0**
48	***Chemical Name:***	***$0***	***$0***	**$0**
49	**5.0 Reporting or Record Keeping Costs – Annual**	***$500***	***$1,500***	**-$1,000**
50	**6.0 Other Annual Costs, specify below**			
51	***Item A: Residual waste disposal***	***$5,000***	***$10,000***	**-$5,000**
52	***Item B:***	***$0***	***$0***	**$0**
53	***Item C***	***$0***	***$0***	**$0**
54	**Total Annual O&M Cost**	**$47,087**	**$36,330**	**$10,757**
55	***Total Annual O&M Cost per 1,000 Gallons of Water (a)***	***$0.64***	***$0.43***	***$0.13***

(a) The cost per 1,000 gallons of water was calculated using 74.00 mg for NAWS and using 84.00 mg for reclaimed water and for NAWS Minus RW. This is why Column (5) is not equal to Column (3) minus Column (4) in Row 55).

O:\4

In Rows 29 and 30, the user enters the annual fixed payment and the price per 1,000 gallons charged in the NAWS column and in the RW/Other Column. If the NAWS is purchased from a water provider, then the fixed and variable charges should be entered in Column (3). The reclaimed water rates charged by the reclaimed water provider are entered in Column (4). If the rate structure has more than one variable rate because it is a declining or inclining block rate structure or if a partial offset is being considered in Column (4), then the user may just calculate the annual water bill offline and enter it in Row 29 under Annual Fixed Payment and entering a zero ($0) in Row 30 for the price per 1,000 gallons. Row 31 calculates the annual water bill using the values in Rows 29 and 30 and the water quantities provided in Row 2 (See Table 4.5.3). The utility water payment under the NAWS minus the utility water payment under RW/Other is provided in Column (5) of Row 31. In this example, the water payment is $38,300 per year for the NAWS and $15,600 per year for RW/Other. Thus, the difference in Column (5) is $22,700 per year which is a cost reduction associated with RW/Other.

The annual pumping energy cost associated with the water supply using the NAWS and RW/Other is estimated in Rows 32 to 38. In Row 33, the user is asked to choose the energy source used for water pumping. The cells in Columns (3) and (4) of Row 33 are drop down menus where the user chooses Electricity, Diesel or Gasoline. The Total Dynamic Head (TDH) is entered in Row 34. A discussion of TDH is provided in Appendix B of this report. The current cost of the energy source in dollars per KWH or dollars per gallon of diesel or gasoline is entered in Row 36.

If a partial offset is being considered under RW/Other (Column (4)) and the energy source is the same for reclaimed water and for the other source, then enter the weighted average TDH based on the proportion of the water supply that is reclaimed water and the proportion that is from the other source. So using the 10% reclaimed water / 90% Floridan Aquifer example with TDHs of 30 and 300, respectively, the weighted average TDH would be 273 which was calculated as (0.10 x 30) + (0.90 x 300). The calculation of the energy cost to pump 1,000 gallons of water using this weighted average is the same as if the calculation was done separately for each water source. If the energy source is different for reclaimed water and for the other source, then the user should calculate the Total Irrigation Pumping Energy Cost – Annual offline and enter it in Row 38, Column (4). The user may use Rows 33 to 38 to calculate the annual cost associated with each of the two energy sources, add the results together, and enter the total in Row 38. Because the model calculation in this cell will be deleted once the value is entered into Row 38, the user is encouraged to maintain a separate copy of this model that is unchanged. This situation is not expected to be common.

The energy cost to pump 1,000 gallons of water is calculated and reported in Row 37. This calculation is made using the following equations.[24]

(1) Energy needed to pump 1,000 gallons of water=

(Motor HP x Hours to Pump 1,000 Gallons) / HP-Hours per Gallon (of fuel or per kWh)

Where,

Energy needed is in kilowatt hours of electricity (kWh), gallons of diesel fuel, or gallons of gasoline;

Motor HP = (TDH x GPM x 1) / (3,956 x Pump Efficiency);

Pump Efficiency is assumed to be 0.75;

Hours to Pump 1,000 Gallons = (1,000 gallons / GPM) / 60 minutes per hour;

For electricity, HP-Hours per kWh = 1.18;

For diesel, HP-Hours per Gallon of diesel = 14.75; and,

For gasoline, HP-Hours per Gallon of gasoline = 11.50.

When calculating the energy needed to pump 1,000 gallons of water, the GPM variable cancels out so it does not affect the value.

The energy cost to pump 1,000 gallons of water is equal to the energy needed per 1,000 gallons of water pumped as described in Equation (1) above times the cost per kilowatt hour or per gallon of diesel or gasoline. This value is provided in Row 37. The total annual pumping energy cost is provided in Row 38 and is the energy cost to pump 1,000 gallons (Row 37) times the amount of water pumped in year (Row 2 times 1,000).

In the numerical example provided in Table 4.5.4, the Total Pumping Energy Cost per year in Row 38 is $1,207 under the NAWS requiring 30 feet of TDH using electricity and $1,370 per year under the RW/Other alternative requiring 30 feet of TDH using electricity. Column (5) reports that reclaimed water costs $163 more per year in fuel using this

[24] Sources: Equation derived from Boman, Brian J., "Water and Florida Citrus", University of Florida, IFAS, July 2002, pages 271 to 273. HP-Hours per Gallon and kWh from Smajstrla, A.G. and F.S. Zazueta, "Loading Effects on Irrigation Power Unit Performance", University of Florida, IFAS, AE242, June 2003.

See also: Smajstrla, A.G., D.S. Harrison, and J.C. Good, "Performance of Irrigation Pumping Systems in Florida", University of Florida, IFAS, Circular 653, 1985 and Florida Energy Extension Service and Helen H. Whiffen, "Energy Efficiency & Environmental News: Energy Use in Irrigation", University of Florida, IFAS, November 1991.

example. This is because the amount of reclaimed water available is 10 million gallons per year greater than the amount of water available from the NAWS and this extra cost is reflected in the RW Comparison Worksheet.

Rows 39 through 48 address any anticipated differences in labor and chemical costs associated with using RW/Other. Rows 39 through 44 estimate the annual Water System Maintenance Labor cost associated with the NAWS and RW/Other. The user enters the Labor Cost per Hour in Row 40 and the estimated Pumping System Labor Hours in Row 41. The estimated Water System Labor Hours are entered into Row 42 and the estimated Water Treatment Labor Hours are entered into Row 43. The estimated data entered into these rows provide the user an opportunity to evaluate whether reclaimed water use will increase or reduce labor costs.

Under the RW/Other alternative, all or a portion of the NAWS may be needed as a backup system that would be used only when reclaimed water is temporarily unavailable. In Row 41, Pumping System Labor Hours, the user should include only those labor hours associated with maintaining the backup system so that it will operate when needed in addition to any other relevant costs not associated with the backup system.

The annual Total Maintenance Labor Cost is calculated and presented in Row 44. Column (5) of this row indicates whether RW/Other increases or reduces labor costs. In the example provided in Table 4.5.4, RW/Other increases labor costs by $780 per year.

Rows 45 through 53 allow the user to enter any additional annual O&M cost items that would be impacted by using reclaimed water instead of the NAWS. Rows 46 through 48 allow the user to enter the costs to use certain chemicals that treat the water. Row 49 allows the user to enter the estimated cost of reporting and record keeping associated with the NAWS and with RW/Other. Other annual costs items may be entered in Rows 51 through 53. Only those cost items that would be affected by the use of RW/Other should be included in these rows. However, if a cost item is entered, then the cost must be entered for both NAWS and RW/Other, even if the cost would be $0 for one of these alternatives.

The Total Annual O&M Cost and the Annual O&M Cost per 1,000 gallons of water are calculated and provided in Rows 54 and 55. Column (5) indicates whether or not RW/Other increases or reduces annual O&M costs. In this numerical example, the Total Annual O&M cost is $47,087 for the NAWS and $36,330 for RW/Other. Column (5), Rows 54 and 55 indicate that RW/Other reduces these annual costs by $10,757 or $0.13 per 1,000 gallons of RW/Other.

4.5.5 Recurring O&M Costs, Other Than Annual

In the event that switching from the NAWS to RW/Other affects recurring O&M costs that are not annual, the user should fill out Rows 56 through 69 as depicted in Table 4.5.5. The cells where the user enters data are in **Comic Sans MS** Font. An example of a recurring O&M cost would be filter media replacement. Such items should be entered in Rows 57 through 61 along with the cost estimate under the NAWS and the RW/Other columns (Columns (3) and (4)). As with the installation cost section, the frequency of replacement in number of years (i.e., Five years means the filter media is replaced once every five years.) should be entered in Rows 63 through 67 in the order of the cost items listed in Rows 57 through 61. In Rows 63 through 67 the model automatically enters the cost item name that was entered by the user in Rows 57 through 61. Row 68 then calculates the Total Annualized Recurring O&M Cost using the interest rate that was entered in Row 15. The user may only aggregate the cost of components into one item if they all have the same useful life (as measured in years).

In the case of filter media replacement, if the media is changed more frequently when reclaimed water is used relative to the NAWS, then the replacement frequency value should be lower for reclaimed water than for the NAWS. In this example, the filter media is replaced every five years when the NAWS is used and every three years when reclaimed water is used. Other costs have been entered for other unspecified items in this example to demonstrate how the replacement frequency is to be entered.

In Rows 57 through 61, the user may enter relevant item names for which costs are to be entered. In Row 57, the user may change the item name from “Filter Media Replacement” to any other relevant item name for which costs are to be entered.

Overall, in this example, the Total Annualized Recurring O&M Cost is $3,060 for the NAWS and $5,540 for RW/Other. The difference in cost is -$2,479 per year meaning that RW/Other increases the recurring O&M cost to the user. The difference in cost per 1,000 gallons of RW/Other is -$0.03 per 1,000 gallons of RW/Other.

Under the RW/Other alternative, all or a portion of the NAWS may be needed as a backup system that would be used only when reclaimed water is temporarily unavailable. In Rows 57 to 61, the user should include only those costs associated with maintaining the backup system so that it will operate when needed in addition to any other relevant costs. In addition, if some cost items need to be replaced less frequently because they will not be used as often, then include the cost of these items in Rows 57 through 61 of Columns (3) and (4) and enter the appropriate useful lives in Rows 63 through 67 of Columns (3) and (4).

Table 4.5.5
RW Comparison Worksheet For Industrial – Rows 56 through 71
Economic Comparison of Reclaimed Water and Next Available Water Source

Row No.	Benefit or Cost Item	Next Available Water Source (NAWS)	Reclaimed Water Used Instead & Other Sources if Applicable (RW/Other)	NAWS Minus RW/Other (Except A. which is RW/Other minus NAWS)
(1)	(2)	(3)	(4)	(5)
56	**D. Recurring O&M Costs, Other than Annual**			
57	***Filter Media Replacement***	***$11,000***	***$11,000***	
58	***Item a replaced:***			
59	***Item b replaced:***	***$500***	***$3,000***	
60	***Item c replaced:***	***$400***	***$2,000***	
61	***Item d replaced:***	***$300***	***$1,000***	
62	**Replacement Frequency - No. of Years**			
63	Filter Media Replacement	***5***	***3***	
64	Item a replaced:			
65	Item b replaced:	***3***	***5***	
66	Item c replaced:	***3***	***5***	
67	Item d replaced:	***3***	***5***	
68	**Total Annualized Recurring O&M Cost**	**$3,060**	**$5,540**	**-$2,479**
69	***Total Annualized O&M Cost per 1,000 Gallons of Water***	***$0.23***	***$0.23***	***-$0.03***
70	**Total Annualized Cost (Negative cost means cost increase associated with RW/Other)**	**$106,514**	**$115,327**	**-$8,813**
71	**Total Annualized Cost Per 1,000 Gallons of Irrigation Water (Negative cost means cost increase associated with RW/Other)**	**$1.44**	**$1.37**	***-$0.10***

4.5.6 Total Annualized Cost

The Total Annualized Cost of each water source is provided in Row 70 in Table 4.5.5. This is a calculated value and is the sum of all of the costs estimated in Items A through D as listed in Table 4.5.2. The difference in these costs between NAWS and RW/Other is provided in Row 70, Column (5). The Total Annualized Cost per 1,000 gallons of water is provided in Row 71. In this example, RW/Other increases the Total Annualized Cost by $8,813 or $0.10 per 1,000 gallons of RW/Other. These two values are negative because they are the cost of RW/Other.

O:\44302-000\wpdocs\R3

4.5.7 Value of Additional Water Available from the Reclaimed Water Source

In the event that more water is available to the user from the reclaimed water system than from the NAWS, this benefit should be considered in the evaluation. The value of this benefit is estimated using Rows 72 through 75 of the RW Comparison Worksheet as presented in Table 4.5.6. The additional amount of water available from the reclaimed water provider relative to the amount needed and available from the NAWS is entered by the model into Row 73. The model inputs into Row 73 the value from Column (5) of Row (2) (See Table 4.5.3) which is the additional amount of water available from the reclaimed water provider relative to the NAWS. If no additional water is provided by the reclaimed water supplier, then this value is zero and the benefit is zero.

In the example provided in these tables, the reclaimed water supplier is expected to provide 10 million gallons annually in additional needed water to the user than is available from the NAWS. This additional water has value to the user. The actual value of this water to the user is not known. However, the cost per 1,000 gallons that the user is currently paying for water from the user's existing supply, be it the NAWS or other source, would either be known or can be estimated.

If the user is already using water from the NAWS or other source for purposes similar to those being contemplated in this economic evaluation, then the cost per 1,000 gallons from this water source is an estimate of the value of additional water to the user. It is likely to be the minimum value of water to the user if it will be used to increase production.

This water cost per 1,000 gallons is entered by the user into Row 74 as shown in Table 4.5.6. It can be estimated in a manner similar to that used in this model to estimate the total annualized cost per 1,000 gallons and using a recollection of how much the water source cost to develop, its useful life in years, the annual O&M costs, and the average annual amount of water obtained from this source. In this example, $0.45 per 1,000 gallons water is used as presented in Row 74 of Table 4.5.6. In this example, the variable rate paid for water from the NAWS is used as provided in Row 30 of the worksheet in Table 4.5.4.

O:\44302-000\wpdocs\R3

Table 4.5.6
RW Comparison Worksheet For Industrial – Rows 72 through 87
Economic Comparison of Reclaimed Water and Next Available Water Source

Row No.	Benefit or Cost Item	Next Available Water Source (NAWS)	Reclaimed Water Used Instead & Other Sources if Applicable (RW/Other)	NAWS Minus RW/Other (Except A. which is RW/Other minus NAWS)
(1)	(2)	(3)	(4)	(5)
72	**E. Value of Additional Water Available from Reclaimed Water Source**			
73	Additional Water Available from Reclaimed Water Source in million gallons per year compared to amount needed and available from NAWS- Annual:			10.00
74	Enter the cost per 1,000 gallons to obtain this fresh water, including any pumping costs. This is a lower bound estimate of the value of water to the operation. The actual value is likely much higher than this value.			***$0.45***
75	**Value of Additional Water Available from Reclaimed Water Source – Annual**			**$4,500**
76	**F. Value of the Additional Water "Freed Up" by the Reclaimed Water Use**			
77	Percent of water needed and available from NAWS that will be "freed up" and used for other purposes when reclaimed water used (% of water amount entered in Row 2, Column (3)):			***20.00%***
78	Amount of fresh water that would be "freed up" due to the reclaimed water use and would be used for other reasonable / beneficial uses by the applicant during a year **in million gallons** (on average)?			15
79	Cost per 1,000 gallons of fresh water, including any pumping costs. This is a lower bound estimate of the value of water to the operation. The actual value is likely much higher than this value. (From E. above)			$0.45
80	**Value of "freed up" NAWS water – Annual**			**$6,660**
81	**G. Value of Water Available During NAWS Water Shortage Restrictions**			
82	Number of years every ten years when NAWS Water Shortage Restriction in Place			***1.0***
83	Percent of total annual water use that is used during the months when NAWS Water Shortage Restriction in Place			***30.00%***
84	Cutback percent or percent of NAWS water use that is cut back during water restriction period:			***20.00%***
85	Annualized amount of water available during NAWS Water Shortage Restriction Due to Reclaimed Water Use in million gallons per year			0.44
86	Cost per 1,000 gallons of fresh water, including any pumping costs. This is a lower bound estimate of the value of water to the operation. The actual value is likely much higher than this value. (From E. above)			$0.45
87	**Value of Water Available During NAWS Water Shortage Restrictions – Annual**			**$200**

O:\4

If the user is not or has not been using another water source for similar industrial processes, then the District could use an estimated water cost per 1,000 gallons that represents the water source of similar industrial users. The same cost estimation method described above would be used. Remember that the goal is to find a reasonable estimate of the value of additional water supply to the user. The cost estimate described here represents either the marginal value of water or the minimum value of water depending on whether the water will be used to enhance the production process or to increase production, respectively.

The annual value of the additional water available from the reclaimed water supplier is calculated and provided in Row 75 of Table 4.5.6 and is Row 73 times Row 74 times 1,000. In the example, this value is $4,500 per year. This means that reclaimed water provides an additional $4,500 per year in value to the user.

4.5.8 Value of Additional Water "Freed Up" by Reclaimed Water Use

The most common benefit noted by the 10 Industrial survey respondents was that 70 percent were able to conserve freshwater or potable water for their other uses. This benefit is different from the benefit described in the previous section where a value was placed on the additional amount of water available from the reclaimed water supplier relative to the NAWS.

If the user is able to use all or a portion of the water from the NAWS that is "freed up" when reclaimed water is used, then this water has a benefit to the user that should be considered in the economic feasibility analysis. The value of this benefit is estimated in Rows 76 through 80 of the RW Comparison Worksheet, as presented in Table 4.5.6. In Row 77, the user enters the percent of water that was entered in Row 2, Column (3) (Amount of Water Needed and Available in Million Gallons from NAWS) that will be "freed up" by the reclaimed water use. In this example, 20 percent is used. The model then calculates and presents in Row 78 the million gallons per year of additional NAWS water that is now available to the user which is the amount of water from the NAWS that was entered in Row 2, Column (3) times the percent of NAWS freed up in Row 77, or in this example, 20 percent. If none of the "freed up" water will be available to the user, then the user enters a zero in Row 77 and the value of the benefit is zero.

The model also enters the marginal or minimum value of this water using the value that the user entered in Row 74. In this example, a value of $0.45 per 1,000 gallons is used as discussed above. The model then calculates and presents in Row 80 the estimated annual value of the "freed up" NAWS water. This value is Row 78 times Row 79. In this example, the annual value of water that is "freed up" due to reclaimed water use is $6,660.

O:\4302-000\wpdocs\R3

4.5.9 Value of Water Available During NAWS Water Shortage Restrictions

A common benefit noted by the 10 Industrial survey respondents was that 50 percent had a guaranteed and reliable water source. This benefit is not captured by the other two water supply benefits discussed in the previous two sections.

The value of this benefit is estimated in Rows 81 through 87 of the RW Comparison Worksheet as presented in Table 4.5.6. In Row 82, the user enters the number of years every ten years when a water shortage restriction associated with the NAWS that would affect the user is in place. It is a projected value. In the example, the value is 1 which means that a NAWS water shortage restriction that would affect the user occurs once every ten years.

In Row 83, the user enters the percent of the total annual water use that is used during the months when the NAWS water shortage restriction is in place. In the example, 30 percent is entered which means that the firm uses 30 percent of its annual water use during the months when the water shortage restriction is in place.

In Row 84, the user enters the percent of the cutback that would be imposed on the firm during the water shortage restriction. In the example, 20 percent is entered which means that during the water shortage restriction period, the firm must reduce its water use by 20 percent.

The model then calculates the annualized amount of water available to the irrigator during the NAWS water shortage restriction because the firm is using the reclaimed water which is not restricted. This value is calculated and presented in Row 85. It is equal to Row 2 which is the NAWS water quantity in million gallons, times (Row 82 divided by 10 years) times Row 83 times Row 84. In the example, the result is 0.44 million gallons per year.

The model then enters the estimated value of water per 1,000 gallons that the user had entered in Row 74 as discussed in the previous sections. In this example, the value is $0.45 per 1,000 gallons. In Row 87, the model calculates the estimated value of water available during NAWS Water Shortage Restrictions as Row 85 times 1,000 gallons times Row 86. In this example, the result is $200 which means that the annualized value to the firm of avoiding water shortage restrictions to the NAWS is $200 per year.

O:\4302-000\wpdocs\R3

4.5.10 Total Benefit Value of the Reclaimed Water

The Total Benefit Value of RW/Other, other than the cost savings, is calculated and presented in Row 88 of the "RW Comparison Worksheet" as presented in Table 4.5.7. This is a calculated value and is the sum of all of the benefits estimated in Items E through G as listed in Table 4.5.2. The Total Benefit, other than the cost savings, per 1,000 gallons of RW/Other, is provided in Row 89. In this example, the benefits, other than cost savings, provided by RW/Other increases the irrigator's net income, by $11,360 per year or $0.14 per 1,000 gallons of RW/Other. These two values are positive because they are the benefit of RW/Other.

For a partial offset, if all of these benefits are attributable to reclaimed water, and not the other source, then the user could calculate the benefits per 1,000 gallons of reclaimed water offline by dividing the benefit value estimate in Row 88 by the amount of reclaimed water being considered in the RW/Other combination. If RW/Other is all reclaimed water, then the benefits and costs per 1,000 gallons calculated in Column (5) of the "RW Comparison Worksheet" are per 1,000 gallons of reclaimed water.

4.5.11 Net Benefit of Reclaimed Water Use Relative to NAWS

The Net Benefit of RW/Other relative to the NAWS is calculated and presented in Row 90 as presented in Table 4.5.7. It is equal to Row 70 (Total Annualized Cost) plus the benefits estimated in Items E through G as listed in Table 4.5.2 (Row 75 plus Row 80 plus Row 87). The Net Benefit of RW/Other per 1,000 gallons of RW/Other is provided in Row 91. In the example, the net benefit of reclaimed water is $2,547 per year or $0.03 per 1,000 gallons of RW/Other. A positive net benefit means that the project is economically feasible. The RW Comparison Worksheet can be used to conduct sensitivity analysis to evaluate uncertainties in the input data.

For a partial offset, the user could calculate the net benefit per 1,000 gallons of reclaimed water offline by dividing the net benefit value estimate in Row 90 by the amount of reclaimed water being considered in the RW/Other combination. If RW/Other is all reclaimed water, then the benefits and costs per 1,000 gallons calculated in Column (5) of the "RW Comparison Worksheet" are per 1,000 gallons of reclaimed water.

Table 4.5.7
RW Comparison Worksheet For Industrial – Rows 88 through 91
Economic Comparison of Reclaimed Water and Next Available Water Source

Row No.	Benefit or Cost Item	Next Available Water Source (NAWS)	Reclaimed Water Used Instead & Other Sources if Applicable (RW/Other)	NAWS Minus RW/Other (Except A. which is RW/Other minus NAWS)
(1)	(2)	(3)	(4)	(5)
88	**Total Benefit Value of Reclaimed Water (Other Than Cost Savings) – Annual**			**$11,360**
89	**Total Benefit Value of Reclaimed Water per 1,000 Gallons (Other Than Cost Savings)**			**$0.14**
90	**Net Benefit of Reclaimed Water Use Relative to Next Available Water Source – Annual (b)**			**$2,547**
91	**Net Benefit of Reclaimed Water Use Relative to Next Available Water Source Per 1,000 Gallons of Irrigation Water (b)**			**$0.03**

(b) Net Benefit is the sum of the benefits minus the sum of the costs of RW/Other. These are benefits and costs when compared to the Next Available Water Source (NAWS). A positive number means the estimated value of the total benefit of RW/Other is greater than the estimated value of the total cost of RW/Other. A negative number means the estimated value of the total benefit of RW/Other is less than the estimated value of the total cost of RW/Other.

4.6 Evaluation Criteria and Recommendations for Further Research

This study used survey research and the available literature to develop evaluation criteria that may be used to assess the economic feasibility of reclaimed water for industrial applications. Any industrial firm with a beneficial need for water would complete the estimation model called "Reclaimed Water Benefit-Cost Comparison for Industrial Applications" as described in this Chapter. The evaluation criteria attempt to measure and compare the benefits of reclaimed water to the costs of reclaimed water. If the value of reclaimed water to the user is greater than the costs of reclaimed water, then it is economically feasible to use.

The evaluation model compares the costs associated with accessing and using reclaimed water with the costs to access and use water from the next available water source (NAWS). The model also provides guidance in estimating the benefits of reclaimed water to the user. These benefits include:

- Value of additional water available from reclaimed water source – annual

- Value of additional water "freed up" by the reclaimed water use (that can be used by the reclaimed water user)

- Value of water available during NAWS water shortage restrictions – annual

Industrial facility system components are numerous and complex. Assigning itemized costs for each possibility associated with connecting to reclaimed water can be quite extensive. Quantifying the costs of these items will take time and effort. A few typical costs can be assumed based on industry design standards and these have been included in the calculator. The four survey respondents personally interviewed over the telephone were very helpful and provided additional information.

In the course of this study several areas of further research to address information gaps were identified. These study areas are as follows.

- Conduct research to estimate representative values of water used by type of industry. The industry types would include those common to Florida that would have access to reclaimed water, such as power generation, phosphate mining, or fertilizer processing. These estimated values would be used in estimating the benefits of reclaimed water as well as the benefits of all other alternative water supplies.

- Round table discussions with industries within the District that are interested in or currently using reclaimed water may be an effective method to further itemize and quantify potential reclaimed water benefits and costs. Mining interests, power companies, and smaller reclaimed water users will have the technical and local knowledge to efficiently address cost and benefit issues.

Chapter 5.0
Conclusions and Recommendations

5.1 Background

Reclaimed water can be an effective way to diversify Florida's water resources in order to use fresh water more efficiently. The Southwest Florida Water Management District (District) water use permitting (WUP) rules require agricultural, recreational/aesthetic, and industrial/commercial water use permittees and applicants in designated Water Use Caution Areas (WUCAs) to investigate the feasibility of using reclaimed water. These permittees and applicants are required to use reclaimed water if it is technically, environmentally, and economically feasible. In general, reclaimed water is economically feasible to a water use permittee or applicant if the present value of the benefits to the permittee or applicant from using the reclaimed water is comparable to or greater than the present value of reclaimed water costs to the permittee or applicant.

For the purposes of this study, the reclaimed water is provided by a utility and is defined as water that flows out of a wastewater treatment plant and has received at least secondary treatment and required disinfection. Also, Agriculture and Recreation / Aesthetic water users use reclaimed water exclusively for irrigation, including crop establishment and frost/freeze protection, and Industrial water users use reclaimed water in certain production processes, primarily as cooling water.

This study gathered the available information from literature reviews, survey research and interviews to address the following study goals.

1. Improve the District's ability to assist water users in assessing the benefits and costs of reclaimed water to them;
2. Identify areas of future research that address how the net benefits of reclaimed water to water users can be as great as possible; and
3. Better assess whether or not reclaimed water is economically feasible to specific water users.

To these ends, this report describes the results of a literature review and survey of reclaimed water users in Florida and provides evaluation criteria and the types of information that a non-utility water use permittee or applicant would provide to the District to document the economic feasibility of reclaimed water. In addition to this report, two Excel models were developed to assist the District and the potential reclaimed water user in organizing the information needed to make an assessment of economic feasibility and that provides estimates of the net benefits of reclaimed water to the user. These Excel

O:\44302-000\wpdocs\R3

models are called Reclaimed Water Benefit-Cost Calculator for Irrigation and Reclaimed Water Benefit-Cost Calculator for Industrial Applications

5.2 Study Methods

The information in this report was based on a thorough literature review, a survey of reclaimed water users, and consultations with District, government, industry and academic experts.

The literature review included internet and web site searches accompanied by email and telephone requests of numerous organizations. While there is an abundance of information regarding the production and uses of reclaimed water, only five documents were located that address the benefits and costs of reclaimed water to users. No documents were located that describe how potential reclaimed water users should evaluate the potential benefits and costs of reclaimed water to their operations.

The most important part of this study was a survey of reclaimed water users in Florida. The results of these surveys were crucial to developing the evaluation criteria for this study. The survey was developed during this study and included questions regarding the use of reclaimed water, the costs and benefits of reclaimed water, the economic feasibility of reclaimed water, satisfaction with reclaimed water reliability, quality and quantity and whether the user would do it all over again. Three reclaimed water surveys were developed, one for each water use type: Agricultural, Recreation / Aesthetic and Industrial, respectively.

About 80 percent of the reclaimed water users who were asked to complete the survey actually completed and returned the survey. A total of 37 completed surveys were obtained and are comprised of 10 agricultural surveys, 17 recreation / aesthetic surveys and 10 industrial surveys. The project team would like to express their sincere appreciation and thanks to the 37 people who took the time to fill out this survey and explain how reclaimed water has affected their operations in terms of benefits and costs.

Of the 16 counties in the Southwest Florida Water Management District, 10 are represented in this survey. Two counties, Orange and St. Lucie, are in the South Florida Water Management District. The four respondents in these two counties were asked to participate in this survey in order to achieve the survey goal. These respondents are believed to be representative of the actual and potential reclaimed water users in the Southwest District.

5.3 Benefits and Costs of Reclaimed Water Use

The survey respondents were very helpful in providing information regarding their benefits and costs associated with reclaimed water. The actual costs associated with connecting to a reclaimed water system and using the reclaimed water will vary depending on factors specific to the farm, golf course, landscaped area or industrial firm. There are potentially three types of costs associated with using reclaimed water: (1) installation costs; (2) annual costs; and (3) recurring O&M costs other than annual.

A list of the potential installation costs is provided in Table 5.3.1. A reclaimed water user will not necessarily need to spend money on all of these cost items.

Table 5.3.1
Potential Installation Cost Items Associated with Using Reclaimed Water For Irrigation and Industrial Applications

(1) Install pipe system to connect irrigation system or industrial operation to reclaimed water pipeline

(2) Install pressure regulating valves to control pressure of water flowing into irrigation system

(3) Install water meter to monitor amount of reclaimed water used

(4) Create storage pond or install storage tank and pump station to match reclaimed water supply with timing of water needs

(5) Disconnect existing water source from irrigation system or industrial operation

(6) For industrial applications, install or expand the water pretreatment system

(7) For micro-sprinkler and drip irrigation systems, install or upgrade filtration and/or chemical injector systems to reduce clogging

(8) Create reclaimed water disposal area such as ditch connection to pasture area during times when reclaimed water flows are higher than crop water needs

(9) For turf and landscape, change plant material to more salt tolerant species

(10) Other costs, if any, specific to the individual reclaimed water user associated with the provision of water for other uses from the existing fresh water source due to the reclaimed water connection.

A list of the potential annual and periodically recurring costs associated with using reclaimed water is provided in Table 5.3.2.

O:\44302-000\wpdocs\R3

Table 5.3.2
Potential Annual or Periodically Recurring Cost Items
Associated with Using Reclaimed Water for Irrigation or Industrial Applications

1. Reclaimed water payment to the utility
2. Irrigation-related management associated with maintaining reclaimed water meter, pipeline, pump and storage pond; repairing pipeline due to fluctuating water pressure; and repairing or replacing rusty controllers, power boxes and equipment
3. Fertilizer management including water quality and plant tissue testing and nutrient evaluations
4. Salinity and pH management including chemical applications, water blending, soil leaching and mechanical means
5. Pest or algae management including cleaning or repairing microjets or drip nozzles, water chlorination, pesticide applications, and filter replacement
6. Chemicals needed for reclaimed water treatment prior to industrial application
7. Recording water data and providing reports to the water management district and the FDEP

The survey responses demonstrated that there are benefits of reclaimed water use relative to using traditional water sources such as ground or surface water. These benefits include cost savings and value-added. The benefits are listed in Table 5.3.3 in order of importance to the 37 Agricultural, Recreation / Aesthetic and Industrial reclaimed water users surveyed.

The top five benefits are related to having more water available when needed relative to traditional water sources. The top three benefits are: (1) having a guaranteed and reliable water source, (2) able to conserve fresh water for their other uses and (3) able to irrigate more frequently that if a traditional water source was used. About 2 of every 3 respondents said they were receiving at least one of these three benefits.

The fourth and fifth ranked benefits are also related to having more water and are: (4) Able to apply more water to the crop/ lawn/ landscape than with a traditional source and (5) Better able to supply water to crops during drought conditions. At least 50 percent of the 27 Agricultural and Recreation / Aesthetic respondents stated that they received at least one of these two benefits from using reclaimed water.

Table 5.3.3
Benefits of Reclaimed Water for Irrigation and Industrial Applications
Ranked in Order of Percent of Respondents Who Said Yes to Benefit

Reclaimed Water Benefits	Survey Respondents Who Said Yes to Benefit		
	Number	% of Responses	Total No. of Respondents (a)
1. Have a guaranteed and reliable water source	25	68%	37
2. Able to conserve fresh water for their other uses	25	68%	37
3. Able to irrigate more frequently than if used traditional source	17	63%	27
4. Able to apply more water to the crop/lawn/ landscape than with traditional source	15	56%	27
5. Better able to supply water to crops during drought conditions	5	50%	10
6. Irrigation or water costs are lower	17	46%	37
7. Our permitting requirements have been reduced	3	30%	10
8. Net income is higher than with traditional water source	11	30%	37
9. Fertilization costs are lower	7	26%	27
10. Revenue is higher than with traditional water source	9	24%	37
11. Business has increased during fresh water shortage restrictions	4	24%	17
12. Better able to protect crops from freezing	2	20%	10
13. Crop yield or product quantity has been higher than with a traditional source	2	10%	20
14. Pounds of juice per acre is higher than with traditional source	1	10%	10
15. Our production cost is lower	1	10%	10
16. Water storage costs are lower	3	8%	37
17. Quality of crop/lawn/landscape/product is higher than with traditional source	3	8%	37

(a) The total number of respondents is 37 if the question was asked of Agricultural, Recreation / Aesthetic and Industrial respondents. The total number of respondents is 27 if the question was asked of the Agricultural and Recreation / Aesthetic respondents. The total number of respondents is 10 if the question was asked of only the Agricultural respondents or only the Industrial respondents.

O:\44302-000\wpdocs\R3

The Agricultural and Recreation / Aesthetic respondents were asked the following question regarding the net benefits of reclaimed water to their firm: "Do you believe that the total benefit your firm is receiving from using reclaimed water is greater than the total cost your firm is paying for reclaimed water (after subtracting any money received from government agencies)?" Of the 10 Agricultural respondents, six answered yes, one answered no, one did not know and two did not answer the question. Of the 17 Recreation / Aesthetic respondents, 15 said yes, one said no and one did not know.

All 37 respondents were asked to rate the supply reliability, quantity and quality of their reclaimed water. For the most part, the Agricultural respondents gave favorable ratings to their reclaimed water. Six of the 10 Agricultural respondents were satisfied with their water supply reliability and water quality and five were satisfied with their water quantity. Three were very satisfied with their reclaimed water quantity and quality and four were very satisfied with their water supply reliability. The 17 Recreation / Aesthetic respondents also gave favorable ratings for their reclaimed water. Nine respondents are very satisfied with the supply reliability of their reclaimed water while 11 respondents are satisfied with their reclaimed water quantity and 10 are satisfied with its quality. All of the Industrial respondents were very satisfied or satisfied with their reclaimed water reliability, quality and supply.

All 37 respondents were asked the following question: "If your firm could do it all over again, would your firm agree to connect to the reclaimed water system? If you cannot speak for your firm, would you agree to connect this facility if the choice was yours alone?" Of the 10 Agricultural respondents, nine would connect again because the reclaimed water saves the farm money and one would not connect, citing the added cost of grove maintenance associated with using the reclaimed water.

All of the 17 Recreation / Aesthetic respondents said they would connect to reclaimed water if they had to do it all over again. The most common reasons were that the reclaimed water is needed as a supplemental water source and is it available during fresh water shortage restrictions. Four said that irrigation is a good use of reclaimed water and three said that reclaimed water is affordable or saves money.

All of the 10 Industrial respondents would use reclaimed water as a supply source for their industrial operations if they had to make the decision again. Three of the 10 survey respondents are interested in obtaining additional reclaimed water quantities.

5.4 Summary of Evaluation Criteria

This study used survey research and the available literature to develop evaluation criteria that may be used to assess the economic feasibility of reclaimed water for irrigation of crops, turf and landscape and for industrial applications. Farmers, golf course own-

O:\44302-000\wpdocs\R3

ers, homeowner and condominium associations, and any entity with a beneficial need for irrigation water would complete the estimation model called “Reclaimed Water Benefit-Cost Calculator for Irrigation”. Industrial firms would complete the estimation model called “Reclaimed Water Benefit-Cost Calculator for Industrial Applications”.

Both models are described in this report and are comprised of the RW Comparison Worksheet Instructions and the RW Comparison Worksheet. The evaluation criteria contained in these models attempt to measure and compare the benefits of reclaimed water to the costs of reclaimed water. If the value of reclaimed water benefits to the user is greater than the total cost of reclaimed water to the user, then reclaimed water is economically feasible to use. The RW Comparison Worksheet can be used to conduct sensitivity analysis to evaluate uncertainties in the input data.

The Reclaimed Water Benefit-Cost Calculators for Irrigation and Industrial Applications are to be used to provide guidance as to the economic feasibility of using reclaimed water for a specific purpose. The values that the user will input into the model are estimates and the model results should not be the only factor in determining economic feasibility. Instead, the model results should be viewed in the proper context of all other information submitted and relevant to the water use permit application or renewal.

The evaluation model compares the costs associated with accessing and using reclaimed water with the costs to access and use water from the next available water source (NAWS). The model also provides guidance in estimating the benefits of reclaimed water to the user. These benefits include:

- Nitrogen fertilizer cost savings - annual
- Change in value of crop production – annual
- Change in quality of crop, lawn and/or landscape – annual
- Value of additional water available from reclaimed water source – annual
- Value of additional water “freed up” by the reclaimed water use (that can be used by the reclaimed water user)
- Value of water available during NAWS water shortage restrictions – annual

The evaluation criteria and the order of benefits and costs in the Reclaimed Water Benefit-Cost Calculator are provided in Table 5.4.1. The model can also evaluate partial off-

O:\4302-000\wpdocs\R3

sets, where only a portion of the next available water source is replaced with reclaimed water. A user guide for the irrigation model and the industrial applications model is provided in Chapter 3.0 and Chapter 4.0, respectively.

5.5 Recommendations for Further Research

In the course of this study several areas of further research to address information gaps were identified. These study areas are as follows.

- Support research and develop a method to estimate the influence of reclaimed water on the amount of macro and micro nutrients taken up by plants, including citrus, tomato, turf, etc. This information would be useful to estimating the cost savings associated with reduced fertilizer requirements.

- Conduct scientific field trials to determine the impact of reclaimed water features on crop productivity per acre for crops commonly produced in Florida that would have access to reclaimed water. Reclaimed water features include differences in water quality and water availability relative to traditional water sources. This information would be useful to estimating the change in the value of crop production associated with reclaimed water use.

- Conduct scientific field trials to determine the impact of reclaimed water features on turf and landscape plant quality. Given these results, conduct research to document the impact of these quality changes on net revenue to the reclaimed water user. This research should be conducted at the nursery production and sales level and at the plant end user level such as golf course and homeowner associations. Reclaimed water features include differences in water quality and water availability relative to traditional water sources. This information would be useful to estimating the change in net revenue from changes in plant quality associated with reclaimed water use.

- Conduct research to estimate representative values of water used for irrigation by type of plant irrigated. The plant types would include those commonly produced and/ or irrigated in Florida that would have access to reclaimed water, such as citrus, tomatoes, St. Augustine grass, and Bermuda grass. These estimated values would be used in estimating the benefits of reclaimed water as well as the benefits of all other alternative water supplies.

- Round table discussions with industries within the District that are interested in or currently using reclaimed water may be an effective method to further itemize and quantify potential reclaimed water benefits and costs for industrial applications. Mining interests, power companies, and smaller reclaimed water users will have the technical and local knowledge to efficiently address cost and benefit issues.

O:\44302-000\wpdocs\R3

Table 5.4.1
Evaluation Criterion and Order of Benefits and Costs Presented
In the Reclaimed Water Benefit-Cost Calculators for Irrigation and Industrial Applications

Benefit or Cost Item	Measure of Benefit Or Cost Item	Evaluation Criterion (a)
A. Amount of water needed and available in million gallons – annual	Amount of water needed and available in million gallons – annual	Negative of Difference in amount of water needed and available (RW minus NAWS)
B. Installation costs	Total annualized installation cost and Per 1,000 gallons	Difference in annualized installation cost (NAWS minus RW)
C. Annual O&M costs	Total annual O&M cost and Per 1,000 gallons of water	Difference in annual O&M cost (NAWS minus RW)
D. Recurring O&M costs, other than annual	Total annualized recurring O&M cost and Per 1,000 gallons of water	Difference in annualized recurring cost (NAWS minus RW)
E. Nitrogen fertilizer cost savings – annual (Irrigation Only)	Total annual nitrogen fertilizer cost savings and Per 1,000 gallons of water	Nitrogen fertilizer cost savings
A. through E.	Total annualized cost and cost savings and Per 1,000 gallons of water	
F. Change in value of crop production – annual (Irrigation Only)	Net value of change in crop production – annual	
G. Change in quality of crop, lawn and/or landscape – annual (Irrigation Only)	Change in net revenue (market value minus variable cost) – annual	
H. Value of additional water available from reclaimed water source – annual	Value of additional water – annual	
I. Value of additional water “freed up” by the reclaimed water use (that can be used by the reclaimed water user)	Value of “freed up” NAWS water – annual	
J. Value of water available during NAWS water shortage restrictions – annual	Value of water available during NAWS water shortage restrictions – annual	
F. through J.	Total benefit value of reclaimed water (other than cost savings) and Per 1,000 gallons	
A. through J.	Net benefit of reclaimed water use relative to next available water source and Per 1,000 gallons	

(a) Positive values are benefits of reclaimed water and negative values are costs of reclaimed water.

O:\4302-0

Chapter 6.0
References

Subject	References
All	Barbarick, K.A. and D. G. Westfall, "Fertilizer Cost Calculations", Colorado State University Extension, no. 0.548.
Citrus	Boman, Brian and Tom Obreza, "Fertigation Nutrient Sources and Application Considerations for Citrus", University of Florida, IFAS Extension, Circular 1410, October 2008.
Industrial	Borisova, Tatiana and Roy R. Carriker, “Water Use in Florida”, University of Florida, IFAS Extension, Document FE797, 2009.
Industrial	Bryck, Jack, Rajesh Prasad, Trevor Lindley, Steve Davis and Guy Carpenter, “National Database of Water Reuse Facilities Summary Report”, WateReuse Foundation, Alexandria, Virginia, 2008.
Health Risk	Burau, Richard G., Bahman Sheikh, Robin P. Cort, Robert C. Cooper and David Ririe, "Reclaimed Water for Irrigation of Vegetables Eaten Raw", California Agriculture, July-August 1987.
Industrial	Cheremisinoff, N.P. and P.N. Cheremisinoff, “Cooling Towers: Selection, Design and Practice”, Ann Arbor Science Publishers, Ann Arbor, MI, 1981.
GC	Cisar, John L., Monika Reuter, George H. Snyder and Michael A. Fidanza, "The Use of Non-Saline Reclaimed Water for Golf Course Irrigation in Florida", Online. Applied Turfgrass Science, doi: 10.1094/ATS-2006-0210-02-TT, 2006.
GC	Dixon, R.W., and D.J. Ray, "Reclaimed Water Use for Irrigation of Texas Golf Courses", Online, Applied Turfgrass Science, doi:10.1094/ATS-2008-0519-01-TT, 2008 Plant Management Network.
Intro	Dukes, Michael, Laurie E. Trenholm. Ed Gilman, Chris J. Martinez, John L. Cisar, Thomas H. Yeager, Amy Shober and Geoffrey Denny, "Frequently Asked Questions About Landscape Irrigation for Florida Friendly Landscaping Ordinances", University of Florida, IFAS Extension, ENH1114, December 2008.
Industrial	Florida Department of Environmental Protection ,Water Reuse Program, Industrial Uses of Reclaimed Water, accessed on October 7, 2009 through website: http://www.dep.state.fl.us/water/reuse/industry.htm.
GC	Florida Department of Environmental Protection, "Best Management Practices for the Enhancement of Environmental Quality on Florida Golf Courses", Tallahassee, January 2007.

Subject	References
Intro	Florida Department of Environmental Protection, "Florida's Reuse Activities", Tallahassee, 2009, www.dep.state.fl.us/water/reuse/activity.htm.
All	Florida Energy Extension Service and Helen H. Whiffen, "Energy Efficiency & Environmental News: Energy Use in Irrigation", Florida Cooperative Extension Service, University of Florida, IFAS, November 1991.
Industrial	From HSW Engineering, Inc., “Reuse and Alternative Best Management Practices For Ensuring Lowest Water Quality Is Used During Mining, Beneficiation, and Chemical Processing of Phosphate”, Prepared for Southwest Florida Water Management District, Brooksville, Florida, 2008.
Citrus	Gaines, David, "Florida Reclamation Project Offers Valuable Lessons", Irrigation Association, Irrigation and Business Technology (IBT), www.irrigation.org/ibt/_9902/p34.html, February 1999.
Turf	Gelernter, Wendy and Larry Stowell, PACE Turfgrass Research Institute, "Keeping an Eye on Nitrogen", Grounds Maintenance, www.groundsmag.com/mag/grounds_maintenance_keeping_eye_nitrogen/index.html.
Intro	Golf Course Superintendents Association of America, "Golf Course Environmental Profile, Volume II, Water Use and Conservation Practices on U.S. Golf Courses", 2009.
GC	Grinnell, P.E., Gary K., and Ram G. Janga, P.E., "AWWA Golf Course Reclaimed Water Market Analysis", AWWA, 2003.
Turf	Gross, Patrick J., "A Step-By-Step Guide for Using Recycled Water", USGA Green Section Record, March-April 2008.
All	Haman, D.Z., "1993 IFAS Task Force on Microirrigation in Florida: Systems, Acreage and Costs", University of Florida, IFAS Extension, BUL276, December 2005.
Salinity	Haman, Dorota Z., "Irrigating with High Salinity Water", University of Florida, IFAS Extension, BUL322, April 2009.
Turf	Harbison, Dave, Coachella Valley (CA) Water District, "Irrigation Water Source", Grounds Maintenance, www.groundsmag.com/mag/grounds_maintenance_irrigation_water_source/index.html.
GC	Harivandi, M. Ali, "Considerations in Retrofitting a Golf Course for Recycled Water Irrigation", USGA Green Section Record, November-December 2004.
Turf	Harivandi, M. Ali, "The Use of Effluent Water for Turfgrass Irrigation", California Turfgrass Culture, University of California Cooperative Extension, Volume 32, Numbers 3 and 4, Summer and Fall 1982.
Intro	Haydu, John and Alan Hodges, "Economic Dimension of the Florida Golf Course Industry", University of Florida, IFAS Extension, FE344, December 2002.

Subject	References
All	Hochmuth, George, Terril Nell, Jerry Sartain, Bryan Unruh, Michael Dukes, Chris Martinez, Laurie Trenholm, and John Cisar, "Unintended Consequences Associated with Certain Urban Fertilizer Ordinances", University of Florida, IFAS Extension, SL 283, March 2009, EDIS Web Site at http://edis.ifas.ufl.edu.
GC	Huck, Mike, R.N.Carrow, and R.R. Duncan, "Effluent Water: Nightmare or Dream Come True?", USGA Green Section Record, March/April, 2000.
GC	King, Kevin W., James C. Balogh and R. Daren Harmel, "Feeding Turf with Wastewater", Golf Course Management, January 2000.
Drip Irrigation	Lamont, William J. Jr., Michael D. Orzolek, Jayson K. Harer, Albert Jarrett and George Greaser, "Drip Irrigation for Vegetable Production", In Agricultural Alternatives, PennState, College of Agricultural Sciences, 2002, http://agalternatives.aers.psu.edu.
Industrial	Marella, R.L. "Water Withdrawals, Use, Discharge, and Trends in Florida, 1985", Florida Department of Environmental Protection, Tallahassee, Florida, 1999.
Turf	Martinez, Christopher J. and Mark W. Clark, "Using Reclaimed Water for Landscape Irrigation", University of Florida, IFAS Extension, AE449, July 2009.
Turf	Martinez, Christopher, Assistant Professor, "Appropriate Application of Reclaimed Water for Landscape Irrigation", University of Florida, www.abe.ufl.edu.
GC	Martinez, John, Director of Golf Course Operations, The SCGA GC, "Reclaimed Water Use: A Case Study", FORE Magazine - The Official Journal of the Southern California Golf Association, no date, www.scga.org.
ALL	Marzolf, Erich, Ph.D., "Is Reclaimed Water a Free ~~Lunch~~ Drink?" Presentation, St. Johns River Water Management District.
All	Metcalf & Eddy | AECOM, "Water Reuse Issues, Technologies, and Applications", Written by Takashi Asano, Franklin L. Burton, Harold L. Leverenz, Ryujiro Tsuchihashi and George Tchobanoglous, McGrall Hill, 2007. (available from AWWA Bookstore)
Industrial	Metropolitan Council Environmental Services, "Recycling Treated Municipal Wastewater for Industrial Water Use", 2007, Publication No. LCMR 05-07d, MCES, Project Number 070186: http://www.metrocouncil.org/directions/ water/water2007/wastewaterRptAug07.htm.
Citrus	Mid-Florida Citrus Foundation, "Research Benefits", Water Conserv II, Orlando, Florida.

Subject	References
All	Miller, Kirk, "Anatomy of the Non-Potable Water Irrigation System and Reclaimed Water Chemistry", Presentation in pdf, Rain Bird Corporation. from web site.
Industrial	Minnesota Metropolitan Council (MMC), “Recycled Wastewater Could Provide Water for Industry”, 2010, http://www.metrocouncil.org/directions/water/water2007/wastewaterRptAug07.htm.
Salinity	Miyamoto, S., I. Martinez, M. Padilla, A. Portillo, and D. Ornelas, "Landscape Plant Lists for Salt Tolerance Assessment", Agricultural Research and Extension Center of El Paso, Texas Agricultural Experiment Station, The Texas AM University System, April 2004.
Salinity	Miyamoto, S., Rick Galceran and Richard Garcia, "Landscape Irrigation with Salty Water", Grounds Maintenance, www.grounds-mag.com/grounds_maintenance_landscape_irrigation_salty/index.html.
Citrus	Morgan, Kelly T., T. Adair Wheaton, Larry R. Parsons, and William S. Castle, "Effects of Reclaimed Municipal Waste Water on Horticultural Characteristics, Fruit Quality, and Soil and Leaf Mineral Concentration of Citrus", HortScience, Volume 43(2), April 2008.
Turf	Morris, Robert and Dr. Dale Devitt, "Sampling and Interpretation of Landscape Irrigation Water", University of Nevada Cooperative Extension, Fact Sheet-02-91, no date.
Industrial	North Carolina Division of Water Quality (NCDWQ), “Land Application Unit: Reclaimed Utilization Systems”, 2009, accessed on August 20, 2009 on website: http://h2o.enr.state.nc.us/lau/reclaimed.html,
Industrial	Orange Water and Sewer Authority (OWASA - North Carolina), Draft Long-Range Water Supply Plan”, 2009, Update accessed on August 20, 2009 on website : http://www.owasa.org/home/index.aspx
All	Oster, Jim, Stephen R. Grattan, and Kenneth K. Tanji, "Drought Tip 92-32 - Maintaining Water Quality for Irrigated Agriculture Under Drought Conditions", California Department of Water Resources, 2002.
Tomato	Ozores-Hampton, Monica, Eric Simonne, Phyllis Gilreath, Steven Sargent, et.al. "Effect of Nitrogen Rate on Yield of Tomato Grown With Seepage Irrigation and Reclaimed Water", Presentation, University of Florida, IFAS Extension, no date.
All	Palm Beach County, "Water Facts", 2009, www.pbcgov.com/waterutilities/waterfacts/reclaimedwater.htm

Subject	References
Citrus	Parsons, L.R., T.A. Wheaton, and P. Cross, "Reclaimed Municipal Water for Citrus Irrigation in Florida", IN: Microirrigation For a Changing World: Conserving Resources / Preserving the Environment, Proceedings of the Fifth International Microirrigation Congress, Orlando, Florida, April, 1995, Editor: F.R. Lamb.
Citrus	Parsons, Larry and T. Adair Wheaton, "Can High Application Rates of Reclaimed Water Provide Adequate Nutrition for Citrus Trees?", USDA-CSREES 2007 National Water Quality Conference, National Water Program - A partnership of USDA CSREES & Land Grant Colleges and Universities.
Intro	Parsons, Lawrence R. "Reclaimed Water for Homeowner Irrigation", University of Florida, IFAS Extension, HS1157, July 2009.
Intro	Parsons, Lawrence R. "Reclaiming a Resource", Florida Grower, May 2007.
Citrus	Parsons, Lawrence R., T. Adair Wheaton, and William S. Castle, "High Application Rates of Reclaimed Water Benefit Citrus Tree Growth and Fruit Production", HortScience 36(7):1273-1277, 2001.
All	Peacock, Bill, Tulare County (CA) Farm Advisor, "The Use of Soil and Water Analysis", University of California Cooperative Extension, Tulare County, Publ. # IG3-96, 1998.
Tomato	Pitts, D.J., A.G. Smajstrla, D.Z. Haman and G.A. Clark, "Irrigation Costs for Tomato Production in Florida", University of Florida, IFAS Extension, AE74, July 2002.
Value	Raucher, Robert S., David Chapman, James Henderson, Marca L. Hagenstad and John Rice, "The Value of Water: Concepts, Estimates and Applications for Water Managers, Prepared by Stratus Consulting and associated firms for the Awwa Research Foundation, #2855, 2005.
Vegetable	Shukla, Sanjay, Edward A. Hanlon, Fouad H. Jaber, Peter J. Stoffella, Thomas A. Obreza, and Monica Ozores-Hampton, "Groundwater Nitrogen: Behavior in Flatwoods and Gravel Soils Using Organic Amendments for Vegetable Production", University of Florida, IFAS Extension, CIR 1494, August 2006.
All	Smajstrla and F.S. Zazueta, "Loading Effects on Irrigation Power Unit Performance", University of Florida, IFAS, AE242, June 2003.
All	Smajstrla, A.G., D.S. Harrison, and J.C. Good, "Performance of Irrigation Pumping Systems in Florida", Circular 653, Florida Cooperative Extension Service, IFAS, University of Florida, 1985.
All	Smith, Tim, "Some Thoughts About Soil pH, Fertilizers and Lime", Washington State University, WSU Extension, Wenatchee, Washington.

O:\44302-000\wpdocs\R3

Subject	References
Intro	Southwest Florida Water Management District, "Reclaimed Water - A Reliable, Safe Alternative Water Supply", Brooksville, Florida, www.watermatters.org.
Industrial	St. Johns River Water Management District, “The Indian River Lagoon National Estuary Program” accessed on January 27, 2010 on website: http://sjr.state.fl.us/itsyourlagoon/index.html.
Nursery	Stamps, Ph.D., Robert H., "Irrigation and Nutrient Management Practices for Commercial Leatherleaf Fern Production in Florida", Second Edition, University of Florida, IFAS Extension.
GC	Stowell, Larry J. and Wendy Gelernter, Ph.D., "Side Effects - Consider Agromonics When Negotiating Reclaimed Water Contracts", Golf Course Industry, September 2008.
Industrial	Texas Natural Resource Conservation Commission (TNRCC), “Chapter 210 – Use of Reclaimed Water”, Rule Log No. 96156-210-WT, Texas Office of Policy and Regulatory Development, Austin, Texas, 2009.
Intro	Toor, Gurpal S. and Donald P. Rainey, "History and Current Status of Reclaimed Water in Florida", University of Florida, IFAS Extension, SL308, November 2009.
Industrial	Treweek, G.P., “Industrial Reuse of Wastewater: Quantity, Quality and Cost”, Ch. 23, 521-548 in E.J. Middlebrooks (ed.). Water Reuse. Ann Arbor Science Publishers, Ann Arbor, MI, 1982.
Industrial	United States Geological Survey, FDEP, and the Florida Water Management Districts, “Water Use in Florida, 2005 and Trends 1950-2005”, 2008
All	University of Florida, Center for Landscape Conservation and Ecology, IFAS Extension, "Irrigating with Reclaimed Water", Gardening in an Minute, Gainesville, Florida, no date.
Citrus	University of Florida, Institute of Food and Agricultural Sciences, Publication SP 281, "Water and Florida Citrus: Use. Regulation, Irrigation, Systems, and Management, Edited by Brian J. Boman, Gainesville, Florida, July 2002.
Industrial	URS Corporation, “Developing a Baseline GIS Database and Tools to Identify Water Reuse Potential In Texas”, Prepared for the Texas Water Development Board, Austin, Texas, 2008.
All	Vagts, Todd, "Nitrogen Fertilizers and Soil pH", Iowa State University Extension, 2005, http://www.extension.iastate.edu/nwcrops/fertilizer_and_soil_ph.htm.
Nursery	Von Merveldt, Joseph K., "Reclaimed Municipal Water for Irrigation of Container-Grown Nursery Crops", Masters Thesis, University of Florida, 2008.

Subject	References
Citrus	Wade, Mark and Brian Boman, "Economic Considerations for Florida Citrus Irrigation Systems", University of Florida, IFAS Extension, FE376, April 2009.
Industrial	Water Encyclopedia Website (WEW), “Science and Issues, Reclamation and Reuse” accessed on January 6, 2010 : http://www.waterencyclopedia.com/Po-Re/Reclamation-and-Reuse.html
All	WateReuse Foundation, "An Economic Framework for Evaluating the Benefits and Costs of Water Reuse", Final Project Report and User Guidance, Prepared by Robert S. Raucher, Ph.D., Stratus Consulting, 2006.
GC	WateReuse Foundation, "Effects of Recycled Water on Turfgrass Quality Maintained under Golf Course Fairway Conditions", Prepared by Sowmya Mitra, Ph.D., California State Polytechnic University, Pomona, California, 2006.
Salinity	Wu, Lin, Department of Environmental Horticulture, UC Davis, "Salt Tolerance of Landscape Plants for Reclaimed Water Irrigation", ANR Impact, University of California, Agricultural Experiment Station and Cooperative Extension Service, www.ucanr.og/delivers/impactview.cfm?impactnum=464.
Salinity	Wu, Lin, Xun Guo, Ali Harivandi, Roger Waters and Jerry Brown, "Study of California Native Grass and Landscape Plant Species for Recycled Water Irrigation in California Landscapes and Gardens", Slosson Report 98-99.
Nursery	Yeager, T.H., University of Florida, IFAS, "Reclaimed Water for Irrigation of Container Grown Plants, Final Report, Deliverable 10", Prepared for the Southwest Florida Water Management District, Contract No. 38213, No date.
Nursery	Yeager, Tom, Claudia Larsen, Jon von Merveldt, and Tracy Irani, "Use of Reclaimed Water for Irrigation in Container Nurseries", University of Florida, IFAS Extension, ENH1119, May 2009.
Citrus	Zekri, Mongi, Thomas Obreza and Arnold Schumann, "Increasing Efficiency and Reducing Costs of Citrus Nutritional Programs", University of Florida IFAS Extension, SL222, January 2005, EDIS Web Site at http://edis.ifas.ufl.edu.
Turf	Zupancic, SoilQuest International, "Reclaimed Water: Challenges of Irrigation Use", Grounds Maintenance, www.grounds-mag.com/mag/grounds_maintenance_reclaimed_water_challenges.

APPENDIX A
SURVEY INSTRUMENTS

HAZEN AND SAWYER
Environmental Engineers & Scientists

Hazen and Sawyer, P.C.
4000 Hollywood Boulevard
750N, North Tower
Hollywood, FL 33021
Phone: (954) 987-0066
Fax: (954) 987-2949
gjohns@hazenandsawyer.com

October 13, 2009

NAME
ADDRESS

Request to Complete
"Reclaimed Water User Survey"

Dear NAME:

Hazen and Sawyer, P.C., on behalf of the Southwest Florida Water Management District, would like you to complete the attached "Reclaimed Water User Survey". This survey is being sent to all reclaimed water users in the District and some outside of this District who receive reclaimed water from a utility. The District will use the survey responses to improve its assistance to water users who are considering the use of reclaimed water.

This survey asks questions regarding the benefits and costs of reclaimed water to the survey respondent's business or operations. While some of the benefits and costs of reclaimed water have been studied at the scientific level, research regarding "on-the-ground" experiences with reclaimed water is limited.

Your participation in this survey will allow the District to learn from experienced reclaimed water users regarding their benefits and costs of reclaimed water in order to:

a. Improve the District's ability to assist water users in assessing the benefits and costs of reclaimed water to them;

a. Identify areas of future research that address how the net benefits of reclaimed water to water users can be as great as possible; and

b. Better assess whether or not reclaimed water is economically feasible to specific water users.

In particular, the District would like to identify the actual benefits that have been experienced by reclaimed water users in addition to the costs of reclaimed water.

We would appreciate your returning this completed survey on or before **Friday, November 6th** at the address, email or fax information provided on the last page of the survey. I am happy to answer any questions. My contact information is on this letterhead. The District's contact person for this project is Mr. Don Rome who can be reached at Don.Rome@swfwmd.state.fl.us or (800) 423-1476 (toll free), extension 4367. We thank you for taking the time to complete this important survey.

Very truly yours,

HAZEN AND SAWYER, P.C.

Grace Johns, Ph.D.
Senior Associate and Project Manager

Enclosure

Reclaimed Water User Survey – 2009
Agricultural Irrigation – October 5, 2009

Water Use Permit Number: _____

Project Name:_____

Name of Respondent: _____ Respondent Telephone number:_____

Business Name:_____

PART A – RECLAIMED WATER USE QUESTIONS

Please Note: All of the questions below pertain to **reclaimed water <u>supplied by a utility</u>**.

1. Does your farm use reclaimed water supplied by a utility for irrigation?

_____ Yes (proceed to question 2); _____ No (proceed to Part B on page 10)

2. What is the name of the utility that provides reclaimed water to your farm?

_____

3. How many total acres does your farm irrigate with reclaimed water from a water utility?

_____ acres

4. Please indicate the crop types that your farm irrigates with reclaimed water, the acres irrigated, and the type of irrigation system used (e.g. sprinker, drip, etc.)? For nurseries, just indicate if field or container. To answer this question, please fill in the table below.

Question 4 - Crops and Acreages Irrigated with Reclaimed Water and Irrigation System Types		
Crop Type (include double-crops on one line)	**Acres Irrigated With Reclaimed Water**	**Type of Irrigation System Used**

5. How long has your farm been using reclaimed water (supplied by a utility) for irrigation?

_____ Years and _____ months

6. About how much reclaimed water does your farm use, on average? _____ Please indicate the unit of measurement here (for example, gallons per month): _____.

7. What percentage of your farm's total irrigation water use is reclaimed water from a utility?

_____%

8. Does your farm know the nutrient contents and chemical constituents of your farm's reclaimed water (for example, nitrogen, phosphorus, chlorine, pH, hardness)?

____ Yes (proceed to question 10) _____ No (proceed to question 9)

9. Does your farm know how to obtain information regarding the nutrient contents and chemical constituents of your farm's reclaimed water (for example, nitrogen, phosphorus, chlorine, pH, hardness)?

____ Yes _____ No

10. What were the primary reasons that your farm connected to the reclaimed water system?

_____

_____

_____

11. If your farm had NOT connected to the reclaimed water supply, what other water source would your farm have been able to use for irrigation (please check all that apply)?

___ Floridan aquifer well

___ Other ground water source, please specify _____

___ Surface water source, please specify: _____

___ Other source, please specify: _____

___ No other water source was available.

12. Does your farm pay its reclaimed water provider for the reclaimed water?

____ Yes (proceed to question 13) _____ No (proceed to question 15)

13. How much does your farm pay your reclaimed water provider?

Fixed charge: $_____ per month

Variable charge: $_____ per 1,000 gallons of reclaimed water

Other charge, if applicable: $_____

14. About how much money does your farm pay your reclaimed water provider annually? $_____

15. When was the reclaimed water connected to your facility? (Check one)

___ Before the irrigation system was installed.

___ During irrigation system installation.

___ After the irrigation system was installed.

16. How is the reclaimed water stored on your farm? (Check all that apply)

____ No Storage ____ Open ponds or lakes

____ Tanks ____ Other – describe _____

17. When your farm connected to the reclaimed water system, did your farm have to make any changes to the irrigation or pumping systems or did your farm construct or develop water storage in order to accept the reclaimed water?

___Yes (proceed to question 18); ___ No (proceed to question 22)

18. Please briefly describe the changes that were made to the irrigation and/or pumping systems to receive the reclaimed water. Also, please indicate the amount and type of storage, if any, that was added to your farm to receive the reclaimed water. If storage was created, about how much land was used to create that storage and what would that land have been used for if it had not been converted to storage? Use additional pages or the back of this page to explain, if needed.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

19. Did your farm receive any money from the Southwest Florida Water Management District or other government agency to pay for some or all of these changes?

____ Yes (proceed to question 20) _____ No (proceed to question 21)

20. How much money did your farm receive from the Southwest Florida Water Management District or other government agency to pay for some or all of these changes? $_____

21. To the best of your knowledge, what was the cost to make the changes to the irrigation and/or pumping systems and/or to develop a water storage area? Include the cost of any employee time spent in making these changes. Please **do not deduct** the money your farm may have received from a government agency. To answer this question, please fill in the table below.

Question 21 **Cost to Change Irrigation and/or Pumping Systems and/or to Develop Water Storage Area**	
Year that these costs were incurred, YEAR:_____	
Item	**One Time Cost in $**
Change irrigation system	
Change pumping system	
Develop water storage / holding ponds	
Land development not included in the items above	
Blend reclaimed water with water from other sources	
Other items, as applicable:	
Explanatory notes, if needed:	

22. Are there any annual costs associated with your farm's use of reclaimed water (other than payments made to the utility)?

___ Yes ___ No

If yes, please describe these costs and provide the estimated annual value of these costs ($) in the table below. Please include the estimated costs of labor, machinery, materials and chemicals, as appropriate.

Question 22 - Annual Costs Associated with Using Reclaimed Water	
Year represented by these costs, YEAR:_____	
Item	**Annual Cost in $**
1. Irrigation management	
2. Fertilizer management	
3. Salinity and pH management	
a. chemical applications	
b. reclaimed water blending	
c. periodic soil leaching – How often? _____	
d. other, describe: _____	
4. Pest or algae management	
5. Recording / reporting	
6. Other items, as applicable:	
Explanatory notes, if needed:	

23. Does your farm adjust its fertilizer to account for nutrients, soil pH and/or salinity in the reclaimed water?

___ Yes ___ No

If yes, what adjustments does your farm make (for example, reducing nutrient applications, applying calcium or lime, increasing soil sampling frequency)?

_____

_____

_____

_____

24. As a result of receiving and using the reclaimed water, did your farm experience any cost reductions associated with its irrigation and/or pumping systems, such as lower fuel costs, or other agronomic or management practices, such as reduced fertilizer application costs?

___ Yes (proceed to question 25) ____ No (proceed to question 27)

25. Please briefly describe the cost reductions associated with receiving and using the reclaimed water. Use additional pages or the back of this page to explain, if needed.

_____

_____

_____

_____

_____

_____

_____

26. To the best of your knowledge, what is the value of the one-time and/or annual cost reductions in dollars associated with receiving and using the reclaimed water? Include the cost savings from any employee time savings. To answer this question, please fill in the table below.

Question 26 - Cost Reductions Associated with Receiving the Reclaimed Water		
Year represented by these costs, YEAR:_____		
Item	**One Time Cost Reduction in $**	**Annual Cost Reduction in $**
Reduced pumping system fuel cost		
Reduced fertilizer cost, including materials, labor and application		
Reduced irrigation system management cost		
Reduced pumping system cost, other than fuel		
Reduced water storage of about _____ acre-feet or _____ gallons		
Other items, as applicable:		
Explanatory notes, if needed:		

27. After your farm began irrigating with reclaimed water, has your farm noticed any changes in crop productivity per acre (crop yield, including pounds of juice per acre)?

___ Yes (proceed to question 28) ____ No (proceed to question 29)

28. In the table below, please describe your understanding of how and why your farm's crop productivity has changed after using reclaimed water.

Question 28 **How Has Your Farm's Crop Productivity Changed After Using Reclaimed Water**				
Name of crop (If applicable, put oranges and juice on different rows)	**Crop Productivity Per Acre (check one)**		**Estimated Percent Change (%) in Yield per Acre**	**Please provide your understanding of when and why this happened. (Use extra space, if needed.)**
	Increased	**Decreased**		

29. The table below is a list of the potential benefits of using reclaimed water. Please review this list and write a YES next to those that you believe <u>your farm has received</u> as a result of using reclaimed water. Otherwise, please write NO or DK for "Don't Know". Please list any other benefits your farm has received from using reclaimed water.

Question 29 - List of Reclaimed Water Benefits Your Farm has Received as a Result of Using Reclaimed Water	
Reclaimed Water Benefit – "Because we use reclaimed water, …"	**If your farm HAS enjoyed this benefit from reclaimed water, please write YES. Otherwise write NO or DK for "Don't Know".**
a. we have been able to irrigate more frequently than if we used a traditional water source.	
b. we have been able to apply more water to the crop than if we used a traditional water source.	
c. the quality of our crop has been higher than if we had used a traditional water source.	
d. the crop yield has been higher than if we had used a traditional water source.	
e. the pounds of juice per acre is higher than if we had used a traditional water source.	
f. we are able to conserve fresh water sources for our other uses.	
g. we are better able to protect our crops from freezing temperatures.	
h. we are better able to supply water to our crops during drought conditions.	
i. our irrigation costs are lower.	

Question 29 - List of Reclaimed Water Benefits Your Farm has Received as a Result of Using Reclaimed Water	
Reclaimed Water Benefit – "Because we use reclaimed water, …"	**If your farm HAS enjoyed this benefit from reclaimed water, please write YES. Otherwise write NO or DK for "Don't Know".**
j. our fertilization costs are lower.	
k. our water storage costs are lower.	
l. we have a guaranteed and reliable water source.	
m. our revenue is higher than if we used a traditional water source.	
n. our net income is higher than if we used a traditional water source.	
Please list any other benefits your farm has received from using reclaimed water:	

30. Since your farm began using reclaimed water, has it ever been restricted or rationed, or has it ever become unavailable when needed?

___ Yes (proceed to question 31) ____ No (proceed to question 32)

31. Please fill in the table below regarding the approximate dates and number of days that the reclaimed water was restricted, rationed or not available. Also, please briefly describe the impact on crop production. If no impact, then please write NONE in the appropriate cell. If you cannot remember the exact month, write your estimated month and place a question mark (?) next to it.

Question 31 - Dates and Number of Days that the Reclaimed Water was Restricted, Rationed or Not Available and Impact on Crop Production				
Month and Year	**Place X in Applicable Column**		**Number of Days**	**Impact on Crop Production**
	Restricted or Rationed	**Not Available**		

32. The table below lists the potential or perceived problems associated with using reclaimed water. Please review this list and write a YES next to those that you believe your farm has encountered as a result of using reclaimed water. Otherwise, please write NO or DK for "Don't Know". Please list any other problems your farm has encountered from using reclaimed water. If your farm was able to correct the problem, how was it corrected?

Question 32 **List of Problems and Solutions Your Farm has Encountered as a Result of Using Reclaimed Water**		
Reclaimed Water Problems – "Because we use reclaimed water, …"	**If your farm HAS encountered this problem from reclaimed water, write YES and indicate the Crop Types affected. Otherwise write NO or DK for "Don't Know".**	**Was Your Farm Able to Correct this Problem? YES or NO. If YES, how was this problem resolved?**
a. the initial investment cost was high and made it difficult to connect to the reclaimed water system.		
b. the irrigation water must be filtered or treated prior to use. Reason:_____		
c. we need to blend it with water from another source to improve water quality. This other water source is: _____		
d. the irrigation water tends to be supplied at pressures greater than desired which causes problems with pipes, valves or application (i.e. drippers, microjet sprinklers) devices.		
e. the water pressure fluctuates and causes irrigation management or other problems.		
f. our record keeping and/or reporting has increased significantly.		
g. our crop sales have fallen due to concerns regarding food safety.		
h. we are forced to take more reclaimed water than needed.		
i. we are limited to certain days and/or times when we may obtain reclaimed water.		
j. our plants experience a toxic reaction when fertilizer or chemicals are applied.		
k. the chloride or salt content of our irrigation water is higher than if we used a traditional water source and has negatively affected crop quality and/or yield.		
l. we need to use more pesticides than we would with a traditional water source.		
m. we have had to address employee health or safety concerns.		
n. we need to change the pH of the reclaimed water before use.		

Question 32 List of Problems and Solutions Your Farm has Encountered as a Result of Using Reclaimed Water		
Reclaimed Water Problems – "Because we use reclaimed water, …"	**If your farm HAS encountered this problem from reclaimed water, write YES and indicate the Crop Types affected. Otherwise write NO or DK for "Don't Know".**	**Was Your Farm Able to Correct this Problem? YES or NO. If YES, how was this problem resolved?**
o. the quality of our crop is lower than if we used a traditional water source.		
p. our equipment has had rust or other problems.		
q. we have problems with algae growth on the irrigation lines/heads or storage ponds.		
r. we have had problems with clogged irrigation heads.		
s. sometimes we do not have enough irrigation water for our needs.		
t. our revenue is lower than if we used a traditional water source.		
u. our net income is lower than if we used a traditional water source.		
Please list any other problems your farm has encountered from using reclaimed water:		**Was Your Farm Able to Correct this Problem? YES or NO. If YES, how was this problem resolved?**

33. Has your farm experienced any issues associated with marketing your crops due to your farm's use of reclaimed water, such as additional record keeping requirements or problems with third party audits?

___ Yes (proceed to question 34) ____ No (proceed to question 35)

34. Please describe the marketing issues associated with your farm's use of reclaimed water, the crop types affected, the amount of time it took your farm to address these issues, and the impact on your farm.

35. Overall, how satisfied is your farm with the following aspects of its **reclaimed water** supplied by a utility? (Please place a check mark or X next to your answer.)

a. Water Supply Reliability	___ Very Satisfied ___ Satisfied ___ Somewhat satisfied ___ Not satisfied
b. Water Quantity	___ Very Satisfied ___ Satisfied ___ Somewhat satisfied ___ Not satisfied
c. Water Quality	___ Very Satisfied ___ Satisfied ___ Somewhat satisfied ___ Not satisfied

36. Do you believe that the total benefit your farm is receiving from using reclaimed water is greater than the total cost your farm is paying for reclaimed water (after subtracting any money received from government agencies)?

____ Yes ____ No

37. If your farm could do it all over again, would your farm agree to connect to the reclaimed water system? If you cannot speak for your business, would you agree to connect this farm if the choice was yours alone?

___ YES ___ NO

If **YES**, what are the reasons that your farm or you **would** connect to the reclaimed water system?

_____

_____

_____

If **NO**, what are the reasons that your farm or you **would not** connect to the reclaimed water system?

_____

_____

_____

PART B – SURVEY COMPLETED

This completes the survey. We thank you for providing this very important information. Please email, fax or mail your completed survey to:

Jenaveve Miller
Hazen and Sawyer
2201 Cantu Court, Suite 109
Sarasota, Florida 34232
(941) 378-2862, voice
(941) 378-0196, fax
jhmiller@hazenandsawyer.com

HAZEN AND SAWYER
Environmental Engineers & Scientists

Hazen and Sawyer, P.C.
4000 Hollywood Boulevard
750N, North Tower
Hollywood, FL 33021
Phone: (954) 987-0066
Fax: (954) 987-2949
gjohns@hazenandsawyer.com

October 5, 2009

NAME
ADDRESS

Request to Complete
"Reclaimed Water User Survey"

Dear NAME:

Hazen and Sawyer, P.C., on behalf of the Southwest Florida Water Management District, would like you to complete the attached "Reclaimed Water User Survey". This survey is being sent to all reclaimed water users in the District and some outside of this District who receive reclaimed water from a utility. The District will use the survey responses to improve its assistance to water users who are considering the use of reclaimed water.

This survey asks questions regarding the benefits and costs of reclaimed water to the survey respondent's business or operations. While some of the benefits and costs of reclaimed water have been studied at the scientific level, research regarding "on-the-ground" experiences with reclaimed water is limited.

Your participation in this survey will allow the District to learn from experienced reclaimed water users regarding their benefits and costs of reclaimed water in order to:

a. Improve the District's ability to assist water users in assessing the benefits and costs of reclaimed water to them;

a. Identify areas of future research that address how the net benefits of reclaimed water to water users can be as great as possible; and

b. Better assess whether or not reclaimed water is economically feasible to specific water users.

In particular, the District would like to identify the actual benefits that have been experienced by reclaimed water users in addition to the costs of reclaimed water.

We would appreciate your returning this completed survey on or before **Thursday, October 30th** at the address, email or fax information provided on the last page of the survey. I am happy to answer any questions. My contact information is on this letterhead. The District's contact person for this project is Mr. Don Rome who can be reached at Don.Rome@swfwmd.state.fl.us or (800) 423-1476 (toll free), extension 4367. We thank you for taking the time to complete this important survey.

Very truly yours,
HAZEN AND SAWYER, P.C.

Grace Johns

Grace Johns, Ph.D.
Senior Associate and Project Manager

enclosure

Reclaimed Water User Survey – 2009
Recreation / Aesthetic Water Uses – October 5, 2009

Water Use Permit Number: _____

Project Name on WUP Permit:_____

Name of Respondent: _____ Respondent Telephone number: _____

Business Name:_____

PART A – RECLAIMED WATER USE QUESTIONS

Please Note: All of the questions below pertain to **reclaimed water <u>supplied by a utility</u>**.

1. Does your firm use reclaimed water supplied by a utility?

_____ Yes (proceed to question 2); _____ No (proceed to Part B on page 10)

2. What is the name of the utility that provides your firm with reclaimed water?

_____

3A. Please briefly describe your firm's uses of reclaimed water.

_____

_____

3B. Please place an X next to all the areas irrigated with reclaimed water:

___ golf course greens; ___ golf course fairways; ___ golf course roughs; ___ golf course tees;

___ ornamental landscape; ___ playing field(s); ___ other lawn; ___ other

4. How many total acres does your firm irrigate with reclaimed water from a water utility?

_____ acres

5. Please indicate the type of lawn/grass (St. Augustine, bahia, Bermuda, etc.) and/or type of landscape plants (trees, flowers, shrubs) that your firm irrigates with reclaimed water, the acres irrigated, and the type of irrigation system used (eg. sprinkler, drip) ? To answer this question, please fill in the table below.

Question 5 **Grass and Landscape Types and Acreages Irrigated with Reclaimed Water and Irrigation Systems Used**		
Grass and/or Landscape Type	**Acres Irrigated With Reclaimed Water**	**Type of Irrigation System Used**

6. How long has your firm been using reclaimed water (supplied by a utility) for irrigation?

_____ Years and _____ months

7. About how much reclaimed water does your firm use, on average? _____ Please indicate the unit of measurement here (for example, gallons per month): _____.

8. What percentage of your firm's total irrigation water use is reclaimed water from a utility? _____%

9. Does your firm know the nutrient contents and chemical constituents of your reclaimed water (for example, nitrogen, phosphorus, chlorine, pH, hardness)?

____ Yes (proceed to question 11) _____ No (proceed to question 10)

10. Does your firm know how to obtain information regarding the nutrient contents and chemical constituents of your reclaimed water (for example, nitrogen, phosphorus, chlorine, pH, hardness)? ____ Yes _____ No

11. What were the primary reasons that your firm connected to the reclaimed water system?

_____

_____

_____

12. If your firm had NOT connected to the reclaimed water supply, what other water source would your firm have been able to use, instead (please check all that apply)?

___ Floridan aquifer well

___ Other ground water source, please specify _____

___ Surface water source, please specify: _____

___ Other source, please specify: _____

___ No other water source was available.

13. Does your firm pay its reclaimed water provider for the reclaimed water?

____ Yes (proceed to question 14) _____ No (proceed to question 16)

14. How much does your firm pay your reclaimed water provider?

Fixed charge: $_____ per month

Variable charge: $_____ per 1,000 gallons of reclaimed water

Other charge, if applicable: $_____

15. About how much does your firm pay your reclaimed water provider annually? $_____

16. When was the reclaimed water connected to your facility? (Check one)

___ Before the irrigation system was installed.

___ During irrigation system installation.

___ After the irrigation system was installed.

17. How is the reclaimed water stored at your facility? (Check all that apply)

____ No Storage ____ Open ponds or lakes

____ Tanks ____ Other – describe _____

18. When your firm connected to the reclaimed water system, did your firm have to make any changes to the irrigation or pumping systems or did your firm construct or develop water storage in order to accept the reclaimed water?

___Yes (proceed to question 19); ___ No (proceed to question 23)

19. Please briefly describe the changes that were made to the irrigation and/or pumping systems to receive the reclaimed water. Also, please indicate the amount and type of storage, if any, that was added to your operation in order to receive the reclaimed water. If storage was created, how much land was used to create that storage and what would this land have been used for if it had not been converted to storage? Use additional pages or the back of this page to explain, if needed.

_____

_____

_____

_____

_____

_____

_____

_____

20. Did your firm receive any money from the Southwest Florida Water Management District or other government agency to pay for some or all of these changes?

____ Yes (proceed to question 21) _____ No (proceed to question 22)

21. How much money did your firm receive from the Southwest Florida Water Management District or other government agency to pay for some or all of these changes?

$_____

22. To the best of your knowledge, how much did it cost to make the changes to the irrigation and/or pumping systems, and/or to develop a water storage area? Include the cost of any employee time spent in making these changes. Please **do not deduct** the money you may have received from government agency(ies). To answer this question, please fill in the table below.

Question 22 **Cost to Change Irrigation and/or Pumping Systems and/or to Develop Water Storage Area**	
Year that these costs were incurred, YEAR:_____	
Item	**One Time Cost in $**
Change irrigation system	
Change pumping system	
Develop water storage / holding ponds	
Land development not included in the items above	
Blend reclaimed water with water from other sources	
change plant material (grass or landscape plants)	
Other items, as applicable:	
Explanatory notes, if needed:	

23. Are there any annual costs associated with your firm's use of reclaimed water (other than payments made to the utility)? ___ Yes ___ No

If yes, please describe these costs and provide the value of these costs ($) in the table below. Please include the estimated costs of labor, machinery, materials and chemicals, as appropriate.

Question 23 - Annual Costs Associated with Using Reclaimed Water	
Year represented by these costs, YEAR:_____	
Item	**Annual Cost in $**
1. Irrigation management	
2. Fertilizer management	
3. Salinity and/or pH management	
a. chemical applications	
b. reclaimed water blending	
c. change plant material (grass or landscape plants), Put one-time cost here, if applicable: $_____	
d. mechanical and other means, describe: _____	
4. Pest or algae management	
5. Recording / reporting	
6. Other items, as applicable:	
Explanatory notes, if needed:	

24. Does your firm adjust its fertilizer to account for nutrients, soil pH and/or salinity in the reclaimed water?

___ Yes ___ No

If yes, what adjustments does your firm make (for example, reducing nutrient applications, applying calcium or lime, increasing soil sampling frequency)?

_____

_____

_____

25. As a result of receiving and using the reclaimed water, did your firm experience any cost reductions associated with its irrigation and/or pumping systems, such as lower fuel costs, or other agronomic or management practices, such as reduced fertilizer application costs?

___ Yes (proceed to question 26) ____ No (proceed to question 28)

26. Please briefly describe the cost reductions associated with receiving and using the reclaimed water. Use additional pages or the back of this page to explain, if needed.

_____

_____

_____

_____

_____

_____

27. To the best of your knowledge, what is the value of the cost reductions in dollars associated with receiving and using the reclaimed water? Include the cost savings from any employee time savings. To answer this question, please fill in the table below.

Question 27 - Cost Reductions Associated with Receiving the Reclaimed Water		
Year represented by these costs, YEAR: _____		
Item	**One Time Cost Reduction in $**	**Annual Cost Reduction in $**
Reduced pumping system fuel cost		
Reduced fertilizer cost, including materials, labor and application		
Reduced irrigation system management cost		
Reduced pumping system cost, other than fuel		
Reduced water storage of about _____ acre-feet or _____ gallons		
Other items, as applicable:		
Explanatory notes, if needed:		

28. Has your firm noticed any changes in the quality of your lawn and/or landscape after you began irrigating with reclaimed water?

___ Yes (proceed to question 29) ____ No (proceed to question 30)

29. In the table below, please describe your understanding of how and why your firm's lawn and/or landscape quality has changed after using reclaimed water.

Question 29 **How Your Firm's Lawn and/or Landscape Quality Has Changed After Using Reclaimed Water**				
Grass or Landscape Type and Area (e.g., fairway, playing field)	**Lawn and/or Landscape Quality (check one)**		**Was change significant, moderate or small? (write answer in box below)**	**Please describe the quality change and provide your understanding of when and why this happened. (Use extra space, if needed.)**
	Increased	**Decreased**		

30. The table below is a list of the potential benefits of using reclaimed water. Please review this list and write a YES next to those that you believe <u>your business has received</u> as a result of using reclaimed water. Otherwise, please write NO or DK for "Don't Know". Please list any other benefits your business has received from using reclaimed water.

Question 30 - List of Reclaimed Water Benefits Your Firm has Received as a Result of Using Reclaimed Water	
Reclaimed Water Benefit – "Because we use reclaimed water, …"	**If your business HAS enjoyed this benefit from reclaimed water, please write YES. Otherwise write NO or DK for "Don't Know".**
a. we have been able to irrigate more frequently than if we used a traditional water source.	
b. we have been able to apply more water to our lawn and/or landscape than if we used a traditional water source.	
c. the quality of our lawn and/or landscape has been higher than if we had used a traditional water source.	
d. we are able to conserve fresh water sources for our other uses	
e. our irrigation costs are lower	
f. our fertilization costs are lower	
g. our water storage costs are lower	
h. we have a guaranteed and reliable water source	
i. our business has increased during fresh water shortage restrictions because we have sufficient reclaimed water supply.	

Question 30 - List of Reclaimed Water Benefits Your Firm has Received as a Result of Using Reclaimed Water	
Reclaimed Water Benefit – "Because we use reclaimed water, …"	**If your business HAS enjoyed this benefit from reclaimed water, please write YES. Otherwise write NO or DK for "Don't Know".**
j. our revenue is higher than if we used a traditional water source.	
k. our net income is higher than if we used a traditional water source.	
Please list any other benefits your firm has received from using reclaimed water:	

31. Since your firm began using reclaimed water, has it ever been restricted or rationed, or has it ever become unavailable when needed?

___ Yes (proceed to question 32) ____ No (proceed to question 33)

32. Please fill in the table below regarding the approximate dates and number of days that the reclaimed water was restricted, rationed or not available. Also, please briefly describe the impact on your business. If no impact, then please write NONE in the appropriate cell. If you cannot remember the exact month, write your estimated month and place a question mark (?) next to it.

Question 32: Dates and Number of Days that the Reclaimed Water was Restricted, Rationed or Not Available and Impact on Business				
Month and Year	**Place X in Applicable Column**		**Number of Days**	**Impact on Business**
	Restricted or Rationed	**Not Available**		

33. The table below is a list of the potential or perceived problems associated with using reclaimed water. Please review this list and write a YES next to those that you believe your business has encountered as a result of using reclaimed water. Otherwise, please write NO or DK for "Don't Know". Please list any other problems your business has encountered from using reclaimed water. If your firm was able to correct the problem, how was it corrected?

Question 33 - List of Problems Your Business HAS Encountered as a Result of Using Reclaimed Water		
Reclaimed Water Problems – "Because we use reclaimed water, …"	**If your business HAS encountered this problem from reclaimed water, write YES and indicate the grass or plant types affected. Otherwise write NO or DK for "Don't Know".**	**Was Your Business Able to Correct this Problem? YES or NO. If YES, how was this problem resolved?**
a. the initial investment cost was high and made it difficult to connect to the reclaimed water system.		
b. the irrigation water must be filtered or treated prior to use. Reason:_____		
c. we need to blend it with water from another source to improve water quality. This other water source is: _____		
d. the irrigation water tends to be supplied at pressures greater than desired which causes problems with pipes, valves or application (i.e. drippers, microjet sprinklers) devices.		
e. the water pressure fluctuates and causes irrigation management or other problems.		
f. our record keeping and/or reporting has increased significantly.		
g. our customers are concerned about potential contact with the reclaimed water.		
h. we are forced to take more reclaimed water than needed.		
i. we are limited to certain days and/or times when we may obtain reclaimed water.		
j. our lawn and/or plants experience a toxic reaction when fertilizer or chemicals are applied.		
k. the chloride or salt content of our irrigation water is higher than if we used a traditional water source and has negatively affected plant/grass quality.		

Question 33 - List of Problems Your Business HAS Encountered as a Result of Using Reclaimed Water		
Reclaimed Water Problems – "Because we use reclaimed water, …"	**If your business HAS encountered this problem from reclaimed water, write YES and indicate the grass or plant types affected. Otherwise write NO or DK for "Don't Know".**	**Was Your Business Able to Correct this Problem? YES or NO. If YES, how was this problem resolved?**
l. we need to use more pesticides or fungicides than we would with a traditional water source.		
m. we have had to address employee health or safety concerns.		
n. we need to change the pH of the reclaimed water before use.		
o. our equipment has had rust or other problems.		
p. we have problems with algae growth on the lawn/landscape, irrigation lines/heads or storage ponds.		
q. we have had problems with clogged irrigation heads.		
r. sometimes we do not have enough reclaimed water for our needs.		
s. our revenue is lower than if we used a traditional water source.		
t. our net income is lower than if we used a traditional water source.		
Please list any other problems your business has encountered from using reclaimed water:		**Was Your Business Able to Correct this Problem? YES or NO. If YES, how was this problem resolved?**

34. Overall, how satisfied is your firm with the following aspects of its **reclaimed water** supplied by a utility? (Please place a check mark or X next to your answer.)

a. Water Supply Reliability	___ Very Satisfied ___ Satisfied ___ Somewhat satisfied ___ Not satisfied
b. Water Quantity	___ Very Satisfied ___ Satisfied ___ Somewhat satisfied ___ Not satisfied
c. Water Quality	___ Very Satisfied ___ Satisfied ___ Somewhat satisfied ___ Not satisfied

35. Do you believe that the total benefit your firm is receiving from using reclaimed water is greater than the total cost your firm is paying for reclaimed water (after subtracting any money received from government agencies)?

___ Yes ____ No

36. If your firm could do it all over again, would your firm agree to connect to the reclaimed water system? If you cannot speak for your firm, would you agree to connect this facility if the choice was yours alone?

___ YES ___ NO

If **YES**, what are the reasons that your firm or you **would** connect to the reclaimed water system?

_____

_____

_____

If **NO**, what are the reasons that your firm or you **would not** connect to the reclaimed water system?

_____

_____

_____

PART B – SURVEY COMPLETED

This completes the survey. We thank you for providing this very important information. Please email, fax or mail your completed survey to:

Jenaveve Miller
Hazen and Sawyer
2201 Cantu Court, Suite 109
Sarasota, Florida 34232
(941) 378-2862, voice
(941) 378-0196, fax
jhmiller@hazenandsawyer.com

HAZEN AND SAWYER
Environmental Engineers & Scientists

Hazen and Sawyer, P.C.
4000 Hollywood Boulevard
750N, North Tower
Hollywood, FL 33021
Phone: (954) 987-0066
Fax: (954) 987-2949
gjohns@hazenandsawyer.com

October 12, 2009

NAME
ADDRESS

Request to Complete
"Reclaimed Water User Survey"

Dear NAME:

Hazen and Sawyer, P.C., on behalf of the Southwest Florida Water Management District, would like you to complete the attached "Reclaimed Water User Survey". This survey is being sent to all reclaimed water users in the District and some outside of this District who receive reclaimed water from a utility. The District will use the survey responses to improve its assistance to water users who are considering the use of reclaimed water.

This survey asks questions regarding the benefits and costs of reclaimed water to the survey respondent's business or operations. While some of the benefits and costs of reclaimed water have been studied at the scientific level, research regarding "on-the-ground" experiences with reclaimed water is limited.

Your participation in this survey will allow the District to learn from experienced reclaimed water users regarding their benefits and costs of reclaimed water in order to:

a. Improve the District's ability to assist water users in assessing the benefits and costs of reclaimed water to them;

a. Identify areas of future research that address how the net benefits of reclaimed water to water users can be as great as possible; and

b. Better assess whether or not reclaimed water is economically feasible to specific water users.

In particular, the District would like to identify the actual benefits that have been experienced by reclaimed water users in addition to the costs of reclaimed water.

We would appreciate your returning this completed survey on or before **Friday, November 6th** at the address, email or fax information provided on the last page of the survey. I am happy to answer any questions. My contact information is on this letterhead. The District's contact person for this project is Mr. Don Rome who can be reached at Don.Rome@swfwmd.state.fl.us or (800) 423-1476 (toll free), extension 4367. We thank you for taking the time to complete this important survey.

Very truly yours,

HAZEN AND SAWYER, P.C.

Grace Johns, Ph.D.
Senior Associate and Project Manager

enclosure

INDUSTRIAL RECLAIMED WATER USE SURVEY October 12, 2009

This survey pertains only to reclaimed water purchased or obtained from a reclaimed water utility and used by your firm or facility. It does not apply to on-site industrial re-use water.

Section 1*: *Respondent and Reclaimed Water Usage Information

1. Water Use Permit Number: _____

   Project Name: _____

   Survey Respondent Name:_____

   Respondent Phone Number: _____

   Address: _____

   City, State, Zip: _____

2. Reclaimed Water purchased from or provided by:
   Utility Name: _____

3. Which of these constituents or characteristics of reclaimed water provide value to your operation?
   (Please check all that apply)
   - ☐ Nitrogen
   - ☐ Phosphorus
   - ☐ Chlorine
   - ☐ pH
   - ☐ Hardness
   - ☐ Other, please specify _____

Please briefly explain how the items checked above provide value to your operation.

_____

_____

_____

4. What were the primary reasons your firm connected to reclaimed water?

_____

_____

_____

5. If your firm had not connected to reclaimed water, what other source would your firm have used? *(Please check all that apply)*

- ☐ Floridan aquifer well
- ☐ Other groundwater source, please specify_____
- ☐ Surface water source, please specify_____
- ☐ Other source, please specify_____
- ☐ No other water source available

6. Does your firm have a public education program that highlights your firm's use of reclaimed water?

____ Yes; _____ No

7. What year was reclaimed water supplied by a utility first used at your facility? _____

8. How much reclaimed water is your facility designed to use? _____
Unit of measurement *(Please check one that applies to your answer):*

- ☐ gpm
- ☐ gpd
- ☐ mgd
- ☐ other, please specify:_____

9. How much reclaimed water does your facility use annually (in total gallons), using the most recent 12-month period of available data? _____
This usage is: ____ Metered; _____ Estimated

10. Of the total water usage at your facility, what percentage (%) is reclaimed water? _____

11. For what purposes does your facility use reclaimed water? To answer this question, please fill in the table below with the percent of the total reclaimed water used in each reclaimed water end use.

Reclaimed Water End Use	**Percent of Total Reclaimed Water Used (%)**
Cooling Water	
Process Water	
High-Purity Use	
Boiler Make-up Water	
Scrubber Make-up Water	
Air Conditioning	
Condensing / Refrigeration	
Onsite Irrigation	
Sanitary	
Storm water Treatment	
Other, Please specify_____	
Other, Please specify_____	
Total	**100%**

Section 2: Costs Associated With Reclaimed Water Use

12. Does your firm pay the utility for reclaimed water? ____ Yes; ____ No

If yes, how much does your firm pay the utility ($)?

Fixed charge: $_____per month

Variable charge: $_____per 1000 gallons of reclaimed water

One-time connection cost: $_____

Other charge, if applicable: $_____

13. Did your firm receive any money from the Southwest Florida Water Management District or other government agency to connect to the utility's reclaimed water? ____ Yes; ____ No

If yes, how much money did your firm receive? Amount $ _____

Approximate Year this money was obtained? _____

14. Were water mains or other infrastructure provided at no charge by the reclaimed water supplier?

____ Yes; ____ No

If yes, please briefly describe what was provided by the reclaimed water supplier:

_____

_____

_____

15. When your firm connected to reclaimed water, were any changes made to your firm's piping or connection equipment? ____ Yes; ____ No

If yes, please briefly describe those changes and provide their costs in the table below. Include the cost of any employee time spent in making these changes. Please **do not deduct** the money you may have received from government agency(ies).

Question 15 - Cost to Change Piping and Connection Equipment	
Year that these costs were incurred, YEAR:_____	
Item	**One Time Cost in $**
Explanatory notes, if needed:	

16. What additional water treatment or pre-treatment equipment was installed specifically to address reclaimed water quality conditioning and improvement? If none were installed, please write None.

_____

_____

_____

_____

17. What was the approximate cost to install the additional water treatment or pre-treatment equipment needed to treat the reclaimed water? To answer this question, please fill in the table below. Include the cost of any employee time spent. Please **do not deduct** the money your firm may have received from government agency(ies). If NONE were installed, please skip to Question 18.

Question 17 **Cost to Install Additional Water Treatment or Pre-Treatment**	
Year that these costs were incurred, YEAR:_____	
Item	**One Time Cost in $**
Explanatory notes, if needed:	

18. When you connected to reclaimed water, were any modifications made to your Industrial Waste Water Permit?

- ☐ Yes
- ☐ No

If yes, please briefly describe the changes made to the permit and the approximate costs associated with the permit modification.

_____

_____

_____

19. Were there any other one-time costs associated with connecting to reclaimed water?

- ☐ Yes
- ☐ No

If yes, please briefly describe these costs and provide these costs ($) in the table below. Include the cost of any employee time spent. Please **do not deduct** the money you may have received from government agency(ies).

Question 19 **Other One-Time Costs Not Included Above**	
Year that these costs were incurred, YEAR:_____	
Item	**One Time Cost in $**
Explanatory notes, if needed:	

20A. What additional water treatment chemicals are required to specifically address reclaimed water quality conditioning and improvement?

_____

_____

20B. What is the approximate annual cost of the chemicals? $_____per year

21. Is additional residual and/or waste generated in the treatment described above?

- ☐ Yes
- ☐ No

If yes, what is the approximate annual cost for handling and disposing the residuals and waste generated from treating the reclaimed water?

$_____per year

22. After receiving reclaimed water, did your firm experience any cost increases associated with processing or manufacturing not included in your answers above, such as additional power or fuel costs?

- ☐ Yes
- ☐ No

If yes, please briefly describe the cost increases and provide the estimated cost and indicate if this cost is annual or a one-time cost ($).

_____

_____

_____

_____

23. Did your firm add additional personnel with specific skills and training to incorporate reclaimed water into your facility?

- ☐ Yes, How many people where added? _____
- ☐ No

Section 3*: *Benefits of Using Reclaimed Water

24. The table below is a list of the potential benefits, including cost savings, from using reclaimed water. Please review this list and write a YES next to those that you believe your firm has received as a result of using reclaimed water. Otherwise, please write NO or DK for "Don't Know". Please list any other benefits your firm has received from using reclaimed water. If you can, please write your estimate of the dollar value of this benefit in the last 2 columns either as a one-time benefit or an annual benefit to your firm. Because many of these items are related, just indicate the approximate cost savings in the most relevant row.

Question 24 **Reclaimed Water Benefits Your Firm has Received as a Result of Using Reclaimed Water**			
Reclaimed Water Benefit – "Because we use reclaimed water, …"	**If your firm HAS enjoyed this benefit from reclaimed water, please write YES. Otherwise write NO or DK for "Don't Know".**	**Estimated One-Time Cost Savings ($)**	**Estimated Annual Cost Savings ($)**
a. we have more water available for beneficial use.			
b. we can conserve fresh water supplies for our other uses.			
c. our facility's permitting requirements are reduced.			
d. our facility's energy use is lower.			
e. we no longer need to pre-treat our water .			
f. we no longer need to employ reverse osmosis to treat lesser quality source water.			
g. our water costs are lower.			
h. the quality of our product has improved.			
i. the quantity of our product has increased.			
j. we have experienced production cost savings.			
k. our water storage costs are lower.			
l. we have a guaranteed and reliable water source.			
m. our sales are higher because our firm markets our use of reclaimed water.			
n. our revenue is higher than if we used a traditional water source.			
o. our net income is higher than if we used a traditional water source.			

Question 24 Reclaimed Water Benefits Your Firm has Received as a Result of Using Reclaimed Water			
Reclaimed Water Benefit – "Because we use reclaimed water, …"	**If your firm HAS enjoyed this benefit from reclaimed water, please write YES. Otherwise write NO or DK for "Don't Know".**	**Estimated One-Time Cost Savings ($)**	**Estimated Annual Cost Savings ($)**
Please list any other benefits, including any cost savings, your firm has received from using reclaimed water:			

Section 4: Reclaimed Water Use Problems and Solutions

25. The table below lists the potential or perceived problems associated with using reclaimed water. Please review this list and write a YES next to those that you believe your firm has encountered as a result of using reclaimed water. Otherwise, please write NO or DK for "Don't Know". Please list any other problems your firm has encountered from using reclaimed water. If your firm was able to correct the problem, how was it corrected?

Question 25 List of Problems Your Firm has Encountered as a Result of Using Reclaimed Water and Solutions		
Reclaimed Water Problems – "Because we use reclaimed water, …"	**If your firm HAS encountered this problem from reclaimed water, write YES. Otherwise write NO or DK for "Don't Know".**	**Was Your Firm Able to Correct this Problem? YES or NO. If YES, how was this problem resolved?**
a. we've had problems with our city council or county commission associated with construction, easements, planning, etc.		
b. our water quality is lower than if we had used a traditional water source.		
c. our employees complain of the smell and/or color of the water.		
d. the amount of available water is less than if we had used a traditional water source.		
e. our cost of water is higher than if we had used a traditional water source.		
f. the initial investment cost was high and made it difficult to connect to the reclaimed water system.		
g. our recording / reporting requirements increased significantly.		

Question 25 List of Problems Your Firm has Encountered as a Result of Using Reclaimed Water and Solutions		
Reclaimed Water Problems – "Because we use reclaimed water, …"	**If your firm HAS encountered this problem from reclaimed water, write YES. Otherwise write NO or DK for "Don't Know".**	**Was Your Firm Able to Correct this Problem? YES or NO. If YES, how was this problem resolved?**
h. our operation and maintenance costs increased. Explain:_____		
i.we had to address increased pipe scaling issues.		
j. disinfection byproducts and/or total trihalomethanes (TTHMs) have caused equipment problems.		
k. we had to segregate potable and food processing water from reclaimed water at considerable expense.		
l. chemical constituent concentrations in waste water exceeded permit disposal limits.		
m. we are forced to take more reclaimed water than needed.		
n. the water pressure fluctuates and causes problems.		
o. we are limited to certain days and/or times when we may obtain reclaimed water.		
p. our water pressure is lower than if we had used a traditional water source and this has caused problems.		
q. our water treatment residuals / solids disposal cost has increased significantly		
r. the cost of disposing the wastewater from our reclaimed water treatment has increased significantly.		
s. our reclaimed water supply is unreliable.		
t. there are significant additional waste water permit requirements.		
u. there are many regulatory requirements to overcome.		
v. funding for reclaimed water infrastructure is not available at this time.		

Question 25 List of Problems Your Firm has Encountered as a Result of Using Reclaimed Water and Solutions		
Reclaimed Water Problems – "Because we use reclaimed water, …"	**If your firm HAS encountered this problem from reclaimed water, write YES. Otherwise write NO or DK for "Don't Know".**	**Was Your Firm Able to Correct this Problem? YES or NO. If YES, how was this problem resolved?**
w. our customers have expressed a negative perception of reclaimed water in general.		
Please list any other problems your firm has encountered from using reclaimed water:		**Was Your Firm Able to Correct this Problem? YES or NO. If YES, how was this problem resolved?**

Section 5*: *Reclaimed Water Supply Reliability

26. Does your firm's supply of reclaimed water fluctuate from day to day? ____ Yes; ____ No

If yes, does this cause production or operational problems? ____ Yes; ____ No

If yes, please briefly explain the problems and if / how they were resolved?

_____

_____

_____

27. Are you interested in increasing your quantities of reclaimed water supply to meet additional industrial water requirements? ____ Yes; ____ No

28. Since your firm began using reclaimed water, has it ever been restricted, rationed, or become unavailable when needed? ____ Yes; ____ No

If yes, please fill in the table below regarding the approximate dates and number of days that the reclaimed water was restricted, rationed or not available. Also, please briefly describe the impact on production. If no impact, then please write NONE in the appropriate cell. If you cannot remember the exact month, write your estimated month and place a question mark (?) next to it.

Question 28 - Dates and Number of Days that the Reclaimed Water was Restricted, Rationed or Not Available and Impact on Production				
Month and Year	**Place X in Applicable Column**		**Number of Days**	**Impact on Production**
	Restricted or Rationed	**Not Available**		

Section 6: Overall Satisfaction From Using Reclaimed Water

29. Overall, how satisfied are you with the following aspects of your firm's reclaimed water supply?

1. Water supply reliability
   - ☐ very satisfied
   - ☐ satisfied
   - ☐ somewhat satisfied
   - ☐ not satisfied

2. Water quantity
   - ☐ very satisfied
   - ☐ satisfied
   - ☐ somewhat satisfied
   - ☐ not satisfied

3. Water quality
   - ☐ very satisfied
   - ☐ satisfied
   - ☐ somewhat satisfied
   - ☐ not satisfied

30. If your firm could do it over again, would your firm agree to connect to reclaimed water? If you cannot answer for your firm, would you agree to connect this firm if the choice was yours alone?

- ☐ Yes
- ☐ No

If yes, what are the reasons you or your firm would connect?

_____

_____

_____

If no, what are the reasons you or your firm would not connect?

_____

_____

_____

31. Please indicate any suggestions to maximize the benefits and /or minimize the cost of using reclaimed water at your facility including future research needs that may benefit your firm as it uses reclaimed water.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

SURVEY COMPLETED

This completes the survey. We thank you for providing this very important information. Please email, fax or mail your completed survey to:

Jenaveve Miller
Hazen and Sawyer
2201 Cantu Court, Suite 109
Sarasota, FL 34232
(941) 378-2862, voice
(941) 378-0196, fax
jhmiller@hazenandsawyer.com

APPENDIX B
TOTAL DYNAMIC HEAD (TDH)

Appendix B
Total Dynamic Head (TDH)

In general, every pump installation is unique and should be analyzed to determine the characteristics and type of pump required and the Total Dynamic Head (TDH) requirements for selection of the appropriate pump size. The ultimate goal to determine TDH knowing flow rate is to select the adequate pump curve and associated pump for the application. This will lead to the selection of an appropriate electric, diesel or gasoline drive to power the pump. The size of the drive and the hours of operation will determine the energy cost for operation. This analysis is valid when the capacity or flow rate used for calculations will be maintained at all times. If the pump is intended to discharge at various flow rates into a given piping system, a system head capacity curve analysis is required.

Below is the description of important terms that are involved in the determination of the required TDH. Good engineering judgment and experience are also important.

Total Dynamic Head: The total dynamic head ($\mathbf{H_t}$) is the head against which the pump must work when water is being pumped. The total dynamic head on a pump, commonly abbreviated TDH, can be determined by considering the static discharge and suction heads, the system pressure head, the frictional head losses, the velocity heads, and the minor head losses. The expression for determining the TDH on a pump in terms of the static head is given by:

$$H_t = H_{stat} + H_{fs} + H_{fd} + \sum H_{ms} + \sum H_{md} + V^2/2g$$

Where,

H_t is Total Dynamic Head, in feet;

H_{stat} is Static Head: Static head ($\mathbf{H_{stat}}$) is measured in feet and is calculated as the static discharge head ($\mathbf{H_d}$) plus the system pressure head ($\mathbf{H_{SP}}$) minus the static suction head ($\mathbf{H_s}$) or ($\mathbf{H_{stat} = H_d + H_{SP} - H_s}$).

Static Discharge Head: The static discharge head ($\mathbf{H_d}$) is the difference in elevation, in feet, between the discharge liquid level and the centerline of the pump impeller.

O:\44302-000\Wpdocs\R3

System Pressure Head: The system pressure head ($\mathbf{H_{SP}}$) is the pressure required at the irrigation system to operate the emitters (in psi or pounds per square inch) multiplied by 2.31 to convert psi to feet.

Static Suction Head: The static suction head ($\mathbf{H_s}$) is the difference in elevation, in feet, between the suction liquid level and the centerline of the pump impeller. If the suction liquid level is below the centerline of the pump impeller, it is a static suction lift. In cases where this information is unknown, a rough estimate can be the depth at which the submersible pump is set if pumping from a well.

Friction Head: The head of water, in feet, that must be supplied to overcome the frictional loss caused by the flow of fluid through the piping system. The frictional head loss in the suction ($\mathbf{H_{fs}}$) and discharge ($\mathbf{H_{fd}}$) piping system may be computed with the Darcy-Weisbach or Hazen-Williams equations. This information can be also available in tables on Hydraulics references. Suction refers to the water before it enters the pump and Discharge refers to the water after it leaves the pump.

Minor Head Loss: The head of water, in feet, that must be supplied to overcome the loss of head through fittings and valves. Minor losses in the suction and discharge piping system are usually estimated as fractions of the velocity head by using the following generalized equation:

$H_m = K \times V^2/2g$

H_m = minor head loss, ft

K = head loss coefficient

Typical values of K for various types of fittings can be obtained from standard books of hydraulics or from fitting manufacturers.

Minor Loss from Suction: This loss ($\sum \mathbf{H_{ms}}$) is the summation of the impacts of all individual values, fittings, etc. due to the water interacting with these accessories prior to entering the pump.

Minor Loss from Discharge: This loss ($\sum \mathbf{H_{md}}$) is the summation of the impacts of all individual values, fittings, etc. due to the the water interacting with these accessories after it leaves the pump.

Velocity Head: The velocity head **($V^2/2g$)** is the kinetic energy contained in a liquid being pumped at any point in the system and is given by

O:\4302-000\Wpdocs\R3

Velocity head = $V^2/2g$.

V = velocity of fluid, ft

g= acceleration due to gravity, 32.2 ft/s2

In determining the head at any point in a piping system, the velocity head must be added to the gage reading. In practice, the term $V^2/2g$ is usually considered to be lost at the outlet of the piping system and is normally taken as the equivalent to the exit loss and included as a minor loss. The term s2 means seconds squared.

Additional definitions are as follows.

Capacity: The capacity or flow rate of a pump is the volume of liquid pumped per unit of time, which usually is measured in liters per second or cubic meters per second or gallons per minute (gpm) or million gallons per day (MGD).

Head: The term head is the elevation of a free surface of water above or below a reference datum. In pumping systems, the head refers to both pumps and pump systems having one or more pumps and the corresponding piping system.

Once the TDH required for the particular flow rate is known, pump curves from manufacturers can be selected to determine the appropriate pump size for the application. Then, the power information can be used to estimate power composition in the way of electricity or fuel.

For additional information regarding the estimation of the various components of TDH, users may refer to the University of Florida, Institute of Food and Agricultural Sciences, Publication SP 281, entitled “Water and Florida Citrus”, (July 2002); edited by Brian J. Boman; Chapter 24 (pp. 264-275), and Appendix 10 (pp. 517-528).

O:\4302-000\Wpdocs\R3

HAZEN AND SAWYER
Environmental Engineers & Scientists