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*make every drop count*

# Economic and Conservation Evaluation of Capital Renovation Projects: Cameron County Irrigation District No. 2 (San Benito) – Interconnect Between Canals 39 and 13-A1 and Replacement of Rio Grande Diversion Pumping Plant

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# Preface[1]

Recognizing the seriousness of the water crisis in South Texas, the U.S. Congress enacted Public Law 106-576, entitled "The Lower Rio Grande Valley Water Resources Conservation and Improvement Act of 2000 (Act)." In that Act, the U.S. Congress authorized water conservation projects for irrigation districts relying on the Rio Grande for supply of agricultural irrigation, and municipal and industrial water. Several phases of project planning, development, evaluation, prioritization, financing, and fund appropriation are necessary, however, before these projects may be constructed.

Based on language in the Act, the "Guidelines for Preparing and Reviewing Proposals for Water Conservation and Improvement Projects Under Public Law 016-576 (Guidelines)" require three economic measures as part of the Bureau of Reclamation's evaluation of proposed projects:

- Number of acre-feet of water saved per dollar of construction costs;
- Number of British Thermal Units (BTU) of energy saved per dollar of construction costs; and
- Dollars of annual economic savings per dollar of initial construction costs.

South Texas irrigation districts have an extensive system of engineered networks – including 24 major pumping stations, 800 miles of large water mains and canals, 1,700 miles of pipelines, and 700 miles of laterals that deliver water to agricultural fields and urban areas. Yet, many key components are more than 100 years old, outdated and in need of repair or replacement. Texas Agricultural Experiment Station and Texas Cooperative Extension economists and engineers are collaborating with Rio Grande Basin irrigation district managers, their consulting engineers, the Bureau of Reclamation, and the Texas Water Development Board to perform economic and energy evaluations of the proposed projects.

Proposed capital improvement projects include, among others, (a) meters for monitoring in-system flows and improving management of system operations; (b) lining for open-delivery canals and installing pipelines to reduce leaks, improve flow rates, and increase head at diversion points; and (c) pumping plant replacement.

The economists have developed a spreadsheet model, Rio Grande Irrigation District Economics (RGIDECON©), to facilitate the analyses. The spreadsheet's calculations are attuned to economic and financial principles consistent with capital budgeting procedures — enabling a comparison of projects with different economic lives. As a result, RGIDECON© is capable of providing valuable information for prioritizing projects in the event of funding limitations. Results of the analyses can be compared with economic values of water to conduct cost-benefit analyses. Methodology is also included in the spreadsheet for appraising the economic costs

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[1] This information is a reproduction of excerpts from a guest column developed by Ed Rister and Ron Lacewell and edited by Rachel Alexander for the first issue of the Rio Grande Basin Initiative newsletter published in *Rio Grande Basin Initiative Outcomes, 1*(1) (Rister and Lacewell).

associated with energy savings. There are energy savings both from pumping less water forthcoming from reducing leaks and from improving the efficiency of pumping plants.

The economic water and energy savings analyses provide estimates of the economic costs per acre-foot of water savings and per BTU (kwh) of energy savings associated with one to five proposed capital improvement activity(ies) (each referred to as a component). An aggregate assessment is also supplied when two or more activities (i.e., components) comprise a proposed capital improvement project for a single irrigation district. The RGIDECON© model also accommodates "what if" analyses for irrigation districts interested in evaluating additional, non-Act authorized capital improvement investments in their water-delivery infrastructure.

The data required for analyzing the proposed capital improvement projects are assimilated from several sources. Extensive interactions with irrigation district managers and engineers are being used in combination with the Rio Grande Regional Water Planning Group Region M report and other studies to identify the information required for the economic and conservation investigations.

The RGIDECON© model applications will provide the basis for Texas Water Resources Institute reports documenting economic analysis of each authorized irrigation district project. An executive summary of the economic analysis of each authorized project will be provided to the irrigation districts for inclusion in their project report. The project reports will be submitted to the Bureau of Reclamation for evaluation prior to being approved for funding appropriations from Congress.

Subsequent to the noted legislation and approval process developed by the Bureau of Reclamation for evaluating legislation-authorized projects being proposed by Rio Grande Basin Irrigation Districts, the binational North American Development Bank (NADBank) announced the availability of an $80 million Water Conservation Fund for funding irrigation projects on both sides of the U.S.-Mexico border. The NADBank also announced a merging of its board with that of the Border Environment Cooperation Commission (BECC), resulting in the latter assuming a facilitation role in assisting U.S. Irrigation Districts and other entities in applying for and being certified for the $40 million of the funding available on the U.S. side of the border. Similar to their efforts on the legislation-authorized projects, Texas Agricultural Experiment Station and Texas Cooperative Extension economists and engineers are collaborating with Rio Grande Basin irrigation district managers, their consulting engineers, the BECC, and NADBank and using RGIDECON© to develop supportive materials documenting the sustainability of the projects being proposed by Texas Irrigation Districts to BECC, NADBank and Bureau of Reclamation.

The U.S. Bureau of Reclamation, in a letter dated July 24, 2002 (Walkoviak), stated that RGIDECON© satisfies the legislation authorizing projects and that the Bureau will use the results for economic and energy evaluation. Subsequently, discussions with NADBank and BECC management indicate these analyses are adequate and acceptable for documenting the sustainability aspects of the Districts' Stage 1 and Stage 2 submissions.

# About the Authors

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# Acknowledgments

Many individuals have contributed to the methodology developed for the Rio Grande Basin Irrigation District economic analyses as described herein. We gratefully acknowledge and appreciate the input and assistance of the following:

- ***Sonia Kaniger, Freddy Ortega, George Carpenter, Wayne Halbert, Bill Friend, Rick Smith, and Edd Fifer.*** These irrigation district managers and assistant managers have been and are a continual source of information, support, and inspiration as we work to develop an accurate, consistent, logical, efficient, and practical analytical approach for these investigations;

- ***Larry Smith and Al Blair.*** These private consulting engineers have substantiated and extended the insights of the irrigation district managers, thereby strengthening the rigor of our methodology and enhancing the integrity of the data;

- ***Guy Fipps and Eric Leigh.*** These agricultural engineers and our colleagues in the Department of Biological and Agricultural Engineering at Texas A&M University and in the Texas Cooperative Extension have provided an extensive amount of background information, contacts, and wisdom;

- ***Jose Amador and Ari Michelsen.*** These Resident Directors of the Agricultural Research and Extension Centers at Weslaco and El Paso, respectively, have been very supportive in identifying contacts, alerting us to critical issues, and arranging meetings, among other collaboration efforts;

- ***Bob Hamilton and Randy Christopherson.*** These economists affiliated with the Bureau of Reclamation have served as reviewers of our methodology. They have also identified appropriate means of satisfying the data requirements specified in the legislative-mandated Bureau of Reclamation Guidelines for Public Law 106-576 authorizing the projects being analyzed, while also assuring principles of economics and finance are met;

- ***Ron Griffin.*** A Resource Economist in the Department of Agricultural Economics at Texas A&M University, Ron has provided insights regarding relevant resource issues, methods for appraising capital water-related projects, and observations on Texas water issues in general;

- ***John Penson and Danny Klinefelter.*** These agricultural economists specializing in finance in the Department of Agricultural Economics at Texas A&M University have served as mentors through our development of the methodology. They have been an excellent sounding board, reacting to an assortment of questions, ideas, and innovative applications of finance methods;

- ***James Allard, Larry Walkoviak, Rick Clark, Mike Irlbeck, and Thomas Michalewicz.*** These individuals are all affiliated with the U.S. Bureau of Reclamation in various management, engineering, and environmental roles. They have been instrumental in fostering a collaborative environment in which the several agencies involved in this effort can mutually fulfill their varied responsibilities and conduct related activities. They have taken the lead in bringing the Texas Water Development Board into planning and facilitating cooperation across State and Federal agencies;

- ***Danny Fox, Debbie Helstrom, Jeff Walker, and Nick Palacios.*** These engineers and managers with the Texas Water Development Board (TWDB) have provided valuable feedback on the methodology and data, as well as insights on accommodating the requirements imposed by the TWDB on the irrigation districts in association with their receipt and use of State Energy Conservation Office (SECO) funding for the development of their project proposals;

- ***Allan Jones and B. L. Harris.*** As Director and Executive Director of the Texas Water Resources Institute, respectively, they provide leadership and oversight for the Rio Grande Basin Initiative funded through a grant from Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture;

- ***Megan Stubbs.*** An undergraduate in the Department of Agricultural Economics at Texas A&M University, Megan contributed several insightful, thought-provoking comments while reviewing and editing this report and during development of related materials on Rio Grande Basin irrigation districts;

- ***Jason Morris.*** A Student Technician in the Department of Agricultural Economics at Texas A&M University, Jason has provided daily support in the form of computer hardware and software assistance, Internet-based data searches, and other bolstering activities; and

- ***Michele Zinn.*** She is the glue that binds it all together! An Administrative Assistant in the Department of Agricultural Economics and in the Texas Agricultural Experiment Station at Texas A&M University, Michele assists in coordinating daily activities and travel, and provides editorial assistance during manuscript preparation.

Thanks to each and every individual noted above. Nonetheless, we, the authors of this manuscript, accept all responsibilities for any errors, omissions, and/or other oversights that are present in the manuscript and/or the economic spreadsheet model, RGIDECON©.

MER
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MCP
JRE

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# Economic and Conservation Evaluation of Capital Renovation Projects: Cameron County Irrigation District No. 2 (San Benito) – Interconnect Between Canals 39 and 13-A1 and Replacement of Rio Grande Diversion Pumping Plant


## Abstract

Initial construction costs and net annual changes in operating and maintenance expenses are identified for the capital renovation project proposed by the Cameron County Irrigation District No. 2 (a.k.a. San Benito) to the North American Development Bank (NADBank) and Bureau of Reclamation. Both nominal and real, expected economic and financial costs of water and energy savings are identified throughout the anticipated useful lives for both components of the proposed project (i.e., a lined interconnect between Canals 39 and 13-A1 and replacement of the Rio Grande diversion pumping plant). Sensitivity results for both the cost of water savings and cost of energy savings are presented for several important parameters.

Expected cost of water savings and cost of energy savings for both components are aggregated into a composite set of cost measures for the total proposed project. Aggregate cost of water savings is estimated to be **$41.26 per ac-ft** and energy savings are measured at an aggregate value of **$0.0001586 per BTU (i.e., $0.541 per kwh)**.

In addition, expected values are indicated for the Bureau of Reclamation's three principal evaluation measures specified in the United States Public Law 106-576 legislation. The aggregate initial construction cost per ac-ft of water savings measure is $157.07 per ac-ft of water savings. The aggregate initial construction cost per BTU (kwh) of energy savings measure is $0.0001777 per BTU ($0.606 per kwh). The ratio of initial construction costs per dollar of total annual economic savings is estimated to be -3.80.

# Bureau of Reclamation's Endorsement of RGIDECON©

**United States Department of the Interior**
**BUREAU OF RECLAMATION**
**Great Plains Region**
**OKLAHOMA - TEXAS AREA OFFICE**
**300 E. 8th Street, Suite G-169**
**Austin, Texas 78701-3225**

IN REPLY
REFER TO:
TX-Clark
PRJ-8.00

JUL 24 2002

Dr. Ron Lacewell
Department of Agricultural Economics
Texas A&M University
College Station, TX 77843-2124

Subject: Economic Model for Use in Preparing Proposals for Water Conservation and Improvement Projects Under Public Law 106-576.

Dear Dr. Lacewell:

Having reviewed the formulas, calculations, and logic which support the "Economic Methodology for South Texas Irrigation Projects" (Model) developed by the Department of Agricultural Economics at Texas A&M University (TAMU), the Bureau of Reclamation (Reclamation) concludes that the Model adequately addresses the specific economic criteria contained in the *Lower Rio Grande Valley Water Resources Conservation and Improvement Act of 2000* (P. L. 106-576). The results of the Model will fully satisfy the economic and conservation analyses required by the Act and it may be used by any irrigation district or other entity seeking to qualify a project for authorization and/or construction funding under P.L. 106-576.

We express our sincere appreciation to you, your colleagues, and to TAMU for this significant contribution to the efforts to improve the water supply in the Lower Rio Grande Valley.

If we may be of further assistance, please call me at (512) 916-5641.

Sincerely,

M L Martin

Larry Walkoviak
Area Manager

A Century of Water for the West
1902-2002

# Economic and Conservation Evaluation of Capital Renovation Projects: Cameron County Irrigation District No. 2 (San Benito) – Interconnect Between Canals 39 and 13-A1 and Replacement of Rio Grande Diversion Pumping Plant

## Executive Summary

### Introduction

Recognizing the seriousness of the water crisis in South Texas, the U.S. Congress enacted Public Law 106-576, entitled "The Lower Rio Grande Valley Water Conservation and Improvement Act of 2000." Therein, Congress authorized investigation into four water conservation projects for irrigation districts relying on the Rio Grande for their municipal, industrial, and agricultural irrigation supply of water. Located in San Benito, Texas, Cameron County Irrigation District No. 2's (i.e., the District) project is included among the four authorized. Project authorization does not guarantee federal funding as several phases of planning, development, evaluation, etc. are necessary before these projects may be approved for financing and construction.

Subsequent to the noted legislation and approval process developed by the U.S. Bureau of Reclamation for evaluating legislation-authorized projects being proposed by Rio Grande Basin Irrigation Districts, the bi-national North American Development Bank (NADBank) announced the availability of an $80 million Water Conservation Investment Fund (WCIF) for funding irrigation projects on both sides of the U.S.-Mexico border. The NADBank also announced a merging of its board with that of the Border Environment Cooperation Commission (BECC), resulting in the latter assuming a facilitation role in assisting U.S. Irrigation Districts and other entities in applying for and being certified for the $40 million available on the U.S. side of the border. Similar to their efforts on the legislation-authorized projects, Texas Agricultural Experiment Station (TAES) and Texas Cooperative Extension (TCE) economists and engineers are collaborating with Rio Grande Basin irrigation district managers, their consulting engineers, the BECC, and NADBank and using RGIDECON© to develop supportive materials documenting the sustainability of the projects being proposed by Texas Irrigation Districts to BECC, NADBank and Bureau of Reclamation.[1]

The U.S. Bureau of Reclamation, in a letter dated July 24, 2002, stated that RGIDECON© satisfies the legislation-authorized projects and that the Bureau will use the results for economic and energy evaluation. Subsequently, the BECC has also acknowledged these analyses are adequate and acceptable for the Districts' Stage 1 and 2 submissions.

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1 This report contains economic and financial analyses results for a capital rehabilitation project proposed by the Cameron County Irrigation District No. 2 (a.k.a. San Benito) in the Rio Grande Basin. Readers interested in the methodological background and/or prior reports are directed to p. 41 which identifies related publications.

This report provides documentation of the economic and conservation analysis conducted for the Cameron County Irrigation District No. 2's project proposal toward its Stage 1 certification with BECC. TAES/TCE agricultural economists have developed this analysis report as facilitated by the Rio Grande Basin Initiative and administered by the Texas Water Resources Institute of the Texas A&M University System.[2]

## District Description

The District's irrigation water right is 147,824 ac-ft per year, with the actual water available varying from year to year. In addition, the District holds municipal/domestic water rights of 5,518 ac-ft per year, municipal water rights of 6,390 ac-ft per year, and industrial water rights of 4,650 ac-ft per year. The District contracts for delivery of municipal water to the East Rio Hondo Water Supply and Arroyo Water Supply Corporations (458 ac-ft and 200 ac-ft per year, respectively). The District's primary municipal customers include the City of San Benito (5,500 ac-ft per year) and the City of Rio Hondo (890 ac-ft per year). The District's largest industrial customer is Central Power and Light (2,400 ac-ft per year). The District is currently the only source of water for these municipal and industrial users. Municipal and industry (M&I) water use has been fairly consistent, ranging from 7,305 to 8,494 ac-ft, with the five-year average at 7,904 ac-ft.

Recent years' *agricultural* water diversions in the District have been significantly hampered by deficit allocations. Comparing long-term historical water-diversion values (i.e., eleven years of data beginning in 1986) with recent years' agricultural water diversions (i.e., five years between 1997-2001) reveals significant variability and a down trend. Long-term historical values range from 45,229 to 94,889 ac-ft, with an average of 75,325 ac-ft. Recent *agricultural* water diversions during 1997-2001 have ranged from 45,229 to 80,922 ac-ft, with the five-year average at 66,323 ac-ft. Inasmuch as current Rio Grande diversions are considered abnormally lower than historical and potential future diversions, statistical procedures were used to calculate an adjusted average diversion level of 93,270 ac-ft per year.

## Proposed Project Components

The capital improvement project proposed by the District to BECC, NADBank and Bureau of Reclamation consists of two distinct and non-related components. Specifically, it includes:

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2 This analysis report is based on the best information available at the time and is subject to an array of resource limitations. At times, District management's best educated estimates (or that of the consulting engineer) are used to base cost and/or savings' values well into the future. Obviously this is imperfect, but given resource limitations, it is believed ample inquiry and review of that information were used to limit the degree of uncertainty.

- Enlarging 6,600 feet of existing "Canal 39" and connecting it to a new 6,000-foot segment of canal to be dug which will result in an "interconnect" between "Canals 39" and "13-A1" – since both segments will be lined with a geomembrane liner and concrete cover, this component will reduce seepage, improve flow rates, and increase head at diversion points in a northern-portion of the District commonly referred to as 'old District 13', and eliminate the need for storage and relift from Reservoir No. 7; and

- Construction of a new Rio Grande diversion pumping plant to replace the current one located near Los Indios, Texas – this will insure the District's diversion and delivery capabilities for years to come and provide improvements in operational efficiencies and capacities.

## Economic and Conservation Analysis Features of RGIDECON©

RGIDECON© is an Excel spreadsheet developed by TAES/TCE economists to investigate the economic and conservation merits of capital renovation projects proposed by Rio Grande Basin Irrigation Districts. RGIDECON© facilitates integration and analysis of information pertaining to proposed projects' costs, productive lives, water and energy savings, and resulting per unit costs of water and energy savings. RGIDECON© simplifies capital budgeting financial analyses of both individual capital components comprising a project and the overall, total project.

### Cost Considerations: Initial & Changes in O&M

Two principal types of costs are analyzed for each component: (a) initial capital outlays and (b) changes in annual operating and maintenance (O&M) expenses. Results related to each type of expenditure for each component are presented in following sections.[3]

### Anticipated Water and Energy Savings

Annual water and energy savings are calculated for each component separately and also as a combined total across both components. Water savings are comprised of and associated with (a) reductions in Rio Grande diversions, (b) increased head at farm diversion points, (c) reduced seepage losses in canals, and (d) better management of water flow. Energy savings are a consequence of reduced diversions and relift pumping and are comprised of (a) the amount of energy used for pumping and (b) the cost (value) of such energy.[4]

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[3] Due to numerical rounding, values as they appear herein may not reconcile exactly with hand calculations the reader may make. In all instances, RGIDECON© values are reported with appropriate rounding-off (as determined by the authors) of values which are in this analysis report.

[4] A major assumption made by the authors and embedded in this and other economic and conservation analyses of Irrigation Districts' proposed capital rehabilitation projects is that only the local Irrigation District's perspective is considered, i.e., activities external to the Irrigation District are ignored. In addition,

## Cost of Water and Energy Savings

The estimated cost per ac-ft of water saved as well as the estimated cost of energy saved as a result of a project component's inception, purchase, installation, and implementation is analyzed to gauge each proposed project component's merit. Results related to each type of cost for each component are presented in following sections, as well as totals across both components.

## Project Components

Discussion pertaining to costs (i.e., initial purchase/construction and subsequent annual O&M) and savings for both water and energy is presented below for each component (i.e., lined interconnect canal and replacement of pumping plant) comprising the Cameron County Irrigation District No. 2's (i.e., San Benito's) NADBank and Bureau of Reclamation project, and then aggregated across both components. With regards to water and energy savings, areas or sources are first identified, with the subsequent discussion quantifying estimates for those sources.

### Component #1: Interconnect Between Canals 39 and 13-A1

Component #1 of the District's proposed NADBank and Bureau of Reclamation project consists of enlarging 6,600 feet of existing Canal 39 and connecting it to a new 6,000-foot segment of canal to be dug which will result in an "interconnect" between Canals 39 and 13-A1. The installation period is projected to take one year with an ensuing expected useful life of 49 years. No losses of operations or otherwise adverse impacts are anticipated during the installation period since this will occur in the off-season.

### Initial and O&M Costs

Estimated initial capital investment costs total $3,585,300 ($1,502,411 per mile). Annual increases in O&M expenditures for the renovated 6,600' of Canal 39 and the additional 6,000' of new interconnect canal of $5,867 ($2,458 per mile) are expected. Additionally, reductions in annual O&M expenditures of $4,162 are anticipated from discontinued maintenance associated with the existing 6,600' segment of Canal 39 (as it is converted from unlined to lined canal). Therefore, a net increase in annual O&M costs of $1,704 is expected (basis 2003 dollars).[5]

### Anticipated Water and Energy Savings

Both off- and on-farm water savings are predicted to be forthcoming from the inter-connect with the nominal total being 468,267 ac-ft over the 49-year productive life of this

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all marginal water and energy diversion/use savings are recognized, not withstanding that in actuality, the "savings" may continue to be utilized in expansion of current activities and/or development of new activities within (or outside) the District. The existence of "on-allocation" status for a District does not alter these assumptions.

5 Note canal 'repair expense' is not included in determining O&M costs for the first two years as contractor's warranty will cover extraordinary repair-type expenses (Allard).

component and the real 2003 total being 196,105 ac-ft. Annual *off-farm* water savings estimates are based on 3,457.1 ac-ft savings from eliminating the need for Reservoir No. 7, 365.9 ac-ft savings associated with changes to Canal 39, and increased water *losses* of 37.9 ac-ft associated with digging the new interconnect segment between Canals 39 and 13-A1. Annual *on-farm* water savings of 5,771.4 ac-ft are based on a 37.5% savings (i.e., water demand declining from 0.835 ac-ft per acre irrigated to 0.522 ac-ft) of applicable flood-irrigation resulting from reduced percolation due to increased head. Combined associated energy savings estimates are 52,977,046,976 BTU (15,526,684 kwh) in nominal terms over the 49-year productive life and 22,186,188,476 BTU (6,502,400 kwh) in real 2003 terms. Energy savings are based on reduced diversions at the Rio Grande, as well as eliminating relifting from Reservoir No. 7.

**Cost of Water and Energy Savings**

The economic and financial cost of water savings forthcoming from the interconnect is estimated to be $22.68 per ac-ft. This value is obtained by dividing the annuity equivalent of the total net cost stream for water savings from all sources of $207,017 (in 2003 terms) by the annuity equivalent of the total net water savings of 9,129 ac-ft (in 2003 terms). The economic and financial cost of energy savings are estimated at $0.0002262 per BTU ($0.772 per kwh). This value is obtained by dividing the annuity equivalent of the total net cost stream for energy savings from all sources of $233,605 (in 2003 terms) by the annuity equivalent of the total net energy savings of 1,032,771,521 BTU (302,688 kwh) (in 2003 terms).

## Component #2: Replacement of Pumping Plant

Component #2 of the District's proposed NADBank and Bureau of Reclamation project consists of constructing a new Rio Grande diversion pumping plant to replace the current one located near Los Indios, Texas. The installation period is projected to take two years with an ensuing expected useful life of 48 years. No losses of operations or otherwise adverse impacts are anticipated during the construction period as the District will continue to depend upon the old pumping plant for diversions during this period.

**Initial and O&M Costs**

Estimated initial capital investment costs total $9,715,000. Annual increases in O&M expenses of $107,648 are expected with the new pumping plant.[6] Also, decreases in annual O&M expenses of $538,843 associated with discontinued maintenance on the old plant are expected.[7] Therefore, a net decrease in annual O&M costs of $431,195 (basis 2003) is expected.

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6 This value includes salary and repair expense estimates by the Bureau of Reclamation, as well as the anticipated insurance premium for the new pumping plant.

7 This value includes historic salary, repair, and insurance premium expenses, as well as two annuity estimates. To account for the cost path anticipated for continued operation of the existing pumping plant, it is estimated the District will require a capital-equipment replacement fund for pumps and motors (i.e., an annuity calculated as 3 pumps and motors @ $300,000 each for 10 years at 6.125%), as well as an "economic sinking fund" (i.e., an annuity calculated as $3,400,000 for 20 years at 6.125%) representing, in

## Anticipated Water and Energy Savings

Only *off-farm* water savings are predicted to be forthcoming from constructing the new pumping plant with the nominal total being 114,250 ac-ft over its 48-year productive life and the real 2003 total being 46,643 ac-ft. These savings estimates are based on the new plant being able to capture an additional amount of no-charge water.[8] The quantity of water savings (i.e., capture of no-charge water) is made possible with a 50 cfs minimal pumping capacity and is an amount above and beyond the amount of no-charge water the District currently lifts (i.e., with its current 75 cfs minimal pumping capacity). That is, if the Rio Grande flow is near 50 cfs (i.e., below 75 cfs), the District is currently unable to lift 'no-charge' water at the lower rate as it would 'burn up' its current 75 cfs pump as pumping capacity would exceed river flow. Associated energy savings estimates are 129,610,087,207 BTU (37,986,544 kwh) in nominal terms over the 48-year productive life and 52,913,560,965 BTU (15,508,078 kwh) in real 2003 terms. Energy savings are based on eliminating the "recirculating"of water which currently leaks through the pumping plant's walls and back into the Rio Grande, and an efficiency improvement realized with the installation of new energy-efficient pumps and motors. These noted energy savings are being partially offset, however, by increased costs of pumping the new "no-charge" water.[9]

## Cost of Water and Energy Savings

The economic and financial cost of water savings forthcoming from the pumping plant replacement component is estimated to be $119.41 per ac-ft. This value is obtained by dividing the annuity equivalent of the total net cost stream for water savings from all sources of $259,266 (in 2003 terms) by the annuity equivalent of the total net water savings of 2,171 ac-ft (in 2003 terms). The economic and financial cost of energy savings are estimated at $0.0001302 per BTU ($0.444 per kwh). This value is obtained by dividing the annuity equivalent of the total net cost stream for energy savings from all sources of $320,688 (in 2003 terms) by the annuity equivalent of the total net energy savings of 2,463,136,869 BTU (721,904 kwh) (in 2003 terms).

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effect, self-insurance in consideration of the existing plant's minimal insurance coverage of approximately $500,000. These annuity accounts are intended to provide, in the absence of a grant/loan to build a new pumping plant in the immediate future, a means for the District to cover impending catastrophic breakdowns and/or casualty losses. The cost distinctions being made with the annuity accounts are unlike eliminating other costs associated with getting rid of the old plant, in that these costs are not currently being "spent," but rather represent recognition that (1) intended continued operation of the existing pumping plant will require some minimal immediate capital improvements (e.g., replacing of three pumps and motors) and (2) since the pumping plant is under-insured, the District needs to have a "contingency fund" and/or an emergency capital loan to use towards replacement construction in the event of a catastrophic event. Recognizing these costs allows for proper comparison of the cost-paths that will be incurred, both with and without a grant/loan. The inclusion of this cost is an indirect application of risk probability that a major failure of the existing pumping plant will occur at some point during the next ten to twenty years.

8 Though this water savings area is not "savings" in the typical sense one might associate with say the elimination of canal seepage, it is an amount of water which can be captured, quantified, and "added" to improve the District's water supply without being counted against its Watermaster-controlled allocation.

9 As mentioned, the capture of no-charge water requires electrical energy to divert it from the Rio Grande. Thus, an adjustment (i.e., reduction) is made to energy savings to account for that electricity used to divert the no-charge water savings.

## Totals Across Both Components

The methodology used in evaluating the economic and conservation potential of the proposed project and the respective individual components accounts for timing of inflows and outflows of funds and the anticipated installation and productive time periods of the investments. The cost measures calculated for the individual components are first converted into 'annuity equivalents,' prior to being aggregated into the comprehensive measures. The 'annuity equivalent' calculations facilitate comparison and aggregation of capital projects with unequal useful lives, effectively serving as development of a common denominator. The finance aspect of the 'annuity equivalent' calculation as it is used in the RGIDECON© analyses is such that it represents an annual cost savings associated with one unit of water (or energy) each year extended indefinitely into the future. Zero salvage values and continual replacement of the respective technologies (i.e., interconnect canal and replacement of pumping plant) with similar capital items as their useful life ends are assumed.

### Initial and O&M Costs

The total capital investment cost required for both components amounts to $13,300,300. Combining these costs with the projected changes in annual O&M expenditures, and the useful lives of the respective project components results in an annuity equivalent of $466,283 cost per year for water savings associated with the total project. The similar measure for costs of energy savings is $554,293 per year.

### Anticipated Water and Energy Savings

Both off- and on-farm water savings are expected from the two components with the nominal total being 582,517 ac-ft over their expected productive lives and the real 2003 total being 242,747 ac-ft. On an average annual basis (or annuity equivalent basis), this amounts to 11,300 ac-ft across the two project components, representing **12.9%** of the current average water diversion by the District, or **12%** of the "adjusted" average water diversion.[10] Annual water savings estimates are based on reduced (canal and reservoir) seepage and evaporation, increased on-farm efficiency through reduced percolation loss, and the capture of additional 'no-charge' water. Associated energy savings estimates are 182,587,134,183 BTU (53,513,228 kwh) in nominal terms over their lives and 75,099,749,441 BTU (22,010,478 kwh) in real 2003 terms. On an average annual basis (or annuity equivalent basis), this amounts to 3,495,908,390 BTU (1,024,592 kwh) across the two project components. Combined energy savings are based on net reduced diversions at the Rio Grande (resulting in improved water supplies), reduced relift pumping in the District's delivery-system infrastructure, and improved Rio Grande water-diversion operations.

### Cost of Water and Energy Savings

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[10] Review of historic volumes of water pumped document an evident down trend in recent years reflecting reduced allocations to an amount such that recent years' volumes do not accurately reflect "normal" volumes the District would have pumped had water supplies been available. Therefore, *adjusted* water-pumped volumes by the District are calculated to assist in energy-savings calculations of component #2.

The aggregation of the economic and financial costs of water and energy savings for the individual project components into cost measures for the total comprehensive project results in estimates of **$41.26 per ac-ft** cost of water savings and **$0.0001586 per BTU ($0.541 per kwh)** cost of energy savings.

## Summary

The following table summarizes key information regarding each of the components of Cameron County Irrigation District No. 2's NADBank and Bureau of Reclamation project, with a more complete discussion provided in the text of the complete report.

Table ES1. Summary of Data and Economic and Conservation Analyses Results for Cameron County Irrigation District No. 2's NADBank and Bureau of Reclamation Project, 2003.

| | Project Component | | |
|---|---|---|---|
| | Interconnect between Canals 39 and 13-A1 | Pumping Plant Replacement | Aggregate |
| Initial Investment Cost ($) | $ 3,585,300 | $ 9,715,000 | $ 13,300,300 |
| Expected Useful Life (years) | 49 | 48 | n/a |
| Net Changes in Annual O&M ($) | $ 1,704 | ($ 431,195) | ($ 429,490) |
| Annuity Equiv. of Net Cost Stream – Water Savings ($/yr) | $ 207,017 | $ 259,266 | $ 466,283 |
| Annuity Equivalent of Water Savings (ac-ft) | 9,129 | 2,171 | 11,300 |
| Calculated Cost of Water Savings ($/ac-ft) | **$22.68** | **$119.41** | **$41.26** |
| Annuity Equiv. of Net Cost Stream – Energy Savings ($/yr) | $ 233,605 | $ 320,688 | $ 554,293 |
| Annuity Equivalent of Energy Savings (BTU) | 1,032,771,521 | 2,463,136,869 | 3,495,908,390 |
| Annuity Equivalent of Energy Savings (kwh) | 302,688 | 721,904 | 1,024,592 |
| Calculated Cost of Energy Savings ($/BTU) | **$ 0.0002262** | **$ 0.0001302** | **$ 0.0001586** |
| Calculated Cost of Energy Savings ($/kwh) | **$ 0.772** | **$ 0.444** | **$ 0.541** |

## Sensitivity Analyses

Sensitivity results for both the costs of water and energy savings are presented within the main text whereby two parameters are varied with all others remaining constant. This permits testing of the stability (or instability) of key input values and shows how sensitive results are to variances in other input factors. Key variables subjected to sensitivity analysis include (a) the amount of reduction in Rio Grande diversions, (b) the expected useful life of the investment, (c) the initial capital investment cost, (d) the value of BTU savings (i.e., cost of energy), and (e) the amount of energy savings estimated.

## Legislative Criteria

United States Public Law 106-576 requires three economic measures be calculated and included as part of the information prepared for the Bureau of Reclamation's (Bureau) evaluation of the proposed projects. According to the Bureau, these measures are more often stated in their inverse mode:

- Dollars of construction cost per ac-ft of water saved;
- Dollars of construction cost per BTU (and kwh) of energy saved; and
- Dollars of construction cost per dollar of annual economic savings.

The noted legislated criteria involve a series of calculations similar to, but different from, those used in developing the cost measures cited in the main body of the full analysis report. Principal differences consist of the legislated criteria not requiring aggregation of the initial capital investment costs with the annual changes in O&M expenditures, but rather entailing separate sets of calculations for each type of cost relative to the anticipated water and energy savings. The approach used in aggregating the legislated criteria results presented in Appendix A into one set of uniform measures utilizes the present value methods followed in the calculation of the economic and financial results reported in the main body of the text, but does not include the development of annuity equivalent measures. These compromises in approaches are intended to maintain the spirit of the legislated criteria's intentions. Only real, present value measures are presented and discussed for the legislated criteria aggregate results, thereby designating all such values in terms of 2003 equivalents. **Differences in useful lives across project components are not fully represented, however, in these calculated values.**

The aggregate initial construction costs per ac-ft of water savings measure is $157.07 per ac-ft of water savings which is substantially higher than the comprehensive economic and financial value of **$41.26 per ac-ft** identified and discussed in the main body of the analysis report. The differences in these values are attributable to the incorporation of both initial capital costs and changes in operating expenses in the latter value, and its treatment of the differences in the useful lives of the respective components of the proposed project.

The aggregate initial construction cost per BTU (kwh) of energy savings measure is $0.0001777 per BTU ($0.606 per kwh). These cost estimates are higher than the **$0.0001586 per BTU ($0.541 per kwh)** comprehensive economic and financial cost estimates identified for reasons similar to those noted above with respect to the estimates for costs of water savings.

The final aggregate legislated criterion of interest is the amount of initial construction costs per dollar of total annual economic savings. The estimate for this ratio measure is -3.80, indicating that (a) the net change in annual O&M expenditures is negative, i.e., a reduction in O&M expenditures is anticipated; and (b) $3.80 of initial construction costs are expended for each such dollar reduction in O&M expenditures, with the latter represented in total real 2003 dollars accrued across the two project components' respective planning periods.

# Economic and Conservation Evaluation of Capital Renovation Projects: Cameron County Irrigation District No. 2 (San Benito) – Interconnect Between Canals 39 and 13-A1 and Replacement of Rio Grande Diversion Pumping Plant

## Introduction

Cameron County Irrigation District No. 2 (a.k.a. San Benito) is included among the four irrigation districts authorized for water conservation projects in the Lower Rio Grande Valley Water Resources Conservation and Improvement Act of 2000 (Act), or United States Public Law (PL) 106-576. As stated in the legislation, "If the Secretary determines that ... meet[s] the review criteria and project requirements, as set forth in section 3 [of the Act], the Secretary may conduct or participate in funding engineering work, infrastructure construction, and improvements for the purpose of conserving and transporting raw water through that project" (United States Public Law 106-576). This report provides documentation of an economic and conservation analysis conducted for two components (i.e., lined interconnect between Canals 39 and 13-A1 and replacement of the Rio Grande diversion pumping plant) comprising Cameron County Irrigation District No. 2's (the District) project proposed to the Border Environment Cooperation Commission (BECC), the North American Development Bank (NADBank), and the Bureau of Reclamation during the Spring of 2003.[1]

## Irrigation District Description[2]

Twenty-eight irrigation districts exist in the Texas Lower Rio Grande Valley (**Exhibit 1**).[3] The Cameron County Irrigation District No. 2 office is located in San Benito, Texas (**Exhibits 2** and **3**). The District boundary covers 64,282 acres of Cameron County (**Exhibit 4**). Postal and street addresses are P.O. Box 687, 216 S. Sam Houston, San Benito, TX 78586. Telephone contact information is 956/399-2484 and the fax number is 956/399-4721. Sonia Kaniger is the District Manager, with James Allard of the Bureau of Reclamation, Oklahoma City, OK, serving as the lead consulting engineer for this project.

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1 Readers interested in the methodological background and/or prior reports are directed to p. 41 which identifies related publications.

2 The general descriptive information presented for the District was assimilated from several sources, including documents provided by Sonia Kaniger (the District manager), the IDEA web site maintained by Guy Fipps and his staff in the Department of Biological and Agricultural Engineering at Texas A&M University, College Station, Texas, the Final Project Plan (by U.S. Bureau Reclamation May 2002), the Region M Rio Grande Regional Water Planning Group report, and Fipps' Technical Memorandum in the latter report (Fipps 2000).

3 Exhibits and Tables are presented at the end of the report, after the References and the Glossary and before the Appendices.

In addition to residential and commercial accounts, there are numerous agricultural irrigation accounts serviced by the District, with the majority of agricultural acreage serviced under "as-needed" individual water orders for vegetable and field crops. Additionally, annual permits for orchards and commercial nurseries that use drip or micro-emitter systems are serviced. Lastly, numerous accounts exist for lawn watering, golf courses, parks, school yards, and ponds.

## Irrigated Acreage and Major Crops

The District delivers water to approximately 57,439 acres of agricultural cropland within its district. Furrow irrigation accounts for approximately 90% of irrigation deliveries. Special turnout connections were historically provided to the small percentage (i.e., 10%) of district customers utilizing polypipe, gated pipe, etc. Flood irrigation is the norm for orchards, sugarcane, and pastures. The typical crop mix across the District is noted in **Table 1**, which illustrates the relative importance (on an acreage basis) of grain sorghum, cotton, sugarcane, citrus, etc. The crop mix distribution within a particular irrigation district may vary considerably, depending on output prices and the relative available local water supplies. For example, in water-short years, sugarcane acreage, although a perennial crop, may "migrate" to districts and/or areas appearing to be water-rich, in a relative sense.

## Municipalities Served

The District's priority in diverting water is to first meet the demands of residential and commercial users[4] within the District. To facilitate delivery, the District contracts 7,075 acre feet (ac-ft) of municipal water diversions to the cities of San Benito and Rio Hondo, and the East Rio Hondo and Arroyo Water Supply Corporations. The District holds 6,390 ac-ft of municipal water rights, as well as 5,518 ac-ft of municipal/domestic water rights. These are in addition to the irrigation and industrial water rights the District holds (**Exhibit 5**). After fulfilling municipalities' requirements, needs of agricultural irrigators are addressed.

It is important to note that each Irrigation District is responsible, under normal "non-allocation status" situations, for maintaining a fully charged delivery system, providing "push water" to facilitate delivery of their water from the Rio Grande to municipal delivery sites. When on an "allocation status" and when local (i.e., within an individual Irrigation District) water supplies (including account balances) are inadequate for charging an Irrigation District's delivery system to facilitate municipal water delivery, however, Valley-wide Irrigation Districts (i.e., as a collective group, drawing on all of their account balances) are responsible for providing the necessary water to facilitate delivery of municipal water in individual Irrigation Districts (Hill).

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[4] Hereafter, residential and commercial users are referred to as "M&I" (or Municipal & Industrial), a term more widely used in irrigation district operations.

## Historic Water Use

Review of the District's historical water-use data reveals useful information (**Table 2**). Recent historical values (i.e., 1997-2001) for M&I water use reflect a fairly consistent range from 7,305 to 8,494 ac-ft, with the five-year average at 7,904 ac-ft. These values are somewhat lower and less variable than the long-term historical values (i.e., select, available data from 1986-2001) which range from 7,305 to 13,035 ac-ft, with an average of 9,290 ac-ft.

Recent years' *agricultural* water use in the District has been significantly hampered by deficit allocations. Comparing long-term historical water-use values (i.e., eleven years of data beginning in 1986) with recent years' agricultural water use (i.e., five years of data for 1997-2001) reveals significant variability and a down trend. *Long-term* historical values range from 45,229 to 94,889 ac-ft, with an average at 75,325 ac-ft. *Recent* agricultural water use during 1997-2001 has ranged from 45,229 to 80,922 ac-ft, with the five-year average at 66,323 ac-ft.

## Adjusted Historic Pumping Volumes

Water and energy savings (and their associated costs) are key considerations for this analysis and any potential grant or loan to the District from NADBank or Bureau of Reclamation. Forecasting future energy savings in this analysis are largely dependent on and require mathematical manipulation of several variables, key of which is the quantity of historic volumes of water pumped (i.e., diverted from the Rio Grande).

Review of historic volumes of water pumped (and that subsequently available to agriculture) by the District from 1986 to 2001 document an evident down trend in recent years reflecting reduced allocations caused by regional drought and non-payment of water releases by Mexico.[5] Thus, recent years' pumped volumes do not accurately reflect "normal" volumes the District would have pumped had water supplies been available. Therefore, to accurately analyze the full water-savings potential of the proposed project, *adjusted* water-pumped volumes by the District are necessary.[6] Adjusting the historic volume upwards for Cameron County Irrigation District No. 2 is an objective and unbiased action taken by the authors which adheres to marginal-economic principles.

Various methods are available to estimate "normal" historic pumping volumes by Cameron County Irrigation District No. 2. The method incorporated into this analysis was to use

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5 Mexico is currently non-compliant (as per a 1944 Treaty with the United States) with regards to releasing water which would be used by Rio Grande Valley agricultural producers. The discussion and prevalent details of that issue is beyond the scope of this analysis report.

6 The supply/demand balance within irrigation districts varies. In recent years, some districts have had appropriations matching their demands, while others have not. Having extreme unavailability of water supplied is an event not realized with other irrigation district analyses and reports completed thus far by the authors (i.e., Cameron County Irrigation District No. 1 (a.k.a. Harlingen) and Hidalgo County Irrigation District No. 1 (a.k.a. Edinburg)). In fact, one of the districts recently had an excess supply and was able to make a one-time sale of water (external to the District).

statistical methods to develop a distribution of probabilities, based on actual historical pumped volumes (i.e., from 1986-2001). The result was an adjusted historical pumping volume estimate of 93,270 ac-ft. This value is 5,757 ac-ft more than that realized with a simple average over the same time-period.

Specifically, *Simetar*™ (a Microsoft Excel® add-in program developed by Richardson et al.) was used to calculate descriptive summary statistics (i.e., mean = 87,513; standard deviation = 16,272; min = 53,724; and max = 110,935) and a "normal" probability-based distribution for the actual 1986-2001 data. For example, according to the historic data, there is a 0% chance of total water diversions being equal to or below 53,718 ac-ft; a 50% chance of water use being equal to or below 93,270 ac-ft; and a 100% chance of water use being equal to or below 110,945 ac-ft (**Table 3**). As visualized by a histogram, *Simetar*™ determined the actual data distribution is skewed to the right. If the data followed a normal distribution, a 50% probability would be expected about the actual mean of 87,513 ac-ft. With the data skewed to the right, however, *Simetar*™ adjusted the expected values to a normal distribution of probabilities and determined 93,270 ac-ft to have a 50% probability of occurring (i.e., adjusted expected mean or "average").

## Assessment of Technology and Efficiency Status

The District's pumping plant diverts water from the Rio Grande near the town of Los Indios (**Exhibit 5**). From there, the water flows into either the High-Line canal which provides water to the southern part of the District, or the Low-Line canal which provides water to the northern part of the District and two reservoirs adjacent to the pumping plant. The original pumping plant was built around 1910 and has a typical operating capacity of 430 cfs and a maximum of 510 cfs. More than 207 miles of canal, 15 miles of resaca, 5.5 miles of pipeline, 10 relift pumping stations, and two storage reservoirs (totaling 5,500 ac-ft holding capacity) comprise the majority of the District's delivery-system infrastructure.

The District has been aggressive in increasing the maximum amount of water deliverable to each turnout while also increasing its overall efficiency by reducing irrigation time requirements. The District has initiated a Geographic Information System (GIS) program for linking a mapping system to a data base, indicating: where water has been ordered; for what types of crops; and various systems necessary to deliver the water. Volumetric pricing in water deliveries is not an important aspect of district operations as only about 1 percent of current agricultural water use is volumetrically measured. Producers' use of water-conserving methods and equipment is encouraged (Kaniger).

## Water Rights Ownership and Sales

The District holds eight Certificates of Adjudication (i.e., #'s 0841-000 through 0841-006, and 0051-000). Additional M&I water rights (i.e., Certificates of Adjudication) for 2,075 ac-ft belong to the East Rio Hondo and Arroyo Water Supply Corporations and the City of San Benito, with the District providing diversion and delivery of the water. Further, users interested in acquiring additional water beyond their available allocations may acquire such water from parties interested in selling or leasing rights. Such external-to-the-District purchases and/or leases are subject to a transportation delivery loss charged by the District; that is, purchase or lease of one ac-ft from sources outside the District will result in users receiving some amount less than one ac-ft at their diversion point.

Water charges assessed irrigators within the District consist of an annual flat-rate maintenance and operations fee assessment of $30.00 for the first irrigated acre and $8.50 for every acre thereafter (which is paid for by the landowner). An additional $7 per acre per irrigation is assessed (either to the landowner-operator, or tenant-producer), with such irrigations approximated as using 0.5 ac-ft of water per acre. This equates to a variable charge of $14.00 per ac-ft of water. Volumetrically-priced irrigation water (i.e., only about 1% of agricultural irrigation use) is priced at $17.50 per ac-ft in the District (Kaniger).

In the event water supplies exceed District demands, current District policy is to sell annual water supplies, even on long-term agreement, rather than market a one-time sale of water rights (Kaniger). The District has control over the irrigation water supplies, but the municipal rights holders control and realize any benefits accruing from sale or lease of their rights.

## Project Data

As proposed by the District, the capital improvements for this project consist of two distinct and independent components, with no anticipated synergies between them. The components of the total project are (1) interconnect between Canals 39 and 13-A1 and (2) replacement of the Rio Grande diversion pumping plant. Though referred to as components within this report, they are locally referred to as the "Interconnect Project" and "Pumping Plant Project," respectively (Kaniger).[7]

### Component #1: Interconnect Between Canals 39 and 13-A1

Once the interconnect is completed, it will assist Canal 13-A1 with water-delivery services to approximately 1,385 acres of agricultural cropland in the northern portions of the District. This will in turn, allow the water currently being diverted to 13-A1 to be available for use by Canals 13-A and 13-B, which service an additional 4,761.3 acres. In total, 6,146.3 acres are expected to realize improvements in water-delivery services as a result of the construction of the interconnect (**Table 4**). Summary data for this component of the District's proposed project are presented in **Table 5** with discussion of that data following.

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7 Due to numerical rounding, values as they appear herein may not reconcile exactly with hand calculations the reader may make. In all instances, RGIDECON© values are reported with appropriate rounding-off (as determined by the authors) of values which are in this analysis report.

## Description

This project component consists of enlarging 6,600 feet of existing Canal 39 and connecting it to a new 6,000-foot segment of canal to be dug which will result in an "interconnect" between Canals 39 and 13-A1. Once readied, the combined 12,600 ft segment will be lined with a geomembrane liner and a concrete cover. Once installed and brought on-line, this component is expected to (**Table 4**):

a) eliminate the need for water storage (and subsequent relift pumping) in Reservoir No. 7, which will reduce seepage and evaporation by 3,457.1 ac-ft per year;
b) reduce losses in Canal 39 (existing) by a net of 365.9 ac-ft per year;
c) increase evaporation and seepage losses in the new interconnect (to be dug) by a total of 37.9 ac-ft per year;
d) increase head at farm-diversion points and reduce on-farm water usage by an estimated 5,771.4 ac-ft per year (caused by faster field irrigation with resulting water savings due to lower percolation losses); and
e) provide several secondary benefits, including reduced travel time and expense of canal operators because more farms can be irrigated simultaneously with the increased head - these benefits are not estimated and included in this report.

## Installation Period

It is anticipated that it will take one year after purchase and project component initiation for the interconnect system to be installed and fully implemented (**Table 6**). No losses of operations or otherwise adverse impacts are anticipated during the installation period since this will occur in the off-season.

## Productive Period

A useful life of 49 years[8] for the interconnect is expected and assumed in the baseline analysis (**Table 6**). A shorter useful life is possible, but 49 years is considered reasonable and consistent with engineering expectations (Allard). Sensitivity analyses are utilized to examine the effects of this assumption. The first year of the productive period is assumed to occur during year 2 of the 50-year planning period.

## Projected Costs

Two principal types of costs are important when evaluating this proposed investment: the initial capital outlay and recurring operating and maintenance expenses. Assumptions related to each type of expenditure are presented below.

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8 Actually, the estimated useful life is 50 years instead of 49 years. RGIDECON© was developed to consider up to a maximum 50-year planning horizon, with the perspectives that projections beyond that length of time are largely discounted and also highly speculative. Allowing for the one-year installation period on the front end reduces to 49 years the time remaining for productive use of the asset during the 50-year planning period allowed within RGIDECON©.

**Initial.** Based on discussions with Bureau of Reclamation management, expenses associated with design, engineering, and other preliminary development of this project component's proposal are ignored in the economic analysis prepared for the planning report. Such costs are to be incorporated, however, into the materials associated with the final design phase of this project component.

Capital investment costs (i.e., excavate, purchase, and install the lining) for the 12,600 feet of interconnect are estimated at $3,585,300 in 2003 nominal dollars (**Table 6**) (Allard). Sensitivity analyses on the total amount of all capital expenditures are utilized to examine the effects of this assumption. All expenditures are assumed to occur on day one of this project component's inception, thereby avoiding the need to account for inflation in the cost estimate.

**Recurring**. Annual operating and maintenance (O&M) expenditures associated with the interconnect are expected to be slightly different than those presently occurring for Canal 39. That is, the "interconnect" is comprised of Canal 39 and a new 6,000-foot segment of canal to be dug. While the existing Canal 39 will experience a change in O&M expenses (as it is converted from unlined to lined canal), the new section of canal to be dug (which will also be lined) will result in increased O&M as it will add to the District's water-delivery infrastructure. Annual O&M expenditures associated with the interconnect system (i.e., modified Canal 39 and new canal to be dug) are anticipated to be $5,867 (basis 2003 dollars) (**Table 6**). In the first two years after completion of the interconnect system, the 'canal repair' portion of O&M are assumed to be covered by warranty (Allard).

## Projected Savings

**Water**. Water savings are reductions in diversions from the Rio Grande, i.e., how much less water will be used by the District for existing agricultural and municipal operations as a result of this project component's installation and utilization? Estimates of such savings are comprised, in this case, of both off-farm and on-farm savings with regards to agricultural (i.e., irrigation) water use only; that is, no savings related to M&I water use are anticipated.[9]

*Off-farm* savings are those occurring in the District's canal delivery system as a result of eliminated seepage, as well as seepage and evaporation savings attributed to eliminating the need for Reservoir No. 7, after the targeted canal segments are transformed into an interconnect between Canals 39 and 13-A1. Historic ponding test studies in the District by Fipps (2000, 2001-2002) have documented annual water losses on nearby earthen canal segments ranging from 1.45 to 9.35 gal/ft$^2$/day, depending on the soil type. Bureau of Reclamation engineers incorporated this and other information to estimate 365.9 ac-ft of annual savings associated with

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9 A major assumption made by the authors and embedded in this and other economic and conservation analyses of Irrigation Districts' proposed capital rehabilitation projects is that only the local Irrigation District's perspective is considered, i.e., activities external to the Irrigation District are ignored. In addition, all marginal water and energy diversion/use savings are recognized, not withstanding that in actuality, the "savings" may continue to be utilized in expansion of current activities and/or development of new activities within (or outside) the District. The existence of "on-allocation" status for a District does not alter these assumptions.

changes to Canal 39 (**Table 4**). Existing estimates of water losses are applicable to canals in their present state. It is highly likely that additional deterioration and increased water loss and associated O&M expenses should be expected as the respective canals age (Carpenter; Halbert). While estimates of ever-increasing seepage losses over time could be developed, the analysis conservatively maintains a constant water savings (Allard), consistent with assumptions embedded in previous analyses (Rister et al. 2002b and 2002c).

Additional *off-farm* savings of 3,457.1 ac-ft (**Table 4**) are expected from eliminating the need for Reservoir No. 7 annually (i.e., 602.7 ac-ft evaporation plus 2,854.4 ac-ft of seepage). Finally, *off-farm* savings will be reduced by increased seepage and evaporation losses of 37.9 ac-ft which will be incurred with digging of the new canal to facilitate the interconnect. Allowing for such increased losses, the estimated total net *off-farm* water savings as per **Table 4** is 3,785.1 ac-ft per year (i.e., 3,457.1 + 365.9 - 37.9). Sensitivity analyses are performed on all water savings to examine the implications of this estimate. Annual net *off-farm* water savings for this component are expected to result in reducing Rio Grande diversions.

*On-farm* water savings are estimated to be forthcoming from increased head at farm diversion points which will allow for faster irrigation of fields and result in lower levels of percolation losses (Lewis and Milne). These water savings will reduce the District's diversions from the Rio Grande.

Annual *on-farm* water savings for the interconnect component are based on an estimated 37.5% savings of applicable flood-irrigation from reduced percolation due to increased head. That is, water demand is estimated by Allard to decrease from 0.835 ac-ft per acre irrigated to 0.522 ac-ft per acre irrigated (i.e., a 0.313 ac-ft reduction equals 37.5%) as head pressure at farm delivery turn-outs is increased from 0.5 head to 1.2-1.5 head on the effected acreage. As mentioned, the interconnect will improve water delivery to a total of 6,146.3 acres (**Table 4**) irrigated by Canals 13-A, 13-B, and 13-A1 as the water currently being diverted to 13-A1 will be available for use by the other two canal-service areas. Annual savings associated with the lessened percolation losses for combined acreage are calculated as:

| | |
|---|---|
| 6,146.3 | acres realizing improved water-delivery service |
| x .313 | reduction (ac-ft) in water demand per irrigated acre (i.e., from 0.835 to 0.522) |
| 1,923.8 | reduced (ac-ft) of water demand per irrigation due to reduced percolation |
| x 3 | number of irrigations per year |
| 5,771.4 | reduced (ac-ft) of water demand per year due to reduced percolation |

Estimates of both off- *and on-farm* water savings do not include any conveyance losses that could potentially be realized during delivery of the water from the Rio Grande to the farm turn-out gates. Thus, all noted water savings are based on a "delivered" basis, which is the same as the "diverted" basis for this project analysis.[10]

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[10] The District's system-wide conveyance loss is estimated to be 60% (Fipps and Pope), as determined by considering total water diversions and total water sales (Allard). For the two components comprising the project being analyzed and reported on here, additional water savings, beyond the local project-area savings

The District does not anticipate any savings due to increased on-farm efficiencies via increased producer adoption of drip irrigation and/or micro-jet technology. Thus, the annual amount of total *on-farm* savings in the base analysis is 5,771.4 ac-ft. As with other estimated water savings, this value is held constant during each year of the interconnect's productive life to provide for a conservative analysis. Combining *off-* and *on-farm* water savings (without any additional conveyance losses included) results in 9,556.5 ac-ft per year (**Table 4**).

**Energy**. In a general sense, energy savings may occur as a result of less water being pumped at the Rio Grande diversion site and/or due to reduced relift pumping at one or more points throughout the canal delivery system. The amount of such energy savings and the associated monetary savings are detailed below. Energy savings associated with both reduced diversions and relift pumping are expected from this component.

Factors constituting energy savings associated with lessened diversion pumping are twofold: (a) less energy used for pumping, and (b) the cost (or value) of such energy. Recent historic records for calendar years 1997-2001 are presented in **Table 7** with electricity representing 96% of the District's total diversion-energy expense. The District's average lift at the Rio Grande diversion site is 20 feet. On average, 109,874 BTU were used to pump each ac-ft of water diverted. Combining the 109,874 BTU per ac-ft with the anticipated 3,785.1 ac-ft of annual *off-farm* water savings results in anticipated annual irrigation energy savings of 415,884,077 BTU (121,888 kwh) (**Table 4**). Assuming the historical average (i.e., 1997-2001) $0.061 cost per kwh,[11] the estimated annual irrigation energy cost savings associated with the water savings are $7,478 in 2003 dollars (**Table 4**).

Additional *off-farm* energy savings due to reduced relift pumping are expected to be forthcoming from the interconnect component.[12] After completion and installation of the interconnect, there will be a net reduction in relift pumping required to delivery water to the 'old District 13' as relifting from Reservoir No. 7 back into Canal 13-A1 will be eliminated. There will be, however, a small increase in the amount of relifting required to deliver water to an area referred to as the "Island" (i.e., an area adjacent to Reservoir No. 7 which constitutes approximately 360 acres). The net amount of relift-energy reduction associated with this component is estimated to be 31,160,505 BTU (9,133 kwh), which, using the average historical (i.e., 1997-2001) relift-energy cost of $0.136/kwh equates to an annual relift-pumping energy savings of $1,239. Total *off-farm* energy savings (from water savings and reduced relifting) amount to 447,039,534 BTU (131,020 kwh), or the equivalent of $8,669.

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being claimed, attributed to conveyance loss are not claimed based on the basic assumption that the claimed water savings will occur throughout the year and on the margin will not effect the "fullness" of the canal system. That is, even though water will be saved at a component/project site, the District's delivery-system infrastructure will remain fully charged as usual and will therefore not produce additional water savings beyond those realized at the component/project site(s) (Allard).

11 This estimated value is calculated using District information provided by Kaniger which incorporates both the amount of electricity and natural gas used to divert water and the respective costs for each.

12 Eliminating the need to relift water saves energy, but not water; i.e., the same amount of water is still diverted from the Rio Grande and delivered to users within the District – it is just not relifted.

Savings anticipated for the *on-farm* reductions in water use are determined in similar fashion as *off-farm* energy savings and also appear in **Table 4**. Using the 109,874 BTU per ac-ft and multiplying by the 5,771.4 ac-ft of annual on-farm water savings results in additional anticipated annual irrigation energy savings of 634,124,690 BTU (185,851 kwh). Again, assuming the historical average $0.061 cost per kwh, the estimated annual irrigation *on-farm* energy cost savings are $11,403 in 2003 dollars. Combining both the *off-* and *on-farm* water savings results in total anticipated irrigation energy cost savings of 1,081,164,224 BTU (316,871 kwh) or the equivalent of $20,071 in 2003 dollars. Sensitivity analyses are performed to examine the effects of the assumptions for both the amount of energy used (per ac-ft of water diverted) and the cost per unit of energy.

**Operating and Maintenance**. It is estimated that annual O&M expenses for the existing earthen Canal 39 are $2,744 per mile (Kaniger). Thus, across the total 6,600 feet of Canal 39 proposed for conversion to a lined canal to result in an interconnect, a reduction of $3,430 in O&M is anticipated. Combining this with the $732 reduction in Reservoir No. 7 O&M results in a total expected reduction in annual O&M of $4,162 (**Table 6**).

**Reclaimed Property**. No real property will be reclaimed in association with this project component (**Table 6**). Consequently, there is no realizable cash income to claim as a credit against the costs of this project component.

### Component #2: Replacement of Pumping Plant

Once completed, the new pumping plant will insure the District's diversion and delivery capability to numerous municipal, industrial, and agricultural irrigation users for many years. Summary data for this component of the District's proposed project are presented in **Table 5** with discussion of that data following.

**Description**

This project component consists of constructing a new Rio Grande diversion pumping plant at a site adjacent to the current pumping plant near Los Indios, TX. The current plant is nearly 100 years old and exhibits signs of structural distress and damage as recorded by previous engineers' structural-integrity inspections and reports (Halff Associates, Inc.). After the new pumping plant is constructed and brought on-line, it is expected to (**Table 8**):

a) allow for the annual capture of 2,380.2 ac-ft of additional "no-charge" water;
b) reduce pumping requirements by eliminating the leaking of 1,399 ac-ft through the old pumping plant's walls and back into the Rio Grande – note that eliminating the "re-circulation"of this water will not save any water, only the energy that would have been used to pump it;
c) improve energy efficiency by 28.2% (for diversion operations) with the installation of new energy-efficient pumps and motors; and

d) provide secondary benefits such as alleviating operational and public-health concerns associated with the old pumping plant's structural integrity and possible demise.[13]

**Installation Period**

Following construction initiation, it is anticipated two years will be required to construct and fully equip the new pumping plant (**Table 6**). No losses of operations or otherwise adverse impacts are anticipated during the construction period as the District will continue to depend on the old pumping plant for diversions during this time period.

**Productive Period**

A useful life of 48 years[14] for the new pumping plant is expected and assumed in the baseline analysis (**Table 6**). Sensitivity analyses are utilized to examine the effects of this assumption. The first year of the productive period is assumed to occur during year 3 of the 50-year planning period.

**Projected Costs**

Two principal types of costs are important when evaluating this proposed investment: the initial capital outlay and recurring operating and maintenance expenses. Assumptions related to each type of expenditure are presented below.

**Initial.** Based on discussions with Bureau of Reclamation management, expenses associated with design, engineering, and other preliminary development of this project component's proposal are ignored in the economic analysis prepared for the planning report. Such costs are to be incorporated, however, into the materials associated with the final design phase of this project component.

Capital investment costs for purchasing, constructing, and equipping the new pumping plant total $9,715,000 in 2003 nominal dollars (**Table 6**) (Allard). Sensitivity analyses on the total amount of all capital expenditures are utilized to examine the effects of this assumption. All expenditures are assumed to occur on day one of this project component's inception, thereby avoiding the need to account for inflation in the cost estimate.

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13 In a November 21, 2002 meeting in San Benito, TX, Mr. Arkelao Lopez (Project Manager for BECC) advised that concerns such as public health, service disruption and chaos, etc., in the event of a complete plant failure, would be considered by BECC separately.

14 The actual estimated useful life is 50 years instead of 48 years. RGIDECON© was developed to consider up to a maximum 50-year planning horizon, with the perspectives that projections beyond that length of time are largely discounted and also highly speculative. Allowing for the two-year construction period on the front end reduces to 48 years the time remaining for productive use of the asset during the 50-year planning period allowed within RGIDECON©.

**Recurring**. Annual operating and maintenance (O&M) expenditures associated with the new pumping plant are expected to be different than those presently occurring for the existing pumping plant. Annual O&M expenditures associated with the new pumping plant are anticipated to be $107,648 (basis 2003 dollars) (**Table 6**) (Allard). This value includes salaries, repairs, and the estimated insurance premium for the new pumping plant.

## Projected Savings

**Water**. Water savings normally are considered to be reductions in diversions from the Rio Grande, i.e., how much less water will be used by the District as a result of this project component's installation and utilization? Estimates of such savings are comprised, in this case, of only off-farm savings with regards to agricultural (i.e., irrigation) water use only; i.e., no savings related to M&I water use are anticipated.[15]

In somewhat of a different approach than previously followed in Rister et al. (2002b and 2002c) and for the other component of this project, *off-farm* savings for this project component are the additional 2,380.2 ac-ft of annual "no-charge" water the District will be able to divert after the new pumping plant is constructed (**Table 8**). This value is based on management's assertion that twice a month, an additional (i.e., beyond current captures) 50 cfs of water could be captured following the construction of the new pumping plant. This quantity of *off-farm* water savings (i.e., capture of no-charge water) will be made possible with the ability to pump at a 50 cfs minimal pumping capacity and is an amount above and beyond the amount of no-charge water the District currently lifts (i.e., with its current 75 cfs minimal pumping capacity). Though this water savings is not "savings" in the typical sense one might think of, it is an amount of water which can be captured, quantified, and "added" to the District's supply without being counted against its Watermaster-controlled allocation. In a marginal-economic sense, it is thought of as water "saved" to the District, representing a credit to its available water account/supply.[16] Annual water savings are therefore calculated as:

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15 The District diverts water for M&I and agricultural concerns, and technically one could allocate a proportionate share of the forecasted water savings to M&I water use (i.e., as opposed to solely agricultural irrigation water use). That is, in the last 5-years, M&I water use has averaged 11% of total District diversions (i.e., 7,904 ac-ft of 74,227 ac-ft) and one could allocate that proportion of the projected savings to M&I. In this instance, however, RGIDECON© results will not change and the authors have opted to simplify and not allocate water savings between M&I and agriculture uses. Under existing legislation and irrigation District operating procedures, municipal users are 'guaranteed' their water rights, leaving agriculture as the residual claimant on available water allocations to the District. Thus, any marginal, additional water supplies (e.g., water savings) are assumed to accrue to agriculture. In this case, it (agriculture) is credited with all of the water savings from this project component.

16 If additional no-charge water is to be diverted, and marginal-economic principles are to be maintained, then the energy cost associated with additional electricity used to divert the "water savings" (i.e., no-charge water) from the Rio Grande must be recognized. Consequently, the associated additional energy costs are considered a "negative" savings.

| | | |
|---|---|---|
| | 24 | annual number of additional opportunities to capture "no-charge" water |
| x | 50 | number of cfs diverted each occurrence |
| | 1,200 | annual "no-charge" (in cfs) water diverted with the new pumping plant |
| x | 646,360 | gallons of water per cfs (Carpenter) |
| | 775,632,000 | annual "no-charge" (in gallons) diverted with the new pumping plant |
| ÷ | 325,851 | gallons of water per ac-ft (Carpenter) |
| | 2,380.2 | annual ac-ft of annual water savings (i.e., additional no-charge water). |

The District does not anticipate any other *off-farm* water savings associated with the new pumping plant so the annual amount of total *off-farm* savings in the base analysis is 2,380.2 ac-ft. As with other estimated water savings, this value is held constant each year of the new pumping plant's productive period to provide for a conservative analysis. As shown in **Table 8**, *on-farm* water savings are not expected to be forthcoming for this component. Therefore, total *off-* and *on-farm* water savings amount to 2,380.2 ac-ft of water (**Table 8**). Sensitivity analyses are performed on all water savings to examine the implications of this estimate. Annual net *off-farm* water savings for this component are <u>not</u> expected to result in reduced diversions from the Rio Grande.

**<u>Energy</u>**. Energy savings <u>may</u> occur as a result of improved operational efficiencies with the new pumping plant at the Rio Grande diversion site. The amount of such energy savings and the associated monetary savings are detailed below.

Energy savings for this component are based on efficiency improvements realized with the installation of new energy-efficient pumps and motors, and eliminating the "recirculating"of water which currently leaks through the existing pumping plant's walls and back into the Rio Grande. These energy savings will be partially offset, however, by increased costs of pumping new "no-charge" water. Factors constituting energy savings associated with efficiency improvements are twofold: (a) less energy used for pumping, and (b) the cost (or value) of such energy.

Recent historic energy records for 1997-2001 are presented in **Table 7**. On average, a rate of 32.20 kwh/ac-ft was used to divert each ac-ft of water from the Rio Grande with the old pumping plant. Bureau of Reclamation engineers anticipate an average energy consumption rate of 23.12 kwh/ac-ft diverted for the new pumping plant (Allard). Multiplying the 9.08 kwh/ac-ft reduction times the adjusted annual 93,270 ac-ft of water diverted (**Table 3**) results in a potential annual *off-farm* energy savings, due to improved operational efficiencies associated with installing modern pumps and motors, of 2,736,559,812 BTU (802,040 kwh) (**Table 8**).[17]

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17 Approximately 1,399 ac-ft (i.e., 1.5% of current use) of water leaks through the existing pumping plant's walls and is never measured. Thus, the energy spent to "re-circulate" this water can conspicuously skew the real total energy consumption rate for the old pumping plant unless it is subtracted from the total. Because this analysis also reports on forthcoming energy saved by eliminating wall leaks, and in order to not double count energy savings with a new pumping plant, the authors have made appropriate calculation adjustments. It is important to note that while such reduced "re-circulation" results in energy savings, there are no relevant water savings to be recognized.

Assuming a $0.061 cost per kwh (**Table 7**), the estimated annual irrigation energy cost savings are $49,208 in 2003 dollars (**Table 8**).

District management estimates 1.5% of the total water pumped by the old pumping plant leaks through the walls and back into the Rio Grande before it reaches the District's metering point in the High-Line delivery canal, just outside the pumping plant (Kaniger). This volume of water is thus "re-circulated" with energy being used and the water never metered (nor counted against the District's Watermaster-controlled allocation). Thus, additional *off-farm* energy savings will be realized with the installation of a new pumping plant. Using the District's loss estimate percentage and multiplying it by the adjusted volume of water pumped results in an estimate of 1,399 ac-ft of "re-circulated" water (i.e., 1.5% x 93,270 ac-ft = 1,399 ac-ft). Adjusting for what the average total energy consumption rate would be (if water was not re-circulated) and multiplying this by the volume of re-circulated water results in an *estimated off-farm* energy savings of 151,413,462 BTU (44,377 kwh). Using the calculated average energy cost of $0.061 per kwh results in an estimated $2,723 (in 2003 terms) of additional *off-farm* energy cost savings attributed to eliminating water leaks in pumping plant walls (**Table 8**).

Note that the effective "water savings" attributed to the new pumping plant is in fact the capture of additional "no-charge" water. Therefore, the additional energy required to divert this additional volume of water must be quantified and included in net energy-savings calculations.[18] Thus, the *off-farm* energy savings calculated above which is attributed to (a) improved efficiencies of the new pumps and motors, and (b) those attributed to eliminated wall leaks and the subsequent "re-circulating" will be partially offset by increased energy costs of pumping new "no-charge" water.[19]

Since the "no-charge" water will be diverted using the new pumping plant, the Bureau of Reclamation's anticipated average energy consumption rate of 78,885 BTU/ac-ft (or 23.12 kwh/ac-ft) diverted is multiplied by the estimate of water savings (i.e., additional diverted no-charge water) of 2,380.2 ac-ft to arrive at an annual energy increase of 187,763,124 BTUs (55,030 kwh), or alternatively, as considered in this analysis "negative savings" (**Table 8**). Assuming the average energy cost of $0.0000180 per BTU ($0.061 per kwh) (**Table 6**) results in reduced off-farm energy savings of $3,376 (**Table 8**).

Combining all sources of *off-farm* energy savings and "negative savings" result in a net anticipated irrigation energy cost savings of 2,700,210,150 BTU (791,386 kwh) or the equivalent of $48,554 in 2003 dollars (**Table 8**). Sensitivity analyses are performed to examine the effects of the assumptions for both the amount of energy saved and the cost per unit of energy.

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18 That is, old pumping plant energy minus new pumping plant energy equals energy savings attributed to modernizing the plant. The volume of water accounted for in the total energy calculations is the "adjusted" historic pumped volume which does not take into account the new "no-charge" water. Consequently, energy costs for this new "no-charge" water must be added into the calculations (or, in RGIDECON terms, included as a "negative savings").

19 As mentioned, the capture of no-charge water will require electrical energy to divert it from the Rio Grande. Thus, an adjustment (i.e., reduction) is made to energy savings to account for that electricity used to lift the no-charge water savings as in the marginal economic sense it is considered a "negative" savings.

**Operating and Maintenance**. The 5-year (i.e., 1997-2001) average of historic O&M expenses for the existing pumping plant are $35,511 per year (Kaniger). Thus, once the new pumping plant is constructed and effectively replaces the existing Rio Grande diversion pumping plant, one would anticipate a corresponding reduction of $35,511 in annual O&M expenses (**Table 6**). Substantial additional capital expenditures are expected in the near future, however, if continued, reliable operation of the existing pumping plant is required. At a minimum, it is expected that three of the primary pumps and motors must be replaced for $300,000 each during the next ten years. Also, the current insurance coverage is limited to approximately $500,000 of capital equipment, due to the dilapidated condition of the existing pumping plant as ascertained by the insurance carrier (Kaniger). Therefore, in the event of a catastrophic loss (e.g., lightening-induced damage), the District could be responsible for funding the replacement of a vast majority of the damaged capital equipment. Recognition of such potential losses are represented by inclusion of a $3.4 million cost item spread across the next twenty years.

The two noted forms of capital expenditures are noticeably less than the estimated $9,715,000 costs of the new pumping plant. Such lower expenditures in a relatively piecemeal fashion may not realize the anticipated energy savings, or allow for the capture of additional no-charge water, one would expect with construction of a new pumping plant. The two capital expenditures are amortized over the respective noted time frames (i.e., ten and twenty years) using a 6.125% interest rate. Repair costs are anticipated to continue at comparable levels throughout the 50-year analysis period, recognizing the continued general state of disrepair and inefficiencies in the existing pumping plant's aging infrastructure. Insurance premiums are estimated to increase over time, reaching levels comparable to those of the new pumping plant in year 22 of the analysis period, reflecting the anticipated improvements in the existing pumping plant and the aging of the new pumping plant. Therefore, a total reduction in annual O&M of $535,843 (2003 dollars) is expected.

**Reclaimed Property**. No real property will be reclaimed in association with this project component (**Table 6**). Consequently, there is no realizable cash income to claim as a credit against the costs of this project component.

## Abbreviated Discussion of Methodology[20]

Texas Agricultural Experiment Station and Texas Cooperative Extension economists have developed an economic spreadsheet model, RGIDECON© (Rio Grande Irrigation District Economics), to facilitate economic and conservation analyses of the capital renovation projects proposed by South Texas irrigation districts. The spreadsheet's calculations are attuned to

20 The publication, "Economic Methodology for South Texas Irrigation Projects – RGIDECON©," Texas Water Resources Institute TR-203 (Rister et al. 2002a), provides a more extensive documentation of the methodology employed in conducting the analyses presented in this report. Excerpts from that publication are included in this section; several of the authors of this report are co-authors of TR-203. The methodology documented in Rister et al. (2002a) was endorsed in July, 2002, as expressed by Larry Walkoviak, Area Manager of the Oklahoma-Texas Office of the Bureau of Reclamation, "The results of the model will fully satisfy the economic and conservation analyses required by the Act and it may be used by any irrigation district or other entity seeking to qualify a project for authorization and/or construction funding under P.L. 106-576."

economic and financial principles consistent with capital budgeting procedures for evaluating projects of different economic lives, thereby "leveling the playing field" and allowing "apples to apples" comparisons across projects. As a result, RGIDECON© also is capable of providing valuable information for implementing a method of prioritization of projects in the event of funding limitations.

The results of a RGIDECON© analysis can be used in comparisons to exogenously-specified economic values of water to easily provide for implications of a cost-benefit analysis. Methodology similar to that presented for water savings also is included in the spreadsheet for appraising the economic costs associated with energy savings (both on a BTU and kwh basis). That is, there are energy savings both from pumping less water forthcoming from reducing seepage and from improving the efficiency of pumping plants.

RGIDECON©'s economic and energy savings analyses provide an estimate of the economic costs per ac-ft of water savings and per BTU (kwh) of energy savings associated with each proposed capital improvement activity (i.e., an individual component). An aggregate assessment is also provided for those proposed projects consisting of two or more activities (i.e., components). Lastly, the RGIDECON© model has been designed to accommodate "what if" analyses for Districts interested in evaluating additional, non-Act authorized capital improvement investments in their water delivery infrastructure.

Public Law 106-576 legislation requires a variation of economic analyses in which the initial construction costs and annual economic savings are used independently in assessing the potential of capital renovations proposed by irrigation districts (Bureau of Reclamation). In addition, all calculations are performed on a nominal rather than real basis (Hamilton).

Detailed results for the economic and financial analyses following the methodology presented in Rister et al. (2003) appear in subsequent sections of the main body of this report. Results for the legislative criteria appear in Appendices A and B.

## Assumed Values for Critical Parameters

This section of the report presents the values assumed for several parameters which are considered critical in their effects on the overall analysis results. This discussion is isolated here to emphasize the importance of these parameters and to highlight the values used.[21]

### Discount Rates and Compound Factors

The discount rate used for calculating net present values of the different cost streams represents a firm's required rate of return on capital (i.e., interest) or, as sometimes expressed, an opportunity cost on its capital. The discount rate is generally considered to contain three

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21 As was the case in the previous "Abbreviated Discussion of Methodology" section, some of the text in this section is a capsulated version of what is presented in Rister et al. (2002a).

components: a risk-free component for time preference (i.e., social time value), a risk premium, and an inflation premium (Rister et al. 1999).

One estimate of such a discount rate from the District's perspectives would be the cost at which it can borrow money (Hamilton). Griffin notes, however, that because of the potential federal funding component of the project, it could be appropriate to ignore the risk component of the standard discount rate as that is the usual approach for federal projects. Hamilton notes that the Federal discount rate consists of two elements, time value of money and inflation, but that the rate is routinely used as a real rate, ignoring the inflationary component. After considering those views and interacting with Penson and Klinefelter, Texas A&M University agricultural economists specializing in financing, the 2002 Federal discount rate of 6.125% was adopted for use in discounting all financial streams for projects analyzed in 2002. In order to maintain consistency, this same rate is adopted for projects analyzed in 2003.

Recognition of the potential for uneven annual flows of water and energy savings associated with different project components and different projects encourages normalizing such flows through calculation of the net present value of water and energy savings. In the absence of complete cost-benefit analysis and the associated valuation of water and energy savings, it is acknowledged that there is no inflationary influence to be accounted for during the discounting process (Klinefelter), i.e., only the time value (t) should be recognized in the discounting process. Accordingly, a lower rate than the 6.125% 2002 Federal discount rate is desired. Consultations with Griffin and Klinefelter contributed to adoption of the 4% rate used by Griffin and Chowdhury for the social time value in these analyses.

As presented in Rister et al. (2002a), use of an overall discount rate of 6.125% in conjunction with a 4% social time value and the assumption of a 0% risk premium infers a 2.043269% annual inflation rate. Such an inferred rate is consistent with recent and expected rates of nominal price increases for irrigation construction, O&M, and energy costs (Rister et al. 2002a). Thus, a 2.043269% rate is used to compound 2003 nominal dollar cost estimates forward for years in the planning period beyond 2003. Rationale for assuming this rate is based both on the mathematical relationship presented above and analyses of several pertinent price index series and discussions with selected professionals.[22]

## Pre-Project Annual Water Use by the District

Water availability and use in the District has varied considerably in recent years as a result of water shortages in the Rio Grande Basin. **Table 2** contains the District's historic water use among agricultural irrigation and M&I along with an indication of the total use for most years from 1986-2001. Rather than isolate one particular year as the baseline on which to base estimates of future water savings, Bureau of Reclamation, Texas Water Development Board,

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22 Admittedly, excessive precision of accuracy is implied in this assumed value for the rate of annual cost increases. Such accuracy of future projections is not claimed, however, but rather that this precise number is that which satisfies the multiplicative elements of the overall discount rate calculation discussed in Rister et al. (2002a), assuming the noted values for risk and time value.

Texas Agricultural Experiment Station, and Texas Cooperative Extension representatives agreed during the summer of 2002 to use the average levels of use during a five-year period as a proxy for the baseline (Clark et al. 2002a). At a subsequent meeting (Clark et al. 2002b), consideration was directed to recognizing, when appropriate, how allocation restrictions in recent years may have adversely affected the five-year average to the extent the values do not adequately represent potential irrigated acreage in future years during the project's planning period. Where an irrigation district has been impacted by allocation restriction(s), a more-lengthy time series of water use is to be used to quantify representative water use.

As discussed in more detail earlier in this report, this District's total water use has averaged 74,227 ac-ft during recent years from 1997-2001, and 87,513 ac-ft in the 16-year period from 1986-2001 (**Table 2**). Review of historic volumes of water pumped (and that subsequently available to agriculture) by the District from 1986 to 2001 reveals an evident down trend, reflecting reduced allocations. The down trend as evidenced in **Table 2** is, in the opinions of Texas Agricultural Experiment Station and Texas Cooperative Extension Service economists, significant enough to warrant *adjustments* for the purpose of this analysis. To accurately analyze the full water-savings potential of the proposed project, statistical methods based on a probability distribution of actual historical data were used to *adjust* water-pumped volumes up from their nominal average of 87,513 ac-ft to an adjusted estimate of 93,270 ac-ft (i.e., an increase of 5,757 ac-ft). This adjusted value is perceived as appropriate for gauging future water and energy savings during this project's planning period (Kaniger).

## Value of Water Savings per Acre-Foot of Water

The analyses reported in this report focus on identifying the costs per ac-ft of water saved and per BTU and kwh of energy saved. The value of water is ignored in the analysis, essentially stopping short of a complete benefit-cost analysis.[23] The results of this analysis can be used, however, in comparisons to exogenously-specified economic values of water to easily provide for implications of a cost-benefit analysis.

## Energy Usage per Acre-Foot of Water

Essential elements of this analysis include calculating the cost of energy savings and also recognizing the value of such savings as a reduction in O&M expenditures when evaluating the cost of water savings associated with the respective project components.[24] Historic average

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23 RGIDECON© includes opportunities for the value of agricultural irrigation water and the incremental differential value associated with M&I water to be specified, thereby facilitating comprehensive benefit-cost analyses. For the purposes of this study, however, such values are set at $0.00, thereby meeting the assessment requirements specified in the Public Law 106-576 legislation.

24 "There are interests in identifying mutually-exclusive estimates of the costs per unit of (a) water saved and (b) energy saved for the respective projects and their component(s). 'Mutually-exclusive' refers to each respective estimate being calculated independent of the other. The measures are not intended to be additive as they are single measures, representing different perspectives of the proposed projects and their

energy usage levels of 109,874 BTU per ac-ft of water pumped by the District for calendar years 1997-2001 are used to estimate energy savings resulting when less water is pumped due to implementation of the proposed project component(s) (**Table 7**). Thus, it is anticipated this amount of energy (i.e., 109,874 BTU) will be saved when diversions from the Rio Grande are lessened by one ac-ft. Another important assumption is there are 3,412 BTU per kwh (Infoplease.com). This equivalency factor allows for converting the energy savings information into an alternative form for readers of this report.

### Value of Energy Savings per BTU/kwh

Average energy consumption rates (e.g., kwh/ac-ft) are key factors used in determining energy savings associated with reduced Rio Grande diversions. Similarly, average costs of energy (e.g., $/kwh) are used to transform the expected energy savings into an economic value. Records of recent costs of energy for the District have ranged from $1.31 to $2.67 per ac-ft diverted, with the average of $1.98 per ac-ft used in this analysis report (**Table 7**). Sensitivity analyses are utilized to examine the effects of this assumption.

## Economic and Financial Evaluation Results by Component

The economic and financial analysis results forthcoming from an evaluation of the aforementioned data using RGIDECON© (Rister et al. 2002a) are presented in this section for individual project components. Results aggregated across the two project components (interconnect and pumping plant replacement) are presented in a subsequent section.

### Component #1: Interconnect Between Canals 39 and 13-A1

The first component evaluated is the enlarging of 6,600 feet of existing Canal 39 and connecting it to a new 6,000-foot segment of canal to be dug which will result in an "interconnect" between Canals 39 and 13-A1. Once readied, the combined 12,600-foot segment will be lined with a geomembrane liner and concrete cover. Results of the analysis of that component follow (**Table 9**).

#### Quantities of Water and Energy Savings

Critical values in the analyses are the quantities of water and energy anticipated being saved during the 49-year productive life of the interconnect.[25] On a nominal (i.e., non-

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component(s)." (Rister et al. 2002a)

25 As noted previously, the estimated useful life is 50 years instead of 49 years. RGIDECON© was developed to consider up to a maximum 50-year planning horizon, with the perspectives that projections beyond that length of time are largely discounted and also highly speculative. Allowing for the one-year installation period on the front end reduces to 49 years the time remaining for productive use of the asset during the 50-year planning period allowed within RGIDECON©.

discounted) basis, 468,267 ac-ft of irrigation water are projected to be saved; no M&I water savings are expected as a result of this project component. Thus, the total nominal water savings anticipated are 468,267 ac-ft over the 49-year productive life of this component (**Table 9**). Using the 4% discount rate previously discussed, those nominal savings translate into 196,105 ac-ft of real irrigation savings and 0.0 ac-ft of real M&I water savings, representing a total real water savings of 196,105 ac-ft (**Table 9**).

On a nominal (i.e., non-discounted) basis, 52,977,046,976 BTU (15,526,684 kwh) of energy savings are projected to be saved in association with the forecast irrigation water savings (**Table 9**). Since there are no M&I-related energy savings, these values represent the total energy savings for this project component. Using the 4% discount rate previously discussed, those nominal savings translate into 22,186,188,476 BTU (6,502,400 kwh) of real irrigation-related energy savings over the 49-year productive life of this component (**Table 9**).

**Cost of Water Saved**

One principal gauge of a proposed project component's merit is the estimated cost per ac-ft of water saved as a result of the project component's inception, purchase, installation, and implementation. Both deterministic results based on the expected values for all parameters integrated into the RGIDECON© assessments and sets of sensitivity analyses for several pairs of the data parameters are presented below for component #1.

**NPV of Net Cost Stream**. Accounting for all capital purchase and installation construction costs, changes in O&M expenditures, and credits for energy savings, the nominal total cost of the 50-year planning period for the interconnect component of the District's project is $1,997,731 (**Table 9**). Using the previously-identified discount rate of 6.125%, these nominal cost dollars translate into present-day, real costs of $3,206,881 (**Table 9**). This amount represents, across the total 50-year planning period, the total net costs, in 2003 dollars, of purchasing and installing the interconnect as well as payment of the net changes in O&M expenditures. Note that the real-value amount of costs is substantially greater than the nominal-value amount. This result occurs because in the nominal-value amount, the savings accruing from reduced O&M savings and energy use in the lengthy planning period dollar for dollar offset the initial investment costs. In the case of the real-value amount, however, the savings occurring during the latter years of the planning period are discounted significantly and thus do not offset as much of the initial investment costs.

**NPV of All Water Savings**. As detailed above, the total nominal water savings anticipated are 468,267 ac-ft (**Table 9**). The corresponding total real water savings expressed in 2003 water quantities are 196,105 ac-ft, assuming the previously-identified discount rate of 4.00% (**Table 9**).

**Cost per Acre-Foot of Water Saved**. The real net cost estimate of $3,206,881 correlates with the real water savings projection of 196,105 ac-ft; the respective annuity equivalents are $207,017 and 9,129 ac-ft (**Table 29**). The estimated cost of saving one ac-ft of water with the interconnect component is $22.68 (**Table 9**). This value can be interpreted as the cost of leasing one ac-ft of water in year 2003. It is not the cost of purchasing the water right of one ac-ft.

Following through with the economic and capital budgeting methodology presented in Rister et al. (2003), this value represents the costs per year in present-day dollars of saving one ac-ft of water each year into perpetuity through a continual replacement series of the interconnect with all of the attributes previously indicated.

**Sensitivity Results**. The results presented above are predicated on numerous assumed values incorporated into the RGIDECON© analysis. Those assumed values and the logic for their assumed values are presented in prior sections. Here, attention is directed toward varying some of those values across a plausible range of possibilities, thereby seeking to identify the stability/instability of the estimated cost measure (i.e., $ costs per ac-ft of water saved) in response to changes in certain key parameters. The two-way Data Table feature of Excel (Walkenbach) is utilized to accomplish these sensitivity analyses whereby two parameters are varied and all others remain constant at the levels assumed for the baseline analysis.

The most critical assumption made in the baseline analysis is considered to be that pertaining to the amount of reduction in Rio Grande diversions that will result from the purchase, installation, and implementation of the interconnect system. Thus, the cost per ac-ft of water-saved sensitivity analyses consist of varying the off-farm water-savings dimension[26] of that factor across a range of 175 to 500 ac-ft (including the baseline 366 ac-ft) for the interconnect, paired with variances in three other fundamental factors: (a) expected useful life of the investment; (b) initial capital investment costs; and (c) value of BTU savings (i.e., cost of energy). Results for these three sets of sensitivity analyses are presented in **Tables 10, 11,** and **12**, respectively.

**Table 10** reveals a range of $15.86 to $106.91 cost per ac-ft of savings around the baseline estimate of $22.68. These calculated values were derived by varying the reduction in Rio Grande diversions arising from off-farm water savings for the interconnect from as low as 175 ac-ft up to 500 ac-ft about the expected 366 ac-ft and by investigating a range of useful lives of the interconnect down from the expected 49 years to as short as only 10 years. As should be expected, shorter-useful lives than the anticipated 49-year productive life resulted in higher cost estimates, lower off-farm (and the assumed linked on-farm) water savings than the predicted 366 ac-ft also increased cost estimates, and higher-than-expected water savings contributed to lower cost estimates.

Similarly, **Table 11** is a presentation of a range of cost estimates varying from $13.27 to $57.80 per ac-ft of savings around the baseline estimate of $22.68. These calculated values were derived by varying the reduction in Rio Grande diversions arising from off-farm water savings for the interconnect from as low as 175 ac-ft up to 500 ac-ft about the expected 366 ac-ft and by considering variations in the cost of the capital investment in the interconnect varying from $500,000 less than the expected $3,585,300 up to $500,000 more than the expected amount. As should be expected, both lower-than-the-anticipated $3,585,300 capital costs and/or higher-than-expected water savings contributed to lower cost estimates, while both higher investment costs and/or lower off-farm water savings than the predicted amounts increased the cost estimates.

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26 On-farm water savings are linked to off-farm water savings within RGIDECON©'s assessment of this component of the proposed project. Thus, as the off-farm water savings associated with the interconnect is varied in the sensitivity analyses, the on-farm savings also vary.

The final set of sensitivity analyses conducted for the costs of water savings accounted for varying both the reduction in Rio Grande diversions arising from investment in the interconnect and the cost of energy. **Table 12** is an illustration of the results of varying those parameters from as low as 175 ac-ft up to 500 ac-ft about the expected 366 ac-ft per mile of off-farm water savings and across a range of $0.0300 to $0.0900 per kwh energy costs about the expected $0.0611 per kwh level. The resulting costs of water savings estimates ranged from a high of $51.99 per ac-ft down to a low of $14.52 per ac-ft. The lower cost results are associated with high water savings and high energy costs – the two factors combined contribute to substantial energy cost savings which substantially offset both the initial capital costs of the interconnect plus the anticipated changes in O&M expenses. The opposite effect is experienced with low energy usage per ac-ft of water savings and low water savings, i.e., higher costs estimates are calculated for these circumstances.

**<u>Cost of Energy Saved</u>**

Besides the estimated cost per ac-ft of water saved as a result of the interconnect's inception, purchase, installation, and implementation, another issue of interest is the cost of energy savings. Reduced water diversions from the Rio Grande will result from reducing seepage and evaporation, and increasing head pressure at on-farm delivery sites (thereby reducing on-farm water use). These reduced diversions and reduced use associated with the proposed interconnect's capital renovation result in less water being pumped, translating into energy savings. Both deterministic results based on the expected values for all parameters integrated into the RGIDECON© assessments and sets of sensitivity analyses for several pairs of the data parameters are presented below for component #1, the interconnect.

**<u>NPV of Net Cost Stream</u>**. Accounting for all capital purchase and installation construction costs, and changes in O&M expenditures, the nominal total cost of the 50-year planning period for the interconnect component of the District's project is $3,730,689 (**Table 9**). Using the previously-identified discount rate of 6.125%, these nominal cost dollars translate into a present-day, real cost of $3,618,755 (**Table 9**). This amount represents, across the total 50-year planning period, the total net costs, in 2003 dollars, of purchasing and installing the interconnect as well as payment of the net changes in O&M expenditures, ignoring the changes in energy costs and allowing no credits for the water savings.

**<u>NPV of All Energy Savings</u>**. As detailed above, the total nominal energy savings anticipated are 52,977,046,976 BTU (15,526,684 kwh) (**Table 9**). The corresponding total real energy savings expressed in 2003 energy quantities are 22,186,188,476 BTU (i.e., 6,502,400 kwh) over the 49-year productive life of this component, assuming the previously-identified discount rate of 4.00% (**Table 9**).

**<u>Cost per BTU & kwh Saved</u>**. The real net cost estimate of $3,618,755 correlates with the real energy savings projection of 22,186,188,476 BTU (6,502,400 kwh); the respective annuity equivalents are $233,605 and 1,032,771,521 BTU (302,688 kwh) (**Table 30**). The estimated cost of saving one BTU of energy using the interconnect comprising this project component is $0.0002262 ($0.772 per kwh) (**Table 9**). An interpretation of this value is that it is the cost of saving one BTU (kwh) of energy in year 2003. Following through with the economic and capital budgeting methodology presented in Rister et al. (2002a), this value represents the costs per year in present-day dollars of saving one BTU (kwh) of energy into perpetuity through a continual replacement series of the interconnect with all of the attributes previously indicated.

**Sensitivity Results**. As with the cost of water-savings estimates, the results presented above for energy savings are predicated on numerous assumed values incorporated into the RGIDECON© analysis. Those assumed values and the logic for their assumed values are presented in prior sections. Here, attention is directed toward varying some of those values across a plausible range of possibilities, thereby seeking to identify the stability/instability of the estimated cost measure (i.e., $ costs per BTU (or kwh) saved) in response to changes in certain key parameters. The two-way Data Table feature of Excel (Walkenbach) again is utilized to accomplish these sensitivity analyses whereby two parameters are varied and all others remain constant at the levels assumed for the baseline analysis.

The most critical assumption made in the baseline analysis in this respect is considered to be that pertaining to the amount of energy savings that will result from the purchase, installation, and implementation of the interconnect in the canal delivery system. Thus, the cost per BTU (or kwh) of energy-saved sensitivity analyses consists of varying the amount of energy savings across a range of 80.0 percent up to 150.0 percent of the baseline 109,874 BTU (32.20 kwh) current average usage per ac-ft of water savings paired with variances in three other fundamental factors: (a) expected useful life of the investment; (b) initial capital investment costs; and (c) off-farm water savings of the interconnect. Results on a BTU and kwh basis for these three sets of sensitivity analyses are presented in **Tables 13** and **14, 15** and **16,** and **17** and **18**, respectively.

**Tables 13** and **14** reveal a range of $0.0001508 to $0.0005997 cost per BTU (and $0.515 to $2.046 per kwh) of energy savings around the baseline estimate of $0.0002262 per BTU ($0.772 per kwh). These calculated values were derived by varying the amount of energy used per ac-ft of water savings across a range as low as 80.0% up to 150.0% of the expected 109,874 BTU (32.20 kwh) current average usage per ac-ft of water savings and by investigating a range of useful lives of the capital investment in the interconnect down from the expected 49 years to as short as only 10 years. As should be expected, shorter-useful lives than the anticipated 49-year productive life resulted in higher cost estimates, lower energy savings than the predicted 100% of current average usage also increased cost estimates, and higher-than-expected energy savings contributed to lower cost estimates.

Similarly, **Tables 15** and **16** are a presentation of a range of cost estimates varying from $0.0001300 to $0.0003218 per BTU (and $0.443 to $1.098 per kwh) of energy savings around the baseline estimate of $0.0002262 per BTU ($0.772 per kwh). These calculated values were derived by varying the amount of energy used per ac-ft of water savings across a range as low as 80.0% up to 150.0% of the expected 109,874 BTU (32.20 kwh) current average usage per ac-ft of water savings and by considering variations in the cost of the capital investment in the interconnect varying from $500,000 less than the expected $3,585,300 up to $500,000 more than the expected amount. As should be expected, both lower-than-the-anticipated $3,585,300 capital costs and/or higher-than-expected energy savings contributed to lower cost estimates while both higher investment costs and/or lower energy savings than the expected 109,874 BTU (32.20 kwh) increased the cost estimates.

The final set of sensitivity analyses conducted for the costs of energy savings accounted for varying both the amount of energy used per ac-ft of water savings and the reduction in Rio Grande diversions arising from water savings from the interconnect. **Tables 17** and **18** are illustrations of the results of varying those parameters from as low as 80.0% up to 150.0% of the expected 109,874 BTU (32.20 kwh) current average usage per ac-ft of water savings and from as low as 175 ac-ft up to 500 ac-ft about the expected 366 ac-ft off-farm water savings from the interconnect. The resulting costs of energy savings estimates ranged from a low of $0.0001112 per BTU ($0.379 per kwh) up to a high of $0.0005732 per BTU ($1.956 per kwh). The lower cost estimates are associated with high energy usage per ac-ft of water savings and high off-farm (and the assumed linked on-farm) water savings – the two factors combined contribute to substantial energy cost savings. The opposite effect is experienced with low energy usage per ac-ft of water savings and low off-farm water savings, i.e., higher costs estimates are calculated for these circumstances.

**Component #2: Replacement of Pumping Plant**

The second component evaluated is replacing the District's current pumping plant at its diversion point near Los Indios, TX along the Rio Grande. Once completed, the new pumping plant will insure the District's diversion and delivery capability for many years and provide for many operations-related efficiencies. Results of the analysis of that component follow (**Table 19**).

**Quantities of Water and Energy Savings**

Critical values in the analyses are the quantities of water and energy anticipated being saved during the 48-year productive life of the new pumping plant.[27] On a nominal (i.e., non-discounted) basis, 114,250 ac-ft of irrigation water are projected to be saved; no M&I water savings are expected as a result of this project component.[28] Thus, the total nominal water savings anticipated are 114,250 ac-ft over the 48-year productive life of this component (**Table 19**). Using the 4% discount rate previously discussed, those nominal savings translate

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[27] As noted previously, the estimated useful life is 50 years instead of 48 years. RGIDECON© was developed to consider up to a maximum 50-year planning horizon, with the perspectives that projections beyond that length of time are largely discounted and also highly speculative. Allowing for the two-year installation period on the front end reduces to 48 years the time remaining for productive use of the asset during the 50-year planning period allowed within RGIDECON©.

[28] As noted previously, the District diverts water for M&I and agricultural concerns, and technically one could allocate a proportionate share of the forecasted water savings to M&I water use (i.e., as opposed to solely agricultural irrigation water use). That is, in the last 5-years, M&I water use has averaged 11% of total District diversions (i.e., 7,904 ac-ft of 74,227 ac-ft) and one could allocate that proportion of the projected savings to M&I. In this instance, however, RGIDECON© results will not change and the authors have opted to simplify and not allocate water savings between M&I and agriculture uses. Under existing legislation and irrigation District operating procedures, municipal users are 'guaranteed' their water rights, leaving agriculture as the residual claimant on available water allocations to the District. Thus, any marginal, additional water supplies (e.g., water savings) are assumed to accrue to agriculture. In this case, it (agriculture) is credited with all of the water savings from this project component.

into 46,643 ac-ft of real irrigation savings and 0.0 ac-ft of real M&I water savings, representing a total real water savings of 46,643 ac-ft (**Table 19**).

On a nominal (i.e., non-discounted) basis, 129,610,087,207 BTU (37,986,544 kwh) of energy savings are projected to be saved in association with the new pumping plant (**Table 19**). Since there are no M&I-related energy savings, these values represent the total energy savings for this project component. Using the 4% discount rate previously discussed, those nominal savings translate into 52,913,560,965 BTU (15,508,078 kwh) of real irrigation-related energy savings over the 48-year productive life of this component (**Table 19**).

## Cost of Water Saved

One principal gauge of a proposed project component's merit is the estimated cost per ac-ft of water saved as a result of the project component's inception, purchase, installation, and implementation. Both deterministic results based on the expected values for all parameters integrated into the RGIDECON© assessments and sets of sensitivity analyses for several pairs of the data parameters are presented below for component #2, the replacement of the existing pumping plant.

**NPV of Net Cost Stream**. Accounting for all capital purchase and installation construction costs, changes in O&M expenditures, and credits for energy savings, the nominal total cost of the 50-year planning period for the pumping-plant replacement component of the District's project is $(3,692,827) (**Table 19**). Using the previously-identified discount rate of 6.125%, these nominal cost dollars translate into present-day, real costs of $4,016,274 (**Table 19**). This amount represents, across the total 50-year planning period, the total net costs, in 2003 dollars, of purchasing and installing the new pumping plant as well as payment of the net changes in O&M expenditures. Note that the positive real-value amount of costs is substantially greater than the negative nominal-value amount. This result occurs because in the nominal-value amount, the savings accruing from reduced energy use in the lengthy planning period are sufficient to more than offset the initial investment costs. In the case of the real-value amount, however, the savings occurring during the latter years of the planning period are discounted significantly and thus do not offset as much of the initial investment costs.

**NPV of All Water Savings**. As detailed above, the total nominal water savings anticipated are 114,250 ac-ft (**Table 19**). The corresponding total real water savings expressed in 2003 water quantities are 46,643 ac-ft, assuming the previously-identified discount rate of 4.00% (**Table 19**).

**Cost per Acre-Foot of Water Saved**. The real net cost estimate of $4,016,274 correlates with the real water savings projection of 46,643 ac-ft; the respective annuity equivalents are $259,266 and 2,171 ac-ft (**Table 29**). The estimated cost of saving one ac-ft of water using the new pumping plant comprising this project component is $119.41 (**Table 19**). This value can be interpreted as the cost of leasing one ac-ft of water in year 2003. It is not the cost of purchasing the water right of one ac-ft. Following through with the economic and capital budgeting methodology presented in Rister et al. (2002a), this value represents the costs per year in present-day dollars of saving one ac-ft of water each year into perpetuity through a continual replacement series of the pumping plant with all of the attributes previously indicated.

**Sensitivity Results**. The results presented above are predicated on numerous assumed values incorporated into the RGIDECON© analysis. Those assumed values and the logic for their assumed values are presented in prior sections. Here, attention is directed toward varying some of those values across a plausible range of possibilities, thereby seeking to identify the stability/instability of the estimated cost measure (i.e., $ costs per ac-ft of water saved) in response to changes in certain key parameters. The two-way Data Table feature of Excel (Walkenbach) is utilized to accomplish these sensitivity analyses whereby two parameters are varied and all others remain constant at the levels assumed for the baseline analysis.

The most critical assumption made in the baseline analysis is considered to be that pertaining to the amount of water savings (i.e., capture of additional no-charge water by the District) that will result from the purchase, installation, and implementation of the new pumping plant. Thus, the cost per ac-ft of water-saved sensitivity analyses consist of varying the *off-farm* water-savings dimension of that factor across a range of 1,000 to 3,250 ac-ft (including the baseline 2,380 ac-ft) paired with variances in three other fundamental factors: (a) expected useful life of the investment; (b) initial capital investment costs; and (c) value of BTU savings (i.e., cost of energy). Results for these three sets of sensitivity analyses are presented in **Tables 20, 21,** and **22**, respectively.

**Table 20** reveals a range of $87.98 to $597.89 cost per ac-ft of savings around the baseline estimate of $119.41. These calculated values were derived by varying the water savings (i.e., additional capture of no-charge water) arising from *off-farm* water savings from the new pumping plant from as low as 1,000 ac-ft up to 3,250 ac-ft about the expected 2,380 ac-ft and by investigating a range of useful lives for the new pumping plant down from the expected 48 years to as short as only 10 years. As should be expected, shorter-useful lives than the anticipated 48-year productive life resulted in higher cost estimates, lower *off-farm* water savings than the predicted 2,380 ac-ft also increased cost estimates, and higher-than-expected water savings contributed to lower cost estimates.

Similarly, **Table 21** is a presentation of a range of cost estimates varying from $33.54 to $458.42 per ac-ft of savings around the baseline estimate of $119.41. These calculated values were derived by varying the water savings (i.e., capture of additional no-charge water) arising from *off-farm* water savings from as low as 1,000 ac-ft up to 3,250 ac-ft about the expected 2,380 ac-ft and by considering variations in the cost of the capital investment in the new pumping plant varying from $2,500,000 less than the expected $9,715,000 up to $2,500,000 more than the expected amount. As should be expected, both lower-than-the-anticipated $9,715,000 capital costs and/or higher-than-expected water savings contributed to lower cost estimates, while both higher investment costs and/or lower off-farm (and the assumed linked on-farm) water savings than the predicted amounts increased the cost estimates.

The final set of sensitivity analyses conducted for the costs of water savings accounted for varying both the water savings (i.e., capture of additional no-charge water) arising from investment in the new pumping plant and the cost of energy. **Table 22** is an illustration of the results of varying those parameters from as low as 1,000 ac-ft up to 3,250 ac-ft about the expected 2,380 ac-ft of off-farm water savings and across a range of $0.0300 to $0.0900 per kwh energy costs about the expected $0.0611 per kwh level.[29] The resulting costs of water savings estimates ranged from a high of $317.30 per ac-ft down to a low of $78.55 per ac-ft. The lower cost results are associated with high water savings and high energy costs – the two factors combined contribute to substantial energy cost savings which substantially offset both the initial capital costs of the pumping plant plus the anticipated changes in O&M expenses. The opposite effect is experienced with low energy usage per ac-ft of water savings and low water savings, i.e., higher costs estimates are calculated for these circumstances.

## Cost of Energy Saved

Besides the estimated cost per ac-ft of water saved as a result of the new pumping plant's inception, purchase, installation, and implementation, another issue of interest is the cost of energy savings. Replacing the old pumping plant pumps and motors with new, modern, highly-efficient pumps and motors will translate into energy savings. Both deterministic results based on the expected values for all parameters integrated into the RGIDECON© assessments and sets of sensitivity analyses for several pairs of the data parameters are presented below for component #2, the replacement of the existing pumping plant.

**NPV of Net Cost Stream**. Accounting for all capital purchase and installation construction costs, and changes in O&M expenditures, the nominal total cost of the 50-year planning period for the pumping plant replacement component of the District's project is $448,792 (**Table 19**). Using the previously-identified discount rate of 6.125%, these nominal cost dollars translate into a present-day, real cost of $4,967,744 (**Table 19**). This amount represents, across the total 50-year planning period, the total net costs, in 2003 dollars, of purchasing and installing the pumping plant as well as payment of the net changes in O&M expenditures, ignoring the changes in energy costs and allowing no credits for the water savings (i.e., additional capture of no-charge water).

**NPV of All Energy Savings**. As detailed above, the total nominal energy savings anticipated are 129,610,087,207 BTU (37,986,544 kwh) (**Table 19**). The corresponding total real energy savings expressed in 2003 energy quantities are 52,913,560,965 BTU (i.e., 15,508,078 kwh) over the 48-year productive life of this component, assuming the previously-identified discount rate of 4.00% (**Table 19**).

**Cost per BTU & kwh Saved**. The real net cost estimate of $4,967,744 correlates with the real energy savings projection of 52,913,560,965 BTU (15,508,078 kwh); the respective annuity equivalents are $320,688 and 2,463,136,869 BTU (721,904 kwh) (**Table 30**). The estimated cost of saving one BTU of energy using the new pumping plant comprising this project component is $0.0001302 ($0.444 per kwh) (**Table 19**). An interpretation of this value is that it is the cost of saving one BTU (kwh) of energy in year 2003. Following through with the economic and capital budgeting methodology presented in Rister et al. (2002a), this value

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29 Energy costs for relift pumping are linked to the energy costs for diversion pumping at the Rio Grande, facilitating variance of both during these sensitivity analyses.

represents the costs per year in present-day dollars of saving one BTU (kwh) of energy into perpetuity through a continual replacement series of the pumping plant with all of the attributes previously indicated.

**Sensitivity Results**. As with the cost of water-savings estimates, the results presented above for energy savings are predicated on numerous assumed values incorporated into the RGIDECON© analysis. Those assumed values and the logic for their assumed values are presented in prior sections. Here, attention is directed toward varying some of those values across a plausible range of possibilities, thereby seeking to identify the stability/instability of the estimated cost measure (i.e., $ costs per BTU (or kwh) saved) in response to changes in certain key parameters. The two-way Data Table feature of Excel (Walkenbach) again is utilized to accomplish these sensitivity analyses whereby two parameters are varied and all others remain constant at the levels assumed for the baseline analysis.

The most critical assumption made in the baseline analysis in this respect is considered to be that pertaining to the amount of energy savings that will result from the purchase, installation, and implementation of the new pumping plant. Thus, the cost per BTU (or kwh) of energy-saved sensitivity analyses consists of varying the amount of energy savings across a range of 80.0 percent up to 150.0 percent of the baseline 109,874 BTU (32.20 kwh) current average usage per ac-ft of water savings paired with variances in three other fundamental factors: (a) expected useful life of the investment; (b) initial capital investment costs; and (c) off-farm water savings. Results on a BTU and kwh basis for these three sets of sensitivity analyses are presented in **Tables 23** and **24, 25** and **26,** and **27** and **28**, respectively.

**Tables 23** and **24** reveal a range of $0.0000868 to $0.0003456 cost per BTU (and $0.296 to $1.179 per kwh) of energy savings around the baseline estimate of $0.0001302 per BTU ($0.444 per kwh). These calculated values were derived by varying the amount of energy saved per ac-ft of water savings across a range as low as 80.0% up to 150.0% of the projected 29,340 BTU (8.60 kwh) average saved per ac-ft of water savings and by investigating a range of useful lives of the capital investment in the new pumping plant down from the expected 48 years to as short as only 10 years. As should be expected, shorter-useful lives than the anticipated 48-year productive life resulted in higher cost estimates, lower energy savings than the predicted 100% of current average usage also increased cost estimates, and higher-than-expected energy savings contributed to lower cost estimates.

Similarly, **Tables 25** and **26** are a presentation of a range of cost estimates varying from $0.0000431 to $0.0002446 per BTU (and $0.147 to $0.834 per kwh) of energy savings around the baseline estimate of $0.0001302 per BTU ($0.444 per kwh). These calculated values were derived by varying the amount of energy saved per ac-ft of water savings across a range as low as 80.0% up to 150.0% of the projected 29,340 BTU (8.60 kwh) average saved per ac-ft of water savings and by considering variations in the cost of the capital investment in the new pumping plant from $2,500,000 less than the expected $9,715,000 up to $2,500,000 more than the expected amount. As should be expected, both lower-than-the-anticipated $9,715,000 capital costs and/or higher-than-expected energy savings contributed to lower cost estimates while both higher investment costs and/or lower energy savings than the 109,874 BTU (32.20 kwh) increased the cost estimates.

The final set of sensitivity analyses conducted for the costs of energy savings accounted for varying both the amount of energy saved per ac-ft of water savings and the water savings. **Tables 27** and **28** are illustrations of the results of varying those parameters from as low as 80.0% up to 150.0% of the projected 29,340 BTU (8.60 kwh) average saved per ac-ft of water savings and from as low as 1,000 ac-ft up to 3,250 ac-ft about the expected 2,380 ac-ft *off-farm* water savings. The resulting costs of energy savings estimates ranged from a low of $0.0000834 per BTU ($0.285 per kwh) up to a high of $0.0001670 per BTU ($0.569 per kwh). The lower cost estimates are associated with high energy usage per ac-ft of water savings and high *off-farm* water savings – the two factors combined contribute to substantial energy cost savings. The opposite effect is experienced with low energy usage per ac-ft of water savings and low off-farm water savings, i.e., higher costs estimates are calculated for these circumstances.

## Economic and Financial Evaluation Results Aggregated Across Components

According to Bureau of Reclamation management (Shaddix), a comprehensive, aggregated measure is required to assess the overall potential performance of a proposed project consisting of multiple components. That is, projects are to be evaluated in the form submitted by Districts and when two or more components comprise a project, one general measure should be determined to represent the total project. Discussions of such comprehensive measures follow for both the cost of water saved and the cost of energy saved. ***Aggregations of only the baseline cost measures are presented; that is, the various sensitivity analyses previously presented and discussed for each individual project component are not duplicated here.***

Following the methodology documented in Rister et al. (2002a), the cost measures calculated for the individual components are expressed in 'annuity equivalents.' The 'annuity equivalent' calculations facilitate comparison and aggregation of capital projects with unequal useful lives, effectively serving as development of a common denominator. The finance aspect of the 'annuity equivalent' calculation as it is used in the RGIDECON© analyses is such that it represents an annual cost savings associated with one unit of water (or energy) each year extended indefinitely into the future. Zero salvage values and continual replacement of the respective technologies (i.e., interconnect canal and replacement of pumping plant) with similar capital items as their useful life ends are assumed.

### Cost of Water Saved

**Table 29** provides aggregated information on the cost of water saved, based on calculated values previously discussed, for the interconnect and pumping plant replacement components. The individual component measures are displayed in the table and then aggregated in the far-right column, indicating that the overall cost of water saved is **$41.26 per ac-ft**.

### <u>Interconnect Between Canals 39 and 13-A1</u>

The initial capital investment associated with the "Interconnect" capital renovation is $3,585,300 in 2003 nominal dollars (**Table 6**). Combining that cost with the changes in O&M

expenditures over the 50-year planning horizon and calculating the net present value (NPV) of that flow of funds contributes to the $3,206,881 value noted at the top of the 'Interconnect' column in **Table 29**. The nominal water savings anticipated during the 50-year planning period total 468,267 ac-ft; discounted into a real 2003 value, those savings are estimated to be 196,105 ac-ft (**Table 9**). Converting both of the real 2003 values into annuity equivalents per the methodology presented in Rister et al. (2002a) results in an annual cost estimate of $207,017 to achieve 9,129 ac-ft of water savings per year (**Table 29**). Dividing the first annuity estimate by the second annuity estimate results in the annuity cost estimate of $22.68 per ac-ft of water savings for the interconnect capital renovation (**Table 29**).

## Replacement of Pumping Plant

The initial capital investment associated with the 'Pumping Plant Replacement' capital renovation is $9,715,000 in 2003 nominal dollars (**Table 6**). Combining that cost with the changes in O&M expenditures over the 50-year planning horizon and calculating the net present value (NPV) of that flow of funds contributes to the $4,016,274 value noted at the top of the 'Pumping Plant Replacement' column in **Table 29**. The nominal water savings anticipated during the 50-year planning period total 114,250 ac-ft; discounted into a real 2003 value, those savings are estimated to be 46,643 ac-ft (**Table 19**). Converting both of the real 2003 values into annuity equivalents per the methodology presented in Rister et al. (2002a) results in an annual cost estimate of $259,266 to achieve 2,171 ac-ft of water savings per year (**Table 29**). Dividing the first annuity estimate by the second annuity estimate results in the annuity cost estimate of $119.41 per ac-ft of water savings for the pumping-plant replacement capital renovation (**Table 29**).

## Aggregate Measure of Cost of Water Savings

Combining the costs of the two components (i.e., interconnect and pumping plant replacement) of the District's proposed project results in a total NPV net cost (i.e., both initial investments and changes in O&M expenditures) estimate of $7,223,155 which translates into an annuity cost equivalent of $466,283 per year (**Table 29**). The total NPV of water savings is 242,747 ac-ft, representing an annuity equivalent of **11,300 ac-ft of water savings** (**Table 29**), representing **12.9%** of the current average water diversion by the District, or **12%** of the "adjusted" average water diversion. Performing the same math as used in calculating the costs of water savings for the individual components (i.e., dividing the annuity of the net cost stream by the annuity amount of water savings) produces the **$41.26 per ac-ft** water savings aggregate cost measure (**Table 29**).

## Cost of Energy Saved

**Table 30** provides aggregated information on the cost of energy saved, based on calculated values previously discussed, for the interconnect and pumping plant replacement components. The individual component measures are displayed in the table and then aggregated in the far-right column, indicating that the overall cost of water saved is **$0.0001586 per BTU (or $0.541 per kwh)**.

## Interconnect Between Canals 39 and 13-A1

The initial capital investment associated with the 'Interconnect' capital renovation is $3,585,300 in 2003 nominal dollars (**Table 6**). Combining that cost with the changes in O&M expenditures over the 50-year planning horizon and calculating the net present value (NPV) of that flow of funds contributes to the $3,618,755 value noted at the top of the 'Interconnect' column in **Table 30.** This value is again higher than the corresponding $3,206,881 value in **Table 29** because of the ignoring of energy savings when calculating the 'Cost of Energy Saved'. The nominal energy savings anticipated during the 50-year planning period total 52,977,046,976 BTU (15,526,684 kwh) (**Table 9**). Discounted into a real 2003 value, those savings are estimated to be 22,186,188,476 BTU (6,502,400 kwh) (**Table 9**). Converting both of the real 2003 values into annuity equivalents per the methodology presented in Rister et al. (2002a) results in an annual cost estimate of $233,605 to achieve 1,032,771,521 BTU (302,688 kwh)of energy savings per year (**Table 30**). Dividing the first annuity estimate by the second annuity estimate results in the annuity cost estimate of $0.0002262 per BTU ($0.772 per kwh) of energy savings for the interconnect capital renovation (**Table 30**).

## Replacement of Pumping Plant

The initial capital investment associated with the 'Pumping Plant Replacement' capital renovation is $9,715,000 in 2003 nominal dollars (**Table 6**). Combining that cost with the changes in O&M expenditures over the 50-year planning horizon and calculating the net present value (NPV) of that flow of funds contributes to the $4,967,744 value noted at the top of the 'Pumping Plant Replacement' column in **Table 30.** This value is again higher than the corresponding $4,016,274 value in **Table 29** because of the ignoring of energy savings when calculating the 'Cost of Energy Saved.' The nominal energy savings anticipated during the 50-year planning period total 129,610,087,207 BTU (37,986,544 kwh) (**Table 19**). Discounted into a real 2003 value, those savings are estimated to be 52,913,560,965 BTU (15,508,078 kwh) (**Table 19**). Converting both of the real 2003 values into annuity equivalents per the methodology presented in Rister et al. (2002a) results in an annual cost estimate of $320,688 to achieve 2,463,136,869 BTU (721,904 kwh) of energy savings per year (**Table 30**). Dividing the first annuity estimate by the second annuity estimate results in the annuity cost estimate of $0.0001302 per BTU ($0.444 per kwh) of energy savings for the pumping plant replacement capital renovation (**Table 30**).

## Aggregate Measure of Cost of Energy Savings

Combining the costs of the two components (i.e., interconnect and pumping plant replacement) of the District's proposed project results in a total NPV net cost (i.e., both initial investments and changes in O&M expenditures) estimate of $8,586,499 which translates into an annuity cost equivalent of $554,293 per year (**Table 30**). The total NPV of energy savings is 75,099,749,441 BTU, representing an annuity equivalent of **3,495,908,390 BTU (1,024,592 kwh)** of energy savings. Performing the same math as used in calculating the costs of energy savings for the individual components (i.e., dividing the annuity of the net cost stream by the annuity amount of energy savings) produces the **$0.0001586 per BTU ($0.541 per kwh)** of energy savings aggregate cost measure (**Table 30**).

## Limitations

The protocol and implementation of the analyses reported in this report are robust, providing insightful information regarding the potential performance of the project proposed by the District. There are limitations, however, to what the results are and are not and how they should and should not be used. The discussion below addresses such issues.

- The analyses are conducted from a District perspective, ignoring income and expense impacts on both water users (i.e., farmers and M&I consumers) and third-party beneficiaries (i.e., the indirect economic impact effects). The spatial component and associated efficiency issues of 28 independent Districts supplying water to an array of agricultural, municipal, and industrial users in a relatively concentrated area are cast aside.

- The analyses are *pro forma* budgeting in nature, based on forecasts of events and economic forces extending into the future several years. Obviously, there is imperfect information about such conditions, contributing to a degree of uncertainty as to the appropriate exact input values. Necessarily, such uncertainty contributes to some ambiguity surrounding the final result measures.

- Constrained financial resources, limited data availability, and a defined time horizon prohibit (a) extensive field experimentation to document all of the engineering- and water-related parameters; and (b) prolonged assimilation of economic costs and savings parameters. The immediate and readily-apparent status of needs for improvement across a wide array of potential projects and the political atmosphere characterizing the U.S.-Mexico water treaty situation discourage a slow, deliberate, elaborate, extensive evaluation process.

- Although the analyses' framework is deterministic, sensitivity analyses are included for several of the dominant parameters in recognition of the prior two limitations.

- Beyond the sensitivity analyses mentioned above, there is no explicit accounting for risk in these analyses; a notable exception is the incorporation of two annuities representing anticipated capital expenditures corresponding to continued operations of the existing pumping plant.

- The economic appraisal of the proposed project is objective and relatively simple in nature, providing straightforward estimates of the cost of water and energy saved. No benefit value of the water savings is conjectured to be forthcoming from the proposed project, i.e., a complete cost-benefit procedure is not applied. Consequently, the comprehensive issue of the net value of the proposed project is not addressed in this report.

- The project is evaluated as proposed, consisting in this case of multiple (i.e., two) components. While such components are assumed mutually independent in the analyses, their joint potential is the bottomline result presented in this report as opposed to them being identified as separate and distinct renovation alternatives. That is, per guidance from Bureau of Reclamation management (Shaddix), the project is appraised as proposed by the District, with the two components viewed as an 'all or none' opportunity.

- An individual project proposed by a District is evaluated in the positive, objective form noted earlier, independent of other District's proposals. Should there be cause for comparison of potential performance across two or more proposed projects, such appraisals need to be conducted exogenous to this report. The results presented in the main body of this report could be useful for such prioritization processes, however, as discussed in Rister et al. (2002a).

- No possible capital renovations to the District besides those contained in the designated proposal are evaluated in comparison to the components of this project proposal. That is, while there may be other more economical means of saving water and energy within the District, those methods are not evaluated here.

- The analyses of the proposed project are conditional on existing District, Rio Grande Valley, State, and Federal infrastructure, policies (e.g., Farm Bill, U.S.-Mexico Water Treaty, etc.), and other institutional parameters (e.g., Domestic, Municipal, and Industrial (DMI) reserve levels, water rights ownership and transfer policies, priority of M&I rights, etc.). The implicit assumption is that the 28 Irrigation Districts in the Rio Grande Valley will retain their autonomy, continuing to operate independently, with any future collaboration, merger, other form of reorganization, and/or change in institutional policies to have no measurable impacts on the performance of the proposed project.

- The projects analyzed in this and other forthcoming reports are limited to those authorized by the Congress as a result of processes initiated by individual Districts or as proposed for other funding should that occur. That is, no comprehensive *a priori* priority systematic plan has been developed whereby third-party entities identify and prioritize projects on a Valley-wide basis, thereby providing preliminary guidance on how best to allocate appropriated funding in the event such funds are limited through time.

While such caveats indicate real limitations, they should not be interpreted as negating of the results contained in this report. These results are bonafide and conducive for use in the appraisal of the proposed projects affiliated with Public Law 106-576 legislation as well as those projects being proposed to the BECC and NADBank. The above issues are worthy of consideration for future research and programs of work, but should not be misinterpreted and/or misapplied to the extent of halting efforts underway at this time.

## Recommended Future Research

The analyses presented in this report are conditioned on the best information available, subject to the array of resource limitations and other problematic issues previously mentioned. Considering those circumstances, the results are highly useful for the Bureau of Reclamation's appraisal and prioritization of the several Rio Grande Basin projects already or potentially authorized by the Congress or submitted in a formal manner. Similarly, the results attend to the needs of BECC and NADBank in their review and certification of proposed projects. Nonetheless, there are opportunities for additional research and/or other programs of work that would provide valuable insight in a holistic manner of the greater issue of water resource management in the immediate Rio Grande Valley Basin area and beyond. These issues are related in large part to addressing the concerns noted in the "Limitations" section.

- A comprehensive economic impact study would provide an overall impact of the proposed renovations, thereby enhancing the economic strength of the analyses. Necessarily, it is suggested such an effort encompass a full cost-benefit assessment and potential alterations in cropping patterns, impacts of projected urban growth, distribution of water use across the Basin, etc. It is relevant to note that evaluation of Federal projects often employ a national perspective and consider such local impacts negligible. A more-localized perspective in the level of analyses results in greater benefits being estimated along with increased attention to the identity of 'winners' and 'losers' in the resulting adjustments that are anticipated. For example, while on a national perspective the issue of the 1.7 million ac-ft of water now owed to the U.S. may not be a high-priority issue, it certainly is viewed as a critical issue within the immediate Rio Grande Valley area.

- A continued, well-defined program akin to the Federal Rio Grande Basin Initiative would enhance information availability in regards to the engineering- and water-related parameters and related economic costs and savings parameters associated with capital renovations using existing and future technologies. It would be valuable to extend such efforts to District infrastructure and farm operations. A similar research agenda should be developed and implemented for the M&I sector of water users.

- Evaluating economies of size for optimal District operations, with intentions of recognizing opportunities for eliminating duplication of expensive capital items (e.g., pumping plants) and redundant O&M services would provide insight into potential for greater efficiency.

- Integration of risk would be useful in future analyses, including incorporation of stochastic elements for and correlation among the numerous parameters of consequence affecting the costs of water and energy measurements of interest. Such recognition of risk could extend beyond the immediate District factors to also allow for variance in the DMI reserve level policy under stochastic water availability scenarios and/or consideration of the effects of agricultural water rights being purchased by M&I users and converted, albeit at a less than 100% rate, from 'soft' to 'firm' rates.

- Attention is needed in identifying an explicit prioritization process for ranking projects competing for limited funds. Such a process could attend to distinguishing distinct components comprising a single project into separate projects and provide for consideration of other opportunities besides those proposed by an individual District whereby such latter projects are identified in the context of the total Rio Grande Basin as opposed to an individual District. Consideration of the development of an economic mixed-integer programming model (Agrawal and Heady) is suggested as a reasonable and useful complement to ongoing and future-anticipated engineering activities. Such an effort would provide a focal point for identifying and assimilating data necessary for both individual and comprehensive, Valley-wide assessments in a timely fashion.

- The issues of water rights ownership and transfer policies, priority of M&I rights, sources and costs of push water, etc. are admittedly contentious, but still should not be ignored as M&I demands accelerate and agricultural economic dynamics affect current and future returns to water used in such ventures.

- Development of a Valley- or Basin-wide based strategic capital investment plan is suggested, thereby providing preliminary guidance on how best to allocate appropriated funding; both agricultural and M&I use should be considered in such a plan.

- Detailed studies of Districts' water pricing (e.g., flat rates versus volumetric) policies, effects of water rights, conventions on sales and leasing of water rights, and various other issues relating to economic efficiency of water use could contribute insights on improved incentives for water conservation and capital improvement financing.

- Consideration of including M&I users as responsible parties for financing capital improvements is warranted.

Clearly, this is not a comprehensive list of possible activities germane to water issues in the Rio Grande Basin and/or the management of Irrigation Districts therein. The items noted could facilitate development, however, of proactive approaches to addressing current and emerging issues in the Rio Grande Basin area and beyond.

## Summary and Conclusions

The District's project proposal consists of two components: an interconnect and pumping plant. Their required respective capital investment costs are $3,585,300 and $9,715,000 (i.e., total of $13,300,300). A one-year (two-year) installation period with an ensuing 49-year (48-year) useful life for the interconnect component (pumping plant component) is expected. Net annual O&M expenditures are expected to increase slightly for the interconnect component, but decrease substantially for the pumping plant component, resulting in an overall decrease in annual O&M for the total project (**Table 6**).

*Off-* and *on-farm* water savings are predicted to be forthcoming from component #1 (interconnect) with its expected water savings over its 49-year useful life being 468,267 nominal ac-ft, which translate into a 2003 basis of 196,105 real ac-ft (**Table 9**). Only *off-farm* water savings are expected from component #2 (pumping plant replacement) with its expected water savings over its 48-year useful life being 114,250 nominal ac-ft, which translate into a 2003 basis of 46,643 real ac-ft (**Table 19**). Across the total project, nominal water savings are 582,517 ac-ft (**Tables 9** and **19**) and real 2003 savings are 242,747 ac-ft. On an average, annual, real basis, this totals **11,300 ac-ft** across both components (**Table 29**).

Energy savings estimates associated with the interconnect are 52,977,046,976 BTU (15,526,684 kwh) in nominal terms and 22,186,188,476 BTU (6,502,400 kwh) in real 2003 terms (**Table 9**). Similar estimates associated with the pumping plant replacement are 129,610,087,207 BTU (37,986,544 kwh) in nominal terms and 52,913,560,965 BTU (15,508,078 kwh) in real 2003 terms (**Table 19**). For the total project, nominal energy savings are 182,587,134,183 BTU (53,513,228 kwh) and real 2003 savings are 75,099,749,441 BTU (22,010,478 kwh) (**Table 9**, **19**, and **30**). On an average, annual, real basis, this totals **3,495,908,390 BTU (1,024,592 kwh)** across both components (**Table 30)**.

Economic and financial costs of *water* savings forthcoming from the interconnect are estimated at $22.68 per ac-ft; while those for the pumping plant are estimated at $119.41 (**Tables 9**, **19**, and **29**). Sensitivity analyses indicate these estimates can be affected by variances in (a) the amount of reduction in Rio Grande diversions resulting from the purchase, installation, and implementation of the project components; (b) the expected useful lives of the project components; (c) the initial capital investment costs of the project components; and (d) the value of BTU savings (i.e., cost of energy).

Economic and financial costs of *energy* savings forthcoming from the interconnect are estimated at $0.0002262 per BTU ($0.772 per kwh); while those for the pumping plant are estimated at $0.0001302 per BTU ($0.444 per kwh) (**Tables 9**, **19**, and **29**). Sensitivity analyses indicate factors of importance are (a) the amount of energy savings resulting from the purchase, installation, and implementation; (b) the expected useful life of the investment; (c) the initial capital investment costs; and (d) the amount of *off*- and *on-farm* water savings.

Aggregation of the economic and financial costs of water and energy savings for the individual project components into cost measures for the total project result in estimates of **$41.26 per ac-ft** cost of water savings (**Table 29**) and **$0.0001586 per BTU ($0.541 per kwh)** cost of energy savings (**Table 30**). These estimates, similar to the other economic and financial cost estimates identified here, are based on methods described in Rister et al. (2002a).

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# Glossary

**Annuity equivalents**: Expression of investment costs (from project components with differing life spans) in relation to water (or energy) savings expressed on an annualized basis into perpetuity. As used in this report/analyses, a form of a common denominator used to establish values for capital investments of unequal useful lives on a common basis so that comparisons across investment alternatives can be made, as well as combined into an aggregate measure when two or more components comprise a total proposed project.

**BTU**: British Thermal Unit, a standard measure of energy equal to 0.0002931 kilowatts; or, 3,412 BTU equals 1 kilowatt.

**Canal lining**: Concrete and/or a combination of concrete and synthetic plastic material placed in an earthen canal to prevent seepage, resulting in increase flow rates.

**Capital budgeting analysis**: Financial analysis method which discounts future cash flow streams into a consistent, present-day, real value, facilitating comparison of capital investment projects having different planning horizons (i.e., years) and/or involving uneven annual cost streams.

**Charged system**: Condition when canals are "full" and have enough water to facilitate the flow of water to a designated delivery point.

**Component**: One independent capital investment aspect of a District's total proposed capital renovation project.

**Delivery system**: The total of pumping stations, canals, etc. used to deliver water within an irrigation district.

**Diversion points**: Point along a canal where end users appropriate irrigation water, using either pumping or gravity flow through a permanent valve apparatus.

**DMI Reserve**: Domestic, municipal, and industrial surplus reserves held in the Falcon and Amistad reservoirs per Allocation and Distribution of Waters policy (Texas Natural Resource Conservation Commission).

**Drip/Micro emitter systems**: Irrigation systems used in horticultural systems which, relative to furrow irrigation, use smaller quantities of water at higher frequencies.

**Flood irrigation**: Common form of irrigation whereby fields are flooded through gravity flow.

**Geographic Information System (GIS)**: Spatial information systems involving extensive, satellite-guided mapping associated with computer database overlays.

**Head**: Standard unit of measure of the flow rate of water; represents 3 cubic feet per second (Carpenter; Fipps 2001-2002).

**Lateral**: Smaller canal which branch off from main canals, and deliver water to end users.

**Lock system**: A system to lift water in a canal to higher elevations.

**M&I**: Municipal and industrial sources of water demand.

**Mains**: Large canals which deliver water from pumping stations to/across an irrigation district.

**Nominal basis**: Refers to non-inflation adjusted dollar values.

**O&M**: Operations and maintenance activities that represent variable costs.

**Off-farm savings**: Conserved units of water or energy that otherwise would have been expended in the irrigation district, i.e., during pumping or conveyance through canals.

**On-farm savings**: Conserved units of water or energy realized at the farm level.

**Percolation losses**: Losses of water in a crop field during irrigation due to seepage into the ground, below the root zone.

**Polypipe**: A flexible, hose-like plastic tubing used to convey water from field diversion points directly to the field.

***Pro forma***: Refers to projected financial statements or other performance measures.

**Proration**: Allocation procedure in which a quantity of water that is smaller than that authorized by collective water rights is distributed proportionally among water rights holders.

**Push water**: Water filling a District's delivery system used to propel (or transport) "other water" from the river-side diversion point to municipalities.

**Real values**: Numbers which are expressed in time- and sometimes inflation-adjusted terms.

**Relift pumping**: Secondary pumping of water to enable continued gravity flow through a canal.

**Sensitivity analyses**: Analysis to examine outcomes over a range of values for a given parameter.

**Telemetry**: Involving a wireless means of data transfer.

**Turnout**: Refers to the yield of water received by the end user at the diversion point.

**Volumetric pricing**: Method of pricing irrigations based on the precise quantity of water used, as opposed to pricing on a per-acre or per-irrigation basis.

# Exhibits

Figure 1.

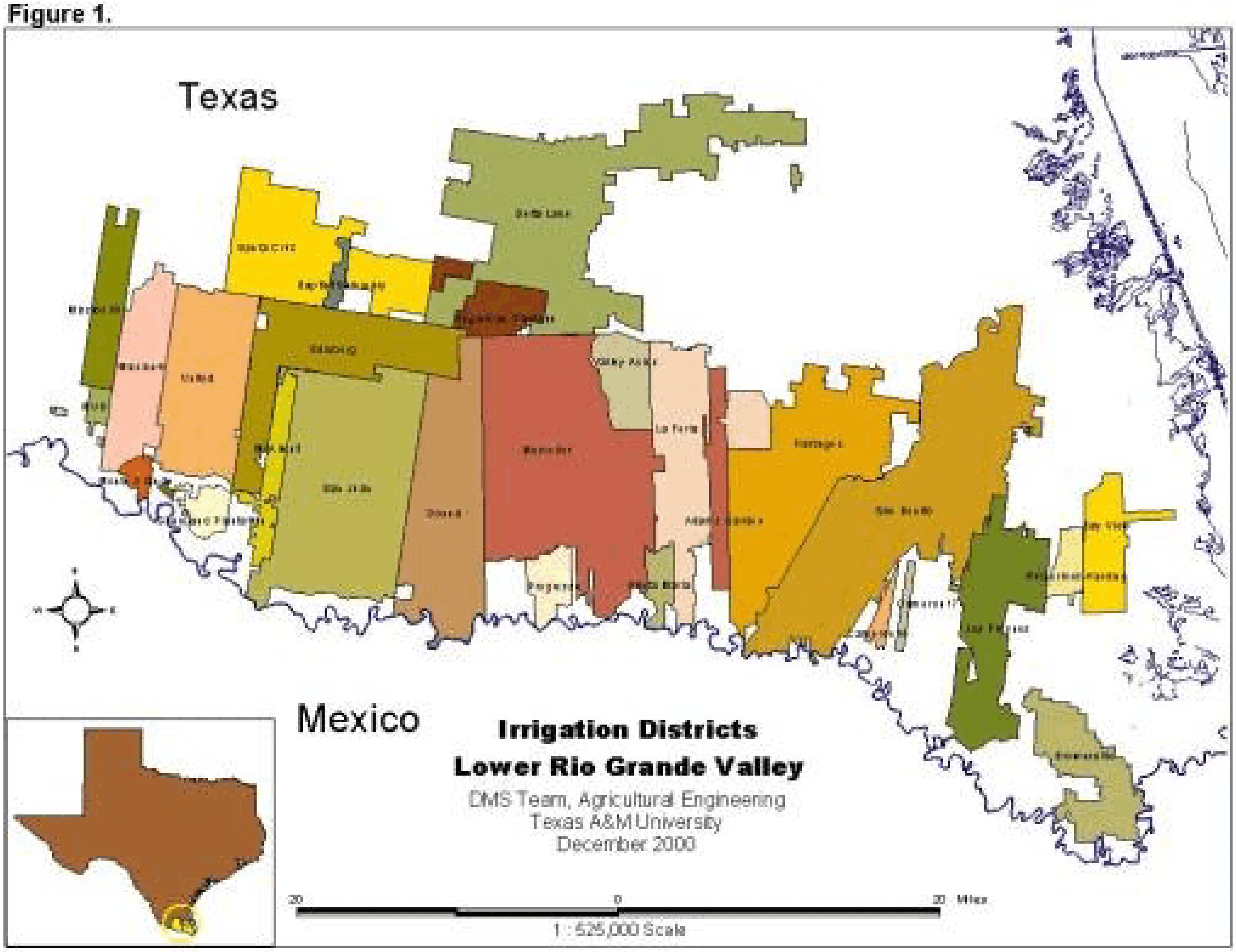


Exhibit 1. Illustration of Twenty-Eight Irrigation Districts in the Texas Lower Rio Grande Valley (Fipps et al.).

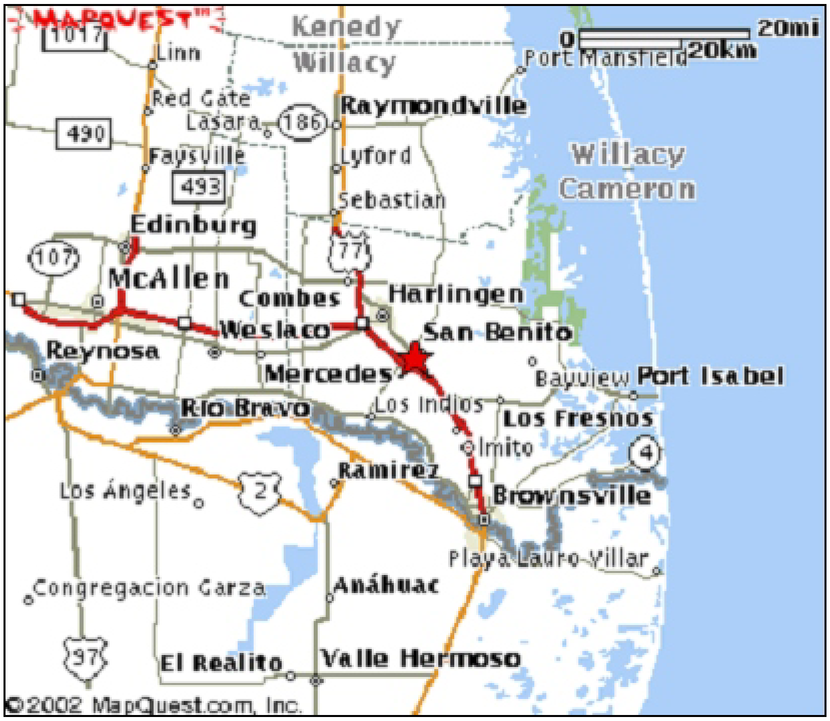


Exhibit 2. San Benito, TX – Location of Cameron County Irrigation District No. 2 Office (MapQuest).

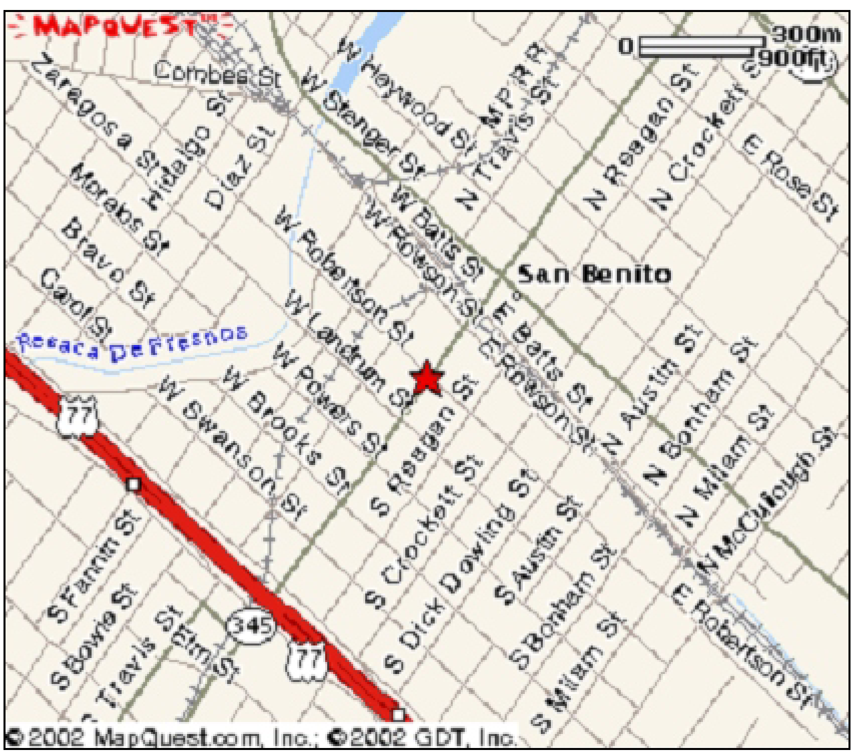


Exhibit 3. Detailed Location of Cameron County Irrigation District No. 2 Office in San Benito, TX (MapQuest).


Exhibit 4. Illustrated Layout of Cameron County Irrigation District No. 2 (Fipps et al.).

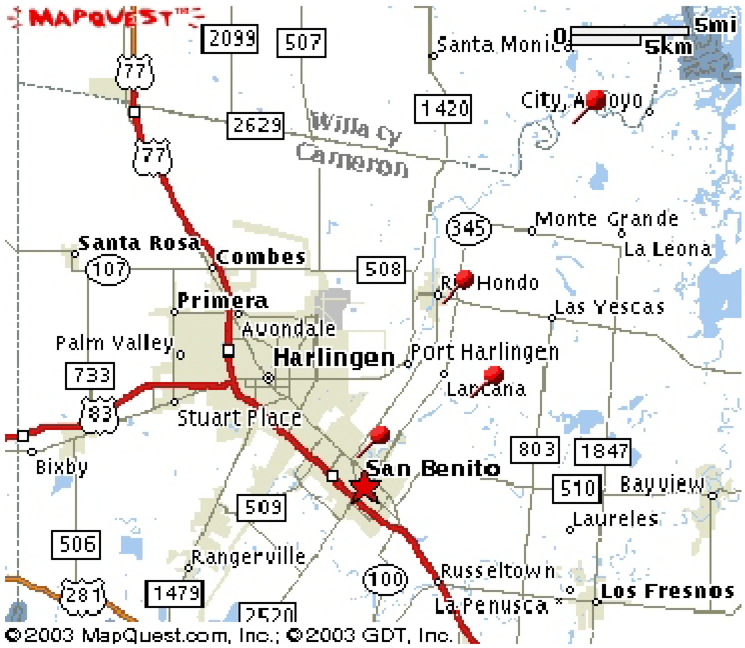


Exhibit 5. Location of Municipalities, Water Supply Corporations, and Industrial Users Served by Cameron County Irrigation District No. 2 (MapQuest).

# Tables

Table 1. Average Acreage Irrigated by Cameron County Irrigation District No. 2 as per District Records for Calendar Years 1998-2002 (Kaniger).

| Crop | Average Acres | % |
|---|---|---|
| Grain sorghum | 11,362 | 49.6 |
| Cotton | 6,367 | 27.8 |
| Sugarcane | 4,646 | 20.3 |
| Citrus | 514 | 2.3 |
| Other (golf courses, ponds, yards, etc.) | | |
| Total | 22,889 | 100.0 |

Table 2. Historic Water-Use Volume (acre-feet), Cameron County Irrigation District No. 2 (Kaniger).

| Year | M&I (ac-ft) | Ag (ac-ft) | Total (ac-ft) |
|---|---|---|---|
| 1986 | 13,034.60 | 80,235.73 | 93,270.33 |
| 1987 | 10,815.32 | 82,455.01 | 93,270.33[a] |
| 1988 | 7,906.78 | 64,731.60 | 72,638.38 |
| 1989 | 8,437.90 | 91,699.82 | 100,137.72 |
| 1990 | 11,587.70 | 94,888.61 | 106,476.31 |
| 1991 | 10,883.30 | 82,945.59 | 93,828.89 |
| 1992 | -[b] | -[b] | -[c] |
| 1993 | -[b] | -[b] | -[c] |
| 1994 | -[b] | -[b] | -[c] |
| 1995 | -[b] | -[b] | 110,934.54 |
| 1996 | -[b] | -[b] | 95,978.26 |
| 1997 | 7,880.77 | 78,214.96 | 86,095.73 |
| 1998 | 8,494.28 | 45,229.22 | 53,723.50 |
| 1999 | 7,305.28 | 68,700.28 | 76,005.56 |
| 2000 | 7,696.34 | 80,921.70 | 88,618.04 |
| 2001 | 8,145.80 | 58,548.28 | 66,694.08 |
| 5 year avg. ('97-'01) | 7,904.49 | 66,322.89 | 74,227.38 |
| 16 year avg. ('86-'01)[d] | 9,289.82 | 75,324.62 | 87,513.21 |

[a] Total volume for 1987 was unavailable from District and water master records. Thus, 1986 total volume was replicated for 1987 with the actual 1987 M&I water usage subtracted to determine an estimated agricultural water-use volume for that year (Kaniger).

[b] Data for this use and year missing and ignored in summary calculations.

[c] Data for this year missing. Water use during these years ignored in calculations documented in Table 3 toward estimating a historical average total water use by the District.

[d] Averages reported are for those years in the sixteen-year series for which data are available.

Table 3. Statistical Distribution of Rio Grande Diversion Levels, Cameron County Irrigation District No. 2, 2003.[a]

| Measurement Point/Year | Water Diversions (ac-ft/yr) | Cumulative Probability |
|---|---|---|
| generated by Simetar™ | 53,718.12 | 0.0% |
| 1998 | 53,723.50 | 3.8% |
| 2001 | 66,694.08 | 11.5% |
| 1988 | 72,638.38 | 19.2% |
| 1999 | 76,005.56 | 26.9% |
| 1997 | 86,095.73 | 34.6% |
| 2000 | 88,618.04 | 42.3% |
| 1986/7[b] | 93,270.33 | 50.0% |
| 1986/7[b] | 93,270.33 | 57.7% |
| 1991 | 93,828.89 | 65.4% |
| 1996 | 95,978.26 | 73.1% |
| 1989 | 100,137.72 | 80.8% |
| 1990 | 106,476.31 | 88.5% |
| 1995 | 110,934.54 | 96.2% |
| generated by Simetar™ | 110,945.63 | 100.0% |

[a] Calculated using Simetar™ (Richardson et al.), assuming a 'normal' probability-based distribution for available data during 1986-2001 period.

[b] The values for 1986 and 1987 are identical inasmuch as the 1986 value was replicated for 1987 during the process of data analysis.

Table 4. Summary of Annual Water and Energy Savings Data (basis 2003) for Project Component #1, Interconnect Between Canals 39 and 13-A1, Cameron County Irrigation District No. 2, 2003 (Kaniger, Allard).

| Item/Savings | Net Affected Area (acres) | Amount of Water Savings by Type | | | Total Water Savings (ac-ft) | Associated Energy Savings | | |
|---|---|---|---|---|---|---|---|---|
| | | Reduced Seepage (ac-ft) | Reduced Evaporation (ac-ft) | Reduced Percolation (ac-ft) | | BTU | kwh | $ |
| **Annual Energy & Water Savings** | | | | | | | | |
| *Agricultural Irrigation Use*: | | | | | | | | |
| Off-farm (Reservoir #7) | | 2,854.4 | 602.7 | - | 3,457.1 | 379,840,477 | 111,325 | $ 6,830 |
| Off-farm (existing Canal 39) | | 370.4 | (4.5) | - | 365.9 | 40,202,763 | 11,783 | 723 |
| Off-farm (new interconnect) | | (25.8) | (12.1) | - | (37.9) | (4,164,211) | (1,220) | (75) |
| Off-farm (relift pumping) | | - | - | - | - | 31,160,505 | 9,133 | 1,191 |
| On-farm (reduced percolation loss) | 6,146.3 | - | - | 5,771.4 | 5,771.4 | 634,124,690 | 185,851 | 11,403 |
| Sub-total | 6,146.3 | 3,199.0 | 586.1 | 5,771.4 | 9,556.5 | 1,081,164,224 | 316,871 | $20,071 |
| *Municipal and Industrial Use*: | | | | | | | | |
| Off-farm | | | | | | | | |
| On-farm | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Sub-total | - | - | - | - | - | - | - | - |
| Total | | 3,199.0 | 586.1 | 5,771.4 | 9,556.5 | 1,081,164,224 | 316,871 | $20,071 |

Table 5. Characteristics of Proposed Interconnect System, Cameron County Irrigation District No. 2, 2003 (Kaniger, Allard).

| Canal Segments | Length | | Status | | Proposed Activity Description |
|---|---|---|---|---|---|
| | Feet | Miles | Existing | Proposed | |
| Canal 39 | 6,600 | 1.25 | Yes | | Enlarge and line with geomembrane and concrete cover |
| Interconnect | 6,000 | 1.14 | | Yes | Dig and line with geomembrane and concrete cover |
| Interconnect System | 12,600 | 2.39 | | Yes | See above |

Table 6. Summary of Project Cost and Expense Data (basis 2003 dollars), Cameron County Irrigation District No. 2, Components 1 and 2, and Aggregate, (Kaniger).

| Item | Component #1 (Interconnect) [a] | | | Component #2 (Replacement of Pumping Plant) [b] | | | Aggregate [c] |
|---|---|---|---|---|---|---|---|
| | Years | Expenses / Revenues | | Years | Expenses / Revenues | | Expenses / Revenues |
| | | (total $'s) | ($/mile) | | (total $'s) | ($/mile) | (total $'s) |
| Installation Period | 1 | | | 2 | | | |
| Productive Period | 49 | | | 48 | | | |
| Planning Period | 50 | | | 50 | | | |
| Initial Capital Investment Costs | | $3,585,300 | $1,502,411 | | $9,715,000 | - | $13,300,300 |
| Annual Increases in O&M Expenses | | $5,867 | $2,458 | | $107,648[d] | - | $113,515 |
| Annual Decreases in O&M Expenses | | $4,162 | $1,744 | | $538,843[e] | - | $543,005 |
| Net Changes in Annual O&M Expenses | | $1,704 | $714 | | $(431,195) | - | $(429,490) |
| Value of Reclaimed Property (revenue) | | - | | | - | | - |

a Component #1 is enlarging and lining 6,600 feet of Canal 39 and connecting it to a 6,000' segment of new lined canal to be dug; the 12,600' combined segments (2.39 miles) will then create an "interconnect" between Canals 39 and 13-A1 in the northern reaches of the District.

b Component #2 is building a new Rio Grande diversion pumping plant.

c The installation, productive, and planning periods (in years) are not additive and are not presented in the Aggregate of components 1 and 2.

d Note the $107,648 value includes estimates for salary and repair costs, and the estimated insurance premium for the proposed new pumping plant (Allard).

e Note the $538,843 value includes salary, repair, and insurance costs as well as a ten-year annuity covering anticipated pumps and motors replacement and a twenty-year annuity covering anticipated catastrophic-loss capital equipment replacement and/or obsolescence/equipment failure-related capital investments associated with continued operations of the existing pumping plant.

Table 7. Summary of Water Diversions, and Electricity and Natural Gas Use and Expenses for Cameron County Irrigation District No. 2 's Rio Grande Diversion Pumping Plant Near Los Indios, TX., per District Records (Kaniger).

| | Calendar Year | | | | | |
|---|---|---|---|---|---|---|
| **Item** | **1997** | **1998** | **1999** | **2000** | **2001** | **Average** |
| Electricity: | | | | | | |
| - kwh used | 1,646,880 | 1,514,400 | 2,130,000 | 2,449,200 | 2,146,800 | 1,977,456 |
| - Btu equivalent | 5,619,154,560 | 5,167,132,800 | 7,267,560,000 | 8,356,670,400 | 7,324,881,600 | 6,747,079,872 |
| - total electric expense | $ 100,354 | $ 87,435 | $ 191,435 | $ 157,216 | $ 172,182 | $ 141,724 |
| Natural Gas: | | | | | | |
| - kwh used | 886,870 | 596,424 | 699,179 | 11,020 | 0 | 438,699 |
| - Btu equivalent | 3,026,000,000 | 2,035,000,000 | 2,385,600,000 | 37,600,000 | 0 | 1,496,840,000 |
| - total natural gas expense | $12,332 | $8,386 | $11,663 | $190 | $0 | $6,514 |
| Total Energy: | | | | | | |
| - kwh used | 2,533,750 | 2,110,824 | 2,829,179 | 2,460,220 | 2,146,800 | 2,416,155 |
| - Btu equivalent | 8,645,154,560 | 7,202,132,800 | 9,653,160,000 | 8,394,270,400 | 7,324,881,600 | 8,243,919,872 |
| - total energy expense | $112,686 | $95,821 | $203,098 | $157,406 | $172,182 | $148,239 |
| Water: | | | | | | |
| - CFS pumped | 43,407 | 27,085 | 38,319 | 44,678 | 35,650 | 37,828 |
| - ac-ft equivalent | 86,096 | 53,724 | 76,006 | 88,618 | 70,712 | 75,031 |
| Calculations: | | | | | | |
| - kwh / ac-ft | 29.43 | 39.29 | 37.22 | 27.76 | 30.36 | 32.20 |
| - Btu / ac-ft | 100,413 | 134,059 | 127,006 | 94,724 | 103,588 | 109,874 |
| - avg. cost per kwh ($/kwh) | $0.044 | $0.045 | $0.072 | $0.064 | $0.080 | $0.061 |
| - avg. cost per Btu ($/Btu) | $0.0000130 | $0.0000133 | $0.0000210 | $0.0000188 | $0.0000235 | $0.0000180 |
| - avg. cost of water pumped ($/ac-ft) | $1.31 | $1.78 | $2.67 | $1.78 | $2.43 | $1.98 |

Table 8. Summary of Annual Water and Energy Savings Data (basis 2003) for Project Component #2, Replacement of Pumping Plant, Cameron County Irrigation District No. 2, 2003 (Kaniger, Allard).

| Item/Savings | Net Affected Area (acres) | Amount of Water Savings by Type | | | Total Water Savings (ac-ft) | Associated Energy Savings [a] | | |
|---|---|---|---|---|---|---|---|---|
| | | Reduced Seepage (ac-ft) | Reduced Evaporation (ac-ft) | Reduced Percolation (ac-ft) | | BTU | kwh | $ |
| **Annual Energy & Water Savings** | | | | | | | | |
| *Agricultural Irrigation Use*: | | | | | | | | |
| Off-farm (new plant efficiency) | | | | | | 2,736,559,812 | 802,040 | 49,208 |
| Off-farm (eliminate 're-circulated') | | | | | | 151,413,462 | 44,377 | 2,723 |
| Off-farm (diversion of 'no-charge') | | | | | 2,380.2 | (187,763,124) | (55,030) | (3,376) |
| Sub-total | - | - | - | - | 2,380.2 | 2,700,210,150 | 791,386 | $48,554 |
| *Municipal and Industrial Use*: | | | | | | | | |
| Off-farm | | | | | | | | |
| On-farm | | | | | | | | |
| Sub-total | - | - | - | - | - | - | - | - |
| Total | | | | | 2,380.2 | 2,700,210,150 | 791,386 | $48,554 |

[a] The negative values (in brackets) represent additional energy and costs associated with pumping no-charge water.

Table 9. Economic and Financial Evaluation Results Across the Component's Useful Life, Cameron County Irrigation District No. 2, Interconnect Component of NADBank and Bureau of Reclamation Project, 2003.

| Results | Nominal | Real[a] |
|---|---|---|
| **Water Savings (ac-ft)** | | |
| Agriculture Irrigation | 468,267 | 196,105 |
| M&I | 0 | 0 |
| Total ac-ft | 468,267 | 196,105 |
| annuity equivalent | | 9,129 |
| **Energy Savings (BTU)** | | |
| Agriculture Irrigation | 52,977,046,976 | 22,186,188,476 |
| M&I | 0 | 0 |
| Total BTU | 52,977,046,976 | 22,186,188,476 |
| annuity equivalent | | 1,032,771,521 |
| **Energy Savings (kwh)** | | |
| Agriculture Irrigation | 15,526,684 | 6,502,400 |
| M&I | 0 | 0 |
| Total kwh's | 15,526,684 | 6,502,400 |
| annuity equivalent | | 302,688 |
| **NPV of Initial Capital Investment Costs and Changes in O&M Expenditures, Including Energy Cost Savings** | $1,997,731 | $3,206,881 |
| annuity equivalent | | $207,017 |
| **Cost of Water Savings ($/ac-ft)** | | $22.68 |
| **NPV of Initial Capital Investment Costs and Changes in O&M Expenditures, Ignoring Both Energy Cost Savings and Value of Water** | $3,730,689 | $3,618,755 |
| **annuity equivalent** | | $233,605 |
| **Cost of Energy Savings ($/BTU)** | | $0.0002262 |
| **Cost of Energy Savings ($/kwh)** | | $0.772 |

[a] Determined using a 4% discount factor.

Table 10. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings for 6,600 Feet of Lined Canal 39 and Expected Useful Life of the Capital Investment, Cameron County Irrigation District No. 2, Interconnect Component of NADBank and Bureau of Reclamation Project, 2003.

| | | ac-ft of water loss for 6,600 feet of unlined canal 39 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 175 | 225 | 250 | 300 | 325 | **366** | 400 | 450 | 475 | 500 |
| **Expected Useful life of Investment (years)** | 10 | 106.91 | 81.86 | 73.09 | 59.94 | 54.88 | 48.10 | 43.50 | 38.02 | 35.72 | 33.64 |
| | 20 | 68.78 | 52.67 | 47.03 | 38.57 | 35.31 | 30.95 | 27.99 | 24.46 | 22.98 | 21.64 |
| | 25 | 61.78 | 47.30 | 42.24 | 34.64 | 31.72 | 27.79 | 25.14 | 21.97 | 20.64 | 19.44 |
| | 30 | 57.42 | 43.97 | 39.26 | 32.19 | 29.48 | 25.83 | 23.37 | 20.42 | 19.18 | 18.07 |
| | 40 | 52.59 | 40.27 | 35.95 | 29.49 | 27.00 | 23.66 | 21.40 | 18.70 | 17.57 | 16.55 |
| | **49** | 50.40 | 38.59 | 34.46 | 28.26 | 25.88 | 22.68 | 20.51 | 17.93 | 16.84 | 15.86 |

Table 11. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings for 6,600 Feet of Lined Canal 39 and Initial Cost of the Capital Investment, Cameron County Irrigation District No. 2, Interconnect Component of NADBank and Bureau of Reclamation Project, 2003.

| | | ac-ft of water loss for 6,600 feet of unlined canal 39 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 175 | 225 | 250 | 300 | 325 | **366** | 400 | 450 | 475 | 500 |
| **Initial Capital Investment Cost ($)** | $ (500,000) | 43.01 | 32.84 | 29.29 | 23.95 | 21.90 | 19.14 | 17.28 | 15.05 | 14.12 | 13.27 |
| | $ (250,000) | 46.71 | 35.72 | 31.87 | 26.10 | 23.89 | 20.91 | 18.89 | 16.49 | 15.48 | 14.57 |
| | $ (100,000) | 48.93 | 37.44 | 33.43 | 27.40 | 25.08 | 21.97 | 19.86 | 17.35 | 16.29 | 15.34 |
| | **$ -** | 50.40 | 38.59 | 34.46 | 28.26 | 25.88 | **22.68** | 20.51 | 17.93 | 16.84 | 15.86 |
| | $ 100,00 | 51.88 | 39.74 | 35.50 | 29.12 | 26.67 | 23.38 | 21.16 | 18.50 | 17.38 | 16.38 |
| | $ 250,000 | 54.10 | 41.47 | 37.05 | 30.42 | 27.87 | 24.45 | 22.13 | 19.36 | 18.20 | 17.15 |
| | $ 500,000 | 57.80 | 44.34 | 39.64 | 32.57 | 29.86 | 26.21 | 23.75 | 20.80 | 19.56 | 18.45 |

Table 12. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings for 6,600 Feet of Lined Canal 39 and Value of Energy Savings, Cameron County Irrigation District No. 2, Interconnect Component of NADBank and Bureau of Reclamation Project, 2003.

| | | **ac-ft of water loss for 6,600 feet of unlined canal 39** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 175 | 225 | 250 | 300 | 325 | **366** | 400 | 450 | 475 | 500 |
| **Value of Energy Savings ($/kwh)** | $ 0.0300 | 51.99 | 40.14 | 35.99 | 29.77 | 27.38 | 24.17 | 21.99 | 19.40 | 18.31 | 17.33 |
| | $ 0.0450 | 51.23 | 39.40 | 35.26 | 29.05 | 26.66 | 23.45 | 21.28 | 18.70 | 17.61 | 16.62 |
| | $ 0.0550 | 50.73 | 38.91 | 34.77 | 28.57 | 26.18 | 22.98 | 20.81 | 18.23 | 17.14 | 16.16 |
| | **$ 0.0611** | 50.42 | 38.61 | 34.47 | 28.27 | 25.89 | **22.68** | 20.52 | 17.94 | 16.85 | 15.87 |
| | $ 0.0675 | 50.09 | 38.29 | 34.16 | 27.97 | 25.58 | 22.39 | 20.22 | 17.64 | 16.55 | 15.57 |
| | $ 0.0750 | 49.71 | 37.92 | 33.80 | 27.60 | 25.22 | 22.03 | 19.87 | 17.29 | 16.20 | 15.22 |
| | $ 0.0900 | 48.96 | 37.18 | 33.06 | 26.88 | 24.51 | 21.32 | 19.16 | 16.58 | 15.50 | 14.52 |

Table 13. Costs per BTU of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Expected Useful Life of the Capital Investment, Cameron County Irrigation District No. 2, Interconnect Component of NADBank and Bureau of Reclamation Project, 2003.

| | | variation in BTU of all energy saved per ac-ft of water saved | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 80.0% | 90.0% | 95.0% | 97.5% | **100.0%** | 102.5% | 105.0% | 110.0% | 125.0% | 150.0% |
| | | BTU of energy saved per ac-ft of water savings | | | | | | | | | |
| | | 87,899 | 98,886 | 104,380 | 107,127 | **109,874** | 112,620 | 115,367 | 120,861 | 137,342 | 164,810 |
| **Expected Useful life of Investment (years)** | 10 | 0.0005997 | 0.0005331 | 0.0005050 | 0.0004921 | 0.0004798 | 0.0004681 | 0.0004569 | 0.0004361 | 0.0003838 | 0.0003198 |
| | 20 | 0.0003858 | 0.0003430 | 0.0003249 | 0.0003166 | 0.0003087 | 0.0003011 | 0.0002940 | 0.0002806 | 0.0002469 | 0.0002058 |
| | 25 | 0.0003465 | 0.0003080 | 0.0002918 | 0.0002843 | 0.0002772 | 0.0002705 | 0.0002640 | 0.0002520 | 0.0002218 | 0.0001848 |
| | 30 | 0.0003221 | 0.0002863 | 0.0002712 | 0.0002643 | 0.0002577 | 0.0002514 | 0.0002454 | 0.0002342 | 0.0002061 | 0.0001718 |
| | 40 | 0.0002950 | 0.0002622 | 0.0002484 | 0.0002420 | 0.0002360 | 0.0002302 | 0.0002248 | 0.0002145 | 0.0001888 | 0.0001573 |
| | **49** | 0.0002827 | 0.0002513 | 0.0002381 | 0.0002320 | **0.0002262** | 0.0002207 | 0.0002154 | 0.0002056 | 0.0001810 | 0.0001508 |

Table 14. Costs per kwh of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Expected Useful Life of the Capital Investment, Cameron County Irrigation District No. 2, Interconnect Component of NADBank and Bureau of Reclamation Project, 2003.

| | | variation in BTU of all energy saved per ac-ft of water saved | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 80.0% | 90.0% | 95.0% | 97.5% | **100.0%** | 102.5% | 105.0% | 110.0% | 125.0% | 150.0% |
| | | BTU of energy saved per ac-ft of water savings | | | | | | | | | |
| | | 87,899 | 98,886 | 104,380 | 107,127 | 109,874 | 112,620 | 115,367 | 120,861 | 137,342 | 164,810 |
| **Expected Useful life of Investment (years)** | 10 | 2.046 | 1.819 | 1.723 | 1.679 | 1.637 | 1.597 | 1.559 | 1.488 | 1.310 | 1.091 |
| | 20 | 1.316 | 1.170 | 1.109 | 1.080 | 1.053 | 1.028 | 1.003 | 0.957 | 0.843 | 0.702 |
| | 25 | 1.182 | 1.051 | 0.996 | 0.970 | 0.946 | 0.923 | 0.901 | 0.860 | 0.757 | 0.631 |
| | 30 | 1.099 | 0.977 | 0.925 | 0.902 | 0.879 | 0.858 | 0.837 | 0.799 | 0.703 | 0.586 |
| | 40 | 1.007 | 0.895 | 0.848 | 0.826 | 0.805 | 0.786 | 0.767 | 0.732 | 0.644 | 0.537 |
| | **49** | 0.965 | 0.858 | 0.812 | 0.792 | 0.772 | 0.753 | 0.735 | 0.702 | 0.617 | 0.515 |

Table 15. Costs per BTU of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Initial Cost of the Capital Investment, Cameron County Irrigation District No. 2, Interconnect Component of NADBank and Bureau of Reclamation Project, 2003.

| | | variation in BTU of all energy saved per ac-ft of water saved | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 80.0% | 90.0% | 95.0% | 97.5% | **100.0%** | 102.5% | 105.0% | 110.0% | 125.0% | 150.0% |
| | | BTU of energy saved per ac-ft of water savings | | | | | | | | | |
| | | 87,899 | 98,886 | 104,380 | 107,127 | **109,874** | 112,620 | 115,367 | 120,861 | 137,342 | 164,810 |
| **Initial Capital Investment Cost ($)** | $ (500,000) | 0.0002437 | 0.0002166 | 0.0002052 | 0.0001999 | 0.0001949 | 0.0001902 | 0.0001857 | 0.0001772 | 0.0001560 | 0.0001300 |
| | $ (250,000) | 0.0002632 | 0.0002340 | 0.0002216 | 0.0002160 | 0.0002106 | 0.0002054 | 0.0002005 | 0.0001914 | 0.0001685 | 0.0001404 |
| | $ (100,000) | 0.0002749 | 0.0002444 | 0.0002315 | 0.0002256 | 0.0002199 | 0.0002146 | 0.0002095 | 0.0001999 | 0.0001760 | 0.0001466 |
| | **$ -** | 0.0002827 | 0.0002513 | 0.0002381 | 0.0002320 | **0.0002262** | 0.0002207 | 0.0002154 | 0.0002056 | 0.0001810 | 0.0001508 |
| | $ 100,000 | 0.0002906 | 0.0002583 | 0.0002447 | 0.0002384 | 0.0002324 | 0.0002268 | 0.0002214 | 0.0002113 | 0.0001860 | 0.0001550 |
| | $ 250,000 | 0.0003023 | 0.0002687 | 0.0002545 | 0.0002480 | 0.0002418 | 0.0002359 | 0.0002303 | 0.0002198 | 0.0001935 | 0.0001612 |
| | $ 500,000 | 0.0003218 | 0.0002861 | 0.0002710 | 0.0002640 | 0.0002574 | 0.0002512 | 0.0002452 | 0.0002340 | 0.0002060 | 0.0001716 |

Table 16. Costs per kwh of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Initial Cost of the Capital Investment, Cameron County Irrigation District No. 2, Interconnect Component of NADBank and Bureau of Reclamation Project, 2003.

| | | variation in BTU of all energy saved per ac-ft of water saved | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 80.0% | 90.0% | 95.0% | 97.5% | **100.0%** | 102.5% | 105.0% | 110.0% | 125.0% | 150.0% |
| | | BTU of energy saved per ac-ft of water savings | | | | | | | | | |
| | | 87,899 | 98,886 | 104,380 | 107,127 | 109,874 | 112,620 | 115,367 | 120,861 | 137,342 | 164,810 |
| **Initial Capital Investment Cost ($)** | $ (500,000) | 0.831 | 0.739 | 0.700 | 0.682 | 0.665 | 0.649 | 0.633 | 0.605 | 0.532 | 0.443 |
| | $ (250,000) | 0.898 | 0.798 | 0.756 | 0.737 | 0.718 | 0.701 | 0.684 | 0.653 | 0.575 | 0.479 |
| | $ (100,000) | 0.938 | 0.834 | 0.790 | 0.770 | 0.750 | 0.732 | 0.715 | 0.682 | 0.600 | 0.500 |
| | **$ -** | 0.965 | 0.858 | 0.812 | 0.792 | **0.772** | 0.753 | 0.735 | 0.702 | 0.617 | 0.515 |
| | $ 100,000 | 0.991 | 0.881 | 0.835 | 0.813 | 0.793 | 0.774 | 0.755 | 0.721 | 0.634 | 0.529 |
| | $ 250,000 | 1.031 | 0.917 | 0.869 | 0.846 | 0.825 | 0.805 | 0.786 | 0.750 | 0.660 | 0.550 |
| | $ 500,000 | 1.098 | 0.976 | 0.925 | 0.901 | 0.878 | 0.857 | 0.837 | 0.799 | 0.703 | 0.586 |

Table 17. Costs per BTU of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Reduced Water Losses in Unlined Canal 39, Cameron County Irrigation District No. 2, Interconnect Component of NADBank and Bureau of Reclamation Project, 2003.

| | | **variation in BTU of all energy saved per ac-ft of water saved** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 80.0% | 90.0% | 95.0% | 97.5% | **100.0%** | 102.5% | 105.0% | 110.0% | 125.0% | 150.0% |
| | | **BTU of energy saved per ac-ft of water savings** | | | | | | | | | |
| | | 87,899 | 98,886 | 104,380 | 107,127 | **109,874** | 112,620 | 115,367 | 120,861 | 137,342 | 164,810 |
| **Ac-Ft of Water Loss for 6,600' of Unlined Canal 39** | 175 | 0.0005732 | 0.0005095 | 0.0004827 | 0.0004703 | 0.0004585 | 0.0004473 | 0.0004367 | 0.0004168 | 0.0003668 | 0.0003057 |
| | 225 | 0.0004516 | 0.0004015 | 0.0003803 | 0.0003706 | 0.0003613 | 0.0003525 | 0.0003441 | 0.0003285 | 0.0002891 | 0.0002409 |
| | 250 | 0.0004084 | 0.0003630 | 0.0003439 | 0.0003351 | 0.0003267 | 0.0003187 | 0.0003111 | 0.0002970 | 0.0002614 | 0.0002178 |
| | 300 | 0.0003427 | 0.0003046 | 0.0002886 | 0.0002812 | 0.0002741 | 0.0002675 | 0.0002611 | 0.0002492 | 0.0002193 | 0.0001828 |
| | 325 | 0.0003172 | 0.0002819 | 0.0002671 | 0.0002602 | 0.0002537 | 0.0002475 | 0.0002417 | 0.0002307 | 0.0002030 | 0.0001692 |
| | **366** | 0.0002827 | 0.0002513 | 0.0002381 | 0.0002320 | 0.0002262 | 0.0002207 | 0.0002154 | 0.0002056 | 0.0001810 | 0.0001508 |
| | 400 | 0.0002593 | 0.0002305 | 0.0002183 | 0.0002127 | 0.0002074 | 0.0002024 | 0.0001975 | 0.0001886 | 0.0001659 | 0.0001383 |
| | 450 | 0.0002311 | 0.0002055 | 0.0001946 | 0.0001897 | 0.0001849 | 0.0001804 | 0.0001761 | 0.0001681 | 0.0001479 | 0.0001233 |
| | 475 | 0.0002193 | 0.0001949 | 0.0001846 | 0.0001799 | 0.0001754 | 0.0001711 | 0.0001670 | 0.0001595 | 0.0001403 | 0.0001169 |
| | 500 | 0.0002085 | 0.0001854 | 0.0001756 | 0.0001711 | 0.0001668 | 0.0001627 | 0.0001589 | 0.0001517 | 0.0001335 | 0.0001112 |

Table 18. Costs per kwh of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Reduced Water Losses in Unlined Canal 39, Cameron County Irrigation District No. 2, Interconnect Component of NADBank and Bureau of Reclamation Project, 2003.

| | | **variation in BTU of all energy saved per ac-ft of water saved** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 80.0% | 90.0% | 95.0% | 97.5% | **100.0%** | 102.5% | 105.0% | 110.0% | 125.0% | 150.0% |
| | | **BTU of energy saved per ac-ft of water savings** | | | | | | | | | |
| | | 87,899 | 98,886 | 104,380 | 107,127 | 109,874 | 112,620 | 115,367 | 120,861 | 137,342 | 164,810 |
| **Ac-Ft of Water Loss for 6,600' of Unlined Canal 39** | 175 | 1.956 | 1.738 | 1.647 | 1.605 | 1.564 | 1.526 | 1.490 | 1.422 | 1.252 | 1.043 |
| | 225 | 1.541 | 1.370 | 1.298 | 1.264 | 1.233 | 1.203 | 1.174 | 1.121 | 0.986 | 0.822 |
| | 250 | 1.393 | 1.239 | 1.173 | 1.143 | 1.115 | 1.087 | 1.062 | 1.013 | 0.892 | 0.743 |
| | 300 | 1.169 | 1.039 | 0.985 | 0.959 | 0.935 | 0.913 | 0.891 | 0.850 | 0.748 | 0.624 |
| | 325 | 1.082 | 0.962 | 0.911 | 0.888 | 0.866 | 0.845 | 0.825 | 0.787 | 0.693 | 0.577 |
| | **366** | 0.965 | 0.858 | 0.812 | 0.792 | **0.772** | 0.753 | 0.735 | 0.702 | 0.617 | 0.515 |
| | 400 | 0.885 | 0.786 | 0.745 | 0.726 | 0.708 | 0.690 | 0.674 | 0.643 | 0.566 | 0.472 |
| | 450 | 0.789 | 0.701 | 0.664 | 0.647 | 0.631 | 0.616 | 0.601 | 0.574 | 0.505 | 0.421 |
| | 475 | 0.748 | 0.665 | 0.630 | 0.614 | 0.598 | 0.584 | 0.570 | 0.544 | 0.479 | 0.399 |
| | 500 | 0.711 | 0.632 | 0.599 | 0.584 | 0.569 | 0.555 | 0.542 | 0.517 | 0.455 | 0.379 |

Table 19. Economic and Financial Evaluation Results Across the Component's Useful Life, Cameron County Irrigation District No. 2, Pumping Plant Replacement Component of NADBank and Bureau of Reclamation Project, 2003.

| Results | Nominal | Real[a] |
|---|---|---|
| **Water Savings (ac-ft)** | | |
| Agriculture Irrigation | 114,250 | 46,643 |
| M&I | 0 | 0 |
| Total ac-ft | 114,250 | 46,643 |
| annuity equivalent | | 2,171 |
| **Energy Savings (BTU)** | | |
| Agriculture Irrigation | 129,610,087,207 | 52,913,560,965 |
| M&I | 0 | 0 |
| Total BTU | 129,610,087,207 | 52,913,560,965 |
| annuity equivalent | | 2,463,136,869 |
| **Energy Savings (kwh)** | | |
| Agriculture Irrigation | 37,986,544 | 15,508,078 |
| M&I | 0 | 0 |
| Total kwh's | 37,986,544 | 15,508,078 |
| annuity equivalent | | 721,904 |
| **NPV of Initial Capital Investment Costs and Changes in O&M Expenditures, Including Energy Cost Savings** | $(3,692,827) | $4,016,274 |
| annuity equivalent | | $259,266 |
| **Cost of Water Savings ($/ac-ft)** | | $119.41 |
| **NPV of Initial Capital Investment Costs and Changes in O&M Expenditures, Ignoring Both Energy Cost Savings and Value of Water** | $448,792 | $4,967,744 |
| **annuity equivalent** | | $320,688 |
| **Cost of Energy Savings ($/BTU)** | | $0.0001302 |
| **Cost of Energy Savings ($/kwh)** | | $0.444 |

[a] Determined using a 4% discount factor.

Table 20. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings with a New Pumping Plant and Expected Useful Life of the Capital Investment, Cameron County Irrigation District No. 2, Pumping Plant Replacement Component of NADBank and Bureau of Reclamation Project, 2003.

| | | **additional ac-ft of 'no-charge' water captured** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1,000 | 1,250 | 1,500 | 1,750 | 2,000 | **2,380** | 2,500 | 2,750 | 3,000 | 3,250 |
| **Expected Useful life of Investment (years)** | 10 | 597.89 | 479.14 | 399.98 | 343.44 | 301.03 | 253.60 | 241.66 | 220.07 | 202.08 | 186.86 |
| | 20 | 384.07 | 307.80 | 256.94 | 220.62 | 193.38 | 162.91 | 155.24 | 141.37 | 129.81 | 120.03 |
| | 25 | 344.71 | 276.25 | 230.61 | 198.01 | 173.56 | 146.21 | 139.33 | 126.88 | 116.51 | 107.73 |
| | 30 | 320.17 | 256.58 | 214.19 | 183.91 | 161.20 | 135.80 | 129.41 | 117.85 | 108.21 | 100.06 |
| | 40 | 292.88 | 234.71 | 195.93 | 168.24 | 147.46 | 124.23 | 118.38 | 107.80 | 98.99 | 91.53 |
| | **48** | 281.51 | 225.60 | 188.33 | 161.70 | 141.74 | **119.41** | 113.78 | 103.62 | 95.15 | 87.98 |

Table 21. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings with a New Pumping Plant and Initial Cost of the Capital Investment, Cameron County Irrigation District No. 2, Pumping Plant Replacement Component of NADBank and Bureau of Reclamation Project, 2003.

| | | **additional ac-ft of 'no-charge' water captured** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1,000 | 1,250 | 1,500 | 1,750 | 2,000 | **2,380** | 2,500 | 2,750 | 3,000 | 3,250 |
| **Initial Capital Investment Cost ($)** | $ (2,500,000) | 104.59 | 84.06 | 70.38 | 60.61 | 53.28 | 45.08 | 43.02 | 39.28 | 36.17 | 33.54 |
| | $ (1,000,000) | 210.74 | 168.98 | 141.15 | 121.26 | 106.35 | 89.67 | 85.48 | 77.88 | 71.56 | 66.20 |
| | $ (500,000) | 246.12 | 197.29 | 164.74 | 141.48 | 124.04 | 104.54 | 99.63 | 90.75 | 83.35 | 77.09 |
| | **$ -** | 281.51 | 225.60 | 188.33 | 161.70 | 141.74 | **119.41** | 113.78 | 103.62 | 95.15 | 87.98 |
| | $ 500,000 | 316.89 | 253.90 | 211.92 | 181.92 | 159.43 | 134.27 | 127.94 | 116.48 | 106.94 | 98.87 |
| | $ 1,000,000 | 352.27 | 282.21 | 235.50 | 202.14 | 177.12 | 149.13 | 142.09 | 129.35 | 118.74 | 109.75 |
| | $ 2,500,000 | 458.42 | 367.13 | 306.27 | 262.80 | 230.20 | 193.73 | 184.55 | 167.95 | 154.12 | 142.42 |

Table 22. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings with a New Pumping Plant and Value of Energy Savings, Cameron County Irrigation District No. 2, Pumping Plant Replacement Component of NADBank and Bureau of Reclamation Project, 2003.

| | | **additional ac-ft of 'no-charge' water captured** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1,000 | 1,250 | 1,500 | 1,750 | 2,000 | **2,380** | 2,500 | 2,750 | 3,000 | 3,250 |
| **Value of Energy Savings ($/kwh)** | $ 0.0300 | 317.30 | 254.03 | 211.86 | 181.73 | 159.13 | 133.86 | 127.50 | 115.99 | 106.41 | 98.30 |
| | $ 0.0450 | 300.18 | 240.43 | 200.60 | 172.15 | 150.81 | 126.94 | 120.94 | 110.07 | 101.02 | 93.36 |
| | $ 0.0550 | 288.76 | 231.36 | 193.09 | 165.76 | 145.26 | 122.33 | 116.56 | 106.13 | 97.43 | 90.07 |
| | **$ 0.0611** | 281.80 | 225.83 | 188.52 | 161.87 | 141.88 | **119.41** | 113.90 | 103.72 | 95.24 | 88.06 |
| | $ 0.0675 | 274.49 | 220.02 | 183.71 | 157.78 | 138.33 | 116.57 | 111.09 | 101.19 | 92.94 | 85.96 |
| | $ 0.0750 | 265.92 | 213.22 | 178.08 | 152.99 | 134.16 | 113.11 | 107.81 | 98.23 | 90.24 | 83.49 |
| | $ 0.0900 | 248.80 | 199.62 | 166.83 | 143.41 | 125.84 | 106.20 | 101.25 | 92.31 | 84.86 | 78.55 |

Table 23. Costs per BTU of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Expected Useful Life of the Capital Investment, Cameron County Irrigation District No. 2, Pumping Plant Replacement Component of NADBank and Bureau of Reclamation Project, 2003.

| | | variation in BTU of all energy saved per ac-ft of water saved | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 80.0% | 90.0% | 95.0% | 97.5% | **100.0%** | 102.5% | 105.0% | 110.0% | 125.0% | 150.0% |
| | | BTU of energy saved per ac-ft of water savings | | | | | | | | | |
| | | 23,472 | 26,406 | 27,873 | 28,607 | 29,340 | 30,074 | 30,807 | 32,274 | 36,675 | 44,010 |
| Expected Useful life of Investment (years) | 10 | 0.0003456 | 0.0003072 | 0.0002911 | 0.0002836 | 0.0002765 | 0.0002698 | 0.0002634 | 0.0002514 | 0.0002212 | 0.0001843 |
| | 20 | 0.0002220 | 0.0001974 | 0.0001870 | 0.0001822 | 0.0001776 | 0.0001733 | 0.0001692 | 0.0001615 | 0.0001421 | 0.0001184 |
| | 25 | 0.0001993 | 0.0001771 | 0.0001678 | 0.0001635 | 0.0001594 | 0.0001555 | 0.0001518 | 0.0001449 | 0.0001275 | 0.0001063 |
| | 30 | 0.0001851 | 0.0001645 | 0.0001559 | 0.0001519 | 0.0001481 | 0.0001445 | 0.0001410 | 0.0001346 | 0.0001185 | 0.0000987 |
| | 40 | 0.0001693 | 0.0001505 | 0.0001426 | 0.0001389 | 0.0001355 | 0.0001322 | 0.0001290 | 0.0001231 | 0.0001084 | 0.0000903 |
| | **48** | 0.0001627 | 0.0001447 | 0.0001370 | 0.0001335 | 0.0001302 | 0.0001270 | 0.0001240 | 0.0001184 | 0.0001042 | 0.0000868 |

Table 24. Costs per kwh of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Expected Useful Life of the Capital Investment, Cameron County Irrigation District No. 2, Pumping Plant Replacement Component of NADBank and Bureau of Reclamation Project, 2003.

| | | variation in BTU of all energy saved per ac-ft of water saved | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 80.0% | 90.0% | 95.0% | 97.5% | **100.0%** | 102.5% | 105.0% | 110.0% | 125.0% | 150.0% |
| | | BTU of energy saved per ac-ft of water savings | | | | | | | | | |
| | | 23,472 | 26,406 | 27,873 | 28,607 | 29,340 | 30,074 | 30,807 | 32,274 | 36,675 | 44,010 |
| Expected Useful life of Investment (years) | 10 | 1.179 | 1.048 | 0.993 | 0.967 | 0.943 | 0.920 | 0.898 | 0.857 | 0.754 | 0.629 |
| | 20 | 0.757 | 0.673 | 0.638 | 0.621 | 0.606 | 0.591 | 0.577 | 0.551 | 0.485 | 0.404 |
| | 25 | 0.680 | 0.604 | 0.572 | 0.558 | 0.544 | 0.530 | 0.518 | 0.494 | 0.435 | 0.362 |
| | 30 | 0.631 | 0.561 | 0.532 | 0.518 | 0.505 | 0.493 | 0.481 | 0.459 | 0.404 | 0.337 |
| | 40 | 0.577 | 0.513 | 0.486 | 0.474 | 0.462 | 0.451 | 0.440 | 0.420 | 0.370 | 0.308 |
| | **48** | 0.555 | 0.493 | 0.467 | 0.455 | **0.444** | 0.433 | 0.423 | 0.404 | 0.355 | 0.296 |

Table 25. Costs per BTU of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Initial Cost of the Capital Investment, Cameron County Irrigation District No. 2, Pumping Plant Replacement Component of NADBank and Bureau of Reclamation Project, 2003.

| | | variation in BTU of all energy saved per ac-ft of water saved | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 80.0% | 90.0% | 95.0% | 97.5% | **100.0%** | 102.5% | 105.0% | 110.0% | 125.0% | 150.0% |
| | | BTU of energy saved per ac-ft of water savings | | | | | | | | | |
| | | 23,472 | 26,406 | 27,873 | 28,607 | **29,340** | 30,074 | 30,807 | 32,274 | 36,675 | 44,010 |
| Initial Capital Investment Cost ($) | $ (2,500,000) | 0.0000808 | 0.0000719 | 0.0000681 | 0.0000663 | 0.0000647 | 0.0000631 | 0.0000616 | 0.0000588 | 0.0000517 | 0.0000431 |
| | $ (1,000,000) | 0.0001300 | 0.0001155 | 0.0001095 | 0.0001067 | 0.0001040 | 0.0001015 | 0.0000990 | 0.0000945 | 0.0000832 | 0.0000693 |
| | $ (500,000) | 0.0001464 | 0.0001301 | 0.0001233 | 0.0001201 | 0.0001171 | 0.0001142 | 0.0001115 | 0.0001064 | 0.0000937 | 0.0000781 |
| | **$ -** | 0.0001627 | 0.0001447 | 0.0001370 | 0.0001335 | **0.0001302** | 0.0001270 | 0.0001240 | 0.0001184 | 0.0001042 | 0.0000868 |
| | $ 500,000 | 0.0001791 | 0.0001592 | 0.0001508 | 0.0001470 | 0.0001433 | 0.0001398 | 0.0001365 | 0.0001303 | 0.0001146 | 0.0000955 |
| | $ 1,000,000 | 0.0001955 | 0.0001738 | 0.0001646 | 0.0001604 | 0.0001564 | 0.0001526 | 0.0001490 | 0.0001422 | 0.0001251 | 0.0001043 |
| | $ 2,500,000 | 0.0002446 | 0.0002175 | 0.0002060 | 0.0002007 | 0.0001957 | 0.0001909 | 0.0001864 | 0.0001779 | 0.0001566 | 0.0001305 |

Table 26. Costs per kwh of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Initial Cost of the Capital Investment, Cameron County Irrigation District No. 2, Pumping Plant Replacement Component of NADBank and Bureau of Reclamation Project, 2003.

| | | variation in BTU of all energy saved per ac-ft of water saved | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 80.0% | 90.0% | 95.0% | 97.5% | **100.0%** | 102.5% | 105.0% | 110.0% | 125.0% | 150.0% |
| | | BTU of energy saved per ac-ft of water savings | | | | | | | | | |
| | | 23,472 | 26,406 | 27,873 | 28,607 | 29,340 | 30,074 | 30,807 | 32,274 | 36,675 | 44,010 |
| Initial Capital Investment Cost ($) | $ (2,500,000) | 0.276 | 0.245 | 0.232 | 0.226 | 0.221 | 0.215 | 0.210 | 0.200 | 0.176 | 0.147 |
| | $ (1,000,000) | 0.443 | 0.394 | 0.373 | 0.364 | 0.355 | 0.346 | 0.338 | 0.322 | 0.284 | 0.236 |
| | $ (500,000) | 0.499 | 0.444 | 0.420 | 0.410 | 0.399 | 0.390 | 0.380 | 0.363 | 0.319 | 0.266 |
| | **$ -** | 0.555 | 0.493 | 0.467 | 0.455 | **0.444** | 0.433 | 0.423 | 0.404 | 0.355 | 0.296 |
| | $ 500,000 | 0.611 | 0.543 | 0.514 | 0.501 | 0.489 | 0.477 | 0.465 | 0.444 | 0.391 | 0.326 |
| | $ 1,000,000 | 0.667 | 0.593 | 0.561 | 0.547 | 0.533 | 0.520 | 0.508 | 0.485 | 0.427 | 0.356 |
| | $ 2,500,000 | 0.834 | 0.742 | 0.703 | 0.685 | 0.667 | 0.651 | 0.636 | 0.607 | 0.534 | 0.445 |

Table 27. Costs per BTU of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Water Savings with a New Pumping Plant, Cameron County Irrigation District No. 2, Pumping Plant Replacement Component of NADBank and Bureau of Reclamation Project, 2003.

| | | **variation in BTU of all energy saved per ac-ft of water saved** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 80.0% | 90.0% | 95.0% | 97.5% | **100.0%** | 102.5% | 105.0% | 110.0% | 125.0% | 150.0% |
| | | **BTU of energy saved per ac-ft of water savings** | | | | | | | | | |
| | | 23,472 | 26,406 | 27,873 | 28,607 | 29,340 | 30,074 | 30,807 | 32,274 | 36,675 | 44,010 |
| **additional ac-ft of 'no-charge' water captured** | 1,000 | 0.0001564 | 0.0001391 | 0.0001317 | 0.0001284 | 0.0001251 | 0.0001221 | 0.0001192 | 0.0001138 | 0.0001001 | 0.0000834 |
| | 1,250 | 0.0001575 | 0.0001400 | 0.0001327 | 0.0001293 | 0.0001260 | 0.0001230 | 0.0001200 | 0.0001146 | 0.0001008 | 0.0000840 |
| | 1,500 | 0.0001587 | 0.0001410 | 0.0001336 | 0.0001302 | 0.0001269 | 0.0001238 | 0.0001209 | 0.0001154 | 0.0001015 | 0.0000846 |
| | 1,750 | 0.0001598 | 0.0001420 | 0.0001346 | 0.0001311 | 0.0001278 | 0.0001247 | 0.0001218 | 0.0001162 | 0.0001023 | 0.0000852 |
| | 2,000 | 0.0001610 | 0.0001431 | 0.0001355 | 0.0001321 | 0.0001288 | 0.0001256 | 0.0001226 | 0.0001171 | 0.0001030 | 0.0000858 |
| | **2,380** | 0.0001627 | 0.0001447 | 0.0001370 | 0.0001335 | 0.0001302 | 0.0001270 | 0.0001240 | 0.0001184 | 0.0001042 | 0.0000868 |
| | 2,500 | 0.0001633 | 0.0001452 | 0.0001375 | 0.0001340 | 0.0001307 | 0.0001275 | 0.0001244 | 0.0001188 | 0.0001045 | 0.0000871 |
| | 2,750 | 0.0001645 | 0.0001462 | 0.0001385 | 0.0001350 | 0.0001316 | 0.0001284 | 0.0001253 | 0.0001197 | 0.0001053 | 0.0000877 |
| | 3,000 | 0.0001657 | 0.0001473 | 0.0001396 | 0.0001360 | 0.0001326 | 0.0001294 | 0.0001263 | 0.0001205 | 0.0001061 | 0.0000884 |
| | 3,250 | 0.0001670 | 0.0001484 | 0.0001406 | 0.0001370 | 0.0001336 | 0.0001303 | 0.0001272 | 0.0001214 | 0.0001069 | 0.0000891 |

Table 28. Costs per kwh of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Water Savings with a New Pumping Plant, Cameron County Irrigation District No. 2, Pumping Plant Replacement Component of NADBank and Bureau of Reclamation Project, 2003.

| | | **variation in BTU of all energy saved per ac-ft of water saved** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 80.0% | 90.0% | 95.0% | 97.5% | **100.0%** | 102.5% | 105.0% | 110.0% | 125.0% | 150.0% |
| | | **BTU of energy saved per ac-ft of water savings** | | | | | | | | | |
| | | 23,472 | 26,406 | 27,873 | 28,607 | 29,340 | 30,074 | 30,807 | 32,274 | 36,675 | 44,010 |
| **additional ac-ft of 'no-charge' water captured** | 1,000 | 0.533 | 0.474 | 0.449 | 0.438 | 0.427 | 0.416 | 0.406 | 0.388 | 0.341 | 0.285 |
| | 1,250 | 0.537 | 0.478 | 0.452 | 0.441 | 0.430 | 0.419 | 0.409 | 0.391 | 0.344 | 0.287 |
| | 1,500 | 0.541 | 0.481 | 0.456 | 0.444 | 0.433 | 0.422 | 0.412 | 0.393 | 0.346 | 0.289 |
| | 1,750 | 0.545 | 0.484 | 0.459 | 0.447 | 0.436 | 0.425 | 0.415 | 0.396 | 0.349 | 0.291 |
| | 2,000 | 0.549 | 0.488 | 0.462 | 0.450 | 0.439 | 0.428 | 0.418 | 0.399 | 0.351 | 0.293 |
| | **2,380** | 0.555 | 0.493 | 0.467 | 0.455 | **0.444** | 0.433 | 0.423 | 0.404 | 0.355 | 0.296 |
| | 2,500 | 0.557 | 0.495 | 0.469 | 0.457 | 0.446 | 0.435 | 0.424 | 0.405 | 0.356 | 0.297 |
| | 2,750 | 0.561 | 0.499 | 0.472 | 0.460 | 0.449 | 0.438 | 0.427 | 0.408 | 0.359 | 0.299 |
| | 3,000 | 0.565 | 0.502 | 0.476 | 0.464 | 0.452 | 0.441 | 0.431 | 0.411 | 0.362 | 0.301 |
| | 3,250 | 0.569 | 0.506 | 0.480 | 0.467 | 0.456 | 0.444 | 0.434 | 0.414 | 0.364 | 0.304 |

Table 29. Economic and Financial Evaluation Results for Cost of Water Saved, Aggregated Across Interconnect Between Canals 39 and 13-A1, and Pumping Plant Replacement, Cameron County Irrigation District No. 2, 2003.

| Economic / Conservation Measures | Project Component | | Aggregate |
|---|---|---|---|
| | **Interconnect Between Canals 39 and 13-A1** | **Pumping Plant Replacement** | |
| NPV of Net Cost Stream, Including Both Initial Investment Cost and Changes in O&M Expenditures, Including Energy Cost Savings ($) | $3,206,881 | $4,016,274 | $7,223,155 |
| Annuity Equivalent of Net Cost Stream for Calculation of Annuity Equivalents ($/yr) | $207,017 | $259,266 | $466,283 |
| | | | |
| NPV of All Water Savings (ac-ft) | 196,105 | 46,643 | 242,747 |
| Annuity Equivalent of All Water Savings Stream for Weighting of Annuity Equivalents (ac-ft/yr) | 9,129 | 2,171 | 11,300 |
| | | | |
| Annuity Equivalent of Costs per ac-ft of Water Savings, Assuming Perpetual Timeline and Replacement with Identical Technology ($) | $22.678 | $119.410 | $41.264 |

Table 30. Economic and Financial Evaluation Results for Cost of Energy Saved, Aggregated Across Interconnect Between Canals 39 and 13-A1, and Pumping Plant Replacement, Cameron County Irrigation District No. 2, for NADBank and Bureau of Reclamation Project, 2003.

| Economic / Conservation Measures | Project Component | | Aggregate |
|---|---|---|---|
| | Interconnect Between Canals 39 and 13-A1 | Pumping Plant Replacement | |
| NPV of Net Cost Stream, Including Both Initial Investment Cost and Changes in O&M Expenditures, Ignoring Both Energy Cost Savings and Value of Water ($) | $3,618,755 | $4,967,744 | $8,586,499 |
| Annuity Equivalent of Net Cost Stream for Calculation of Annuity Equivalents ($/yr) | $233,605 | $320,688 | $554,293 |
| | | | |
| NPV of All Energy Savings (BTU) | 22,186,188,476 | 52,913,560,965 | 75,099,749,441 |
| | | | |
| Annuity Equivalent of All Energy Savings Stream for Weighting of Annuity Equivalents (BTU/yr) | 1,032,771,521 | 2,463,136,869 | 3,495,908,390 |
| Annuity Equivalent of All Energy Savings Stream for Weighting of Annuity Equivalents (kwh/yr) | 302,688 | 721,904 | 1,024,592 |
| | | | |
| Annuity Equivalent of Costs per BTU of Energy Savings, Assuming Perpetual Timeline and Replacement with Identical Technology ($) | $0.0002262 | $0.0001302 | $0.0001586 |
| Annuity Equivalent of Costs per kwh of Energy Savings, Assuming Perpetual Timeline and Replacement with Identical Technology ($) | $0.772 | $0.444 | $0.541 |

# Appendices

## Appendix A: Legislated Criteria Results by Component

United States Public Law 106-576 legislation requires three economic measures be calculated and included as part of the information prepared for the Bureau of Reclamation's evaluation of the proposed projects (Bureau of Reclamation):

- Number of ac-ft of water saved per dollar of construction costs;
- Number of BTU of energy saved per dollar of construction costs; and
- Dollars of annual economic savings per dollar of initial construction costs.

Discussions with Bob Hamilton of the Denver Bureau of Reclamation office on April 9, 2002 indicated these measures are often stated in an inverse mode, i.e.,

- Dollars of construction cost per ac-ft of water saved;
- Dollars of construction cost per BTU (and kwh) of energy saved; and
- Dollars of construction cost per dollar of annual economic savings.

Hamilton's suggested convention is adopted and used in the RGIDECON© model section reporting the Public Law 106-576 legislation's required measures. It is on that basis that the legislated criteria results are presented in both Appendices A and B of this report. Appendix A is focused on results for the individual capital renovation components comprising the total proposed project. Aggregated results for the total project are presented in Appendix B.

The noted criteria involve a series of calculations similar to, but different than, those used in developing the cost measures cited in the main body of this report. Principal differences consist of the legislated criteria not requiring aggregation of the initial capital investment costs with the annual changes in O&M expenditures, but rather entailing separate sets of calculations for each type of costs relative to the anticipated water and energy savings. While the legislated criteria do not specify the need for discounting the nominal values into real terms, both nominal and real values are presented in Appendix A to account for the differences in length of planning periods across multiple components of a single project and across different projects. With regards to the annual economic savings referred to in the third criteria, these are summed into a single present value quantity inasmuch as the annual values may vary through the planning period. Only real results are presented in Appendix B since the aggregation of results requires combining of results for the different components, necessitating a common basis of evaluation. Readers are directed to Rister et al. (2002a) for more information regarding the issues associated with comparing capital investments having differences in length of planning periods.

### Component #1: Interconnect Between Canals 39 and 13-A1

Component #1 of the District's NADBank and Bureau of Reclamation project consists of enlarging 6,600 feet of existing Canal 39 and connecting it to a new 6,000-foot segment of canal to be dug which will result in an "interconnect" between Canals 39 and 13-A1. Details on the cost estimates and related projections of associated water and energy savings are presented in the main body of this report (**Tables 6** and **9**). Below, a summary of the calculated values and results corresponding to the legislated criteria are presented, with nominal and their discounted (i.e., real) transformations presented.

The principal evaluation criteria specified in the United States Public Law 106-576 legislation, transformed according to Hamilton, are presented in **Table A2** (as determined by the calculated values reported in **Table A1**, which are derived in RGIDECON©, using the several input parameters described in the main body of this report).

**Summary Calculated Values**

The initial construction costs associated with the purchase and installation of component #1 amount to $3,585,300. It is assumed all costs occur on the first day of the planning period, thus, the nominal and real values are equal because there are no future costs to discount.

A total of 468,267 ac-ft of nominal *off*- and *on-farm* water savings are projected to occur during the productive life of the interconnect, with associated energy savings of 52,977,046,976 BTU (15,526,684 kwh). Using the 4% discount rate, the present or real value of such anticipated savings become 196,105 ac-ft and 22,186,188,476 BTU (6,502,400 kwh) (**Table A1**).

The accrued annual net changes in O&M expenditures over the interconnect's productive life are a total decrease of $1,587,569. Using the 2002 Federal discount rate of 6.125%, this anticipated net decrease in expenditures represents a real cost reduction of $378,419 (**Table A1**). As noted in the main body of the text, this anticipated net cost savings stems from energy savings and anticipated changes in O&M expenditures.

**Criteria Stated in Legislated Guidelines**

The estimated initial construction costs per ac-ft of water saved are $7.66 in a nominal sense and $18.28 in real terms, while the initial construction costs per BTU (kwh) of energy saved are $0.0000677 ($0.231) in a nominal sense and $0.0001616 ($0.551) in real terms (**Table A2**). The estimated real values are higher (than the nominal values) because future water and energy savings are discounted and construction costs are not because they occur at the onset, i.e., with the real or present values, the discounting of the denominators (i.e., ac-ft of water; BTU (or kwh) of energy) increases the ratio of $/water saved and $/energy saved.

Changes in both energy savings and other O&M expenditures forthcoming from the interconnect result in anticipated net decreases in annual costs (**Table A1**). Dividing the initial construction costs by the decreases in operating costs results in a ratio measure of -2.26 of construction costs per dollar reduction in nominal operating expenditures, suggesting construction costs are more than the expected nominal decreases in O&M costs during the planning period for the installed interconnect. On a real basis, this ratio measure is -9.47 (**Table A2**) signifying construction costs are substantially higher than the expected real values of economic savings in O&M during the planning period.

**Component #2: Replacement of Pumping Plant**

Component #2 of the District's NADBank and Bureau of Reclamation project consists of replacing the current pumping plant at its diversion point along the Rio Grande. Details on the cost estimates and related projections of associated water and energy savings are presented in the main body of this report (**Tables 6** and **19**). Below, a summary of the calculated values and results corresponding to the legislated criteria are presented, with nominal and their discounted (i.e., real) transformations presented.

The principal evaluation criteria specified in the Public Law 106-576 legislation, transformed according to Hamilton, are presented in **Table A4** (which are determined by the calculated values reported in **Table A3**, which are derived in RGIDECON©, using the several input parameters described in the main body of this report).

**Summary Calculated Values**

The initial construction costs associated with the purchase and installation of component #2 amount to $9,715,000. It is assumed all costs occur on the first day of the planning period, thus, the nominal and real values are equal because there are no future costs to discount.

A total of 114,250 ac-ft of nominal *off-farm* water savings (i.e., additional captured no-charge water) are projected to occur during the productive life of the pumping plant. Energy savings of 129,610,087,207 BTU (37,986,544 kwh) are anticipated due to the use of the more efficient new pumping plant. Energy savings are not forthcoming from the capture of 'no-charge' water, but rather are considered as a negative, additional use. Using the 4% discount rate, the present or real value of such anticipated savings become 46,643 ac-ft and 52,913,560,965 BTU (15,508,078 kwh) (**Table A3**).

The accrued annual net changes in O&M expenditures over the pumping plant's productive life are a total decrease of $13,407,827. Using the 2002 Federal discount rate of 6.125%, this anticipated net decrease in expenditures represents a real cost reduction of $5,698,726 (**Table A3**). As noted in the main body of the text, this anticipated net cost savings stems from energy savings and anticipated changes in O&M expenditures.

**Criteria Stated in Legislated Guidelines**

The estimated initial construction costs per ac-ft of water saved are $85.03 in a nominal sense and $208.29 in real terms, while the initial construction costs per BTU (kwh) of energy saved are $0.0000750 ($0.256) in a nominal sense and $0.0001836 ($0.626) in real terms (**Table A4**). The estimated real values are higher (than the nominal values) because future water and energy savings are discounted and construction costs are not because they occur at the onset, i.e., with the real or present values, the discounting of the denominators (i.e., ac-ft of water; BTU (or kwh) of energy) increases the ratio of $/water saved and $/energy saved.

Changes in both energy savings and other O&M expenditures forthcoming from the pumping plant result in anticipated net decreases in annual costs (**Table A4**). Dividing the initial construction costs by the decreases in operating costs results in a ratio measure of -0.72 of construction costs per dollar reduction in nominal operating expenditures, suggesting construction costs are less than the expected nominal decreases in O&M costs during the planning period for the installed pumping plant. On a real basis, this ratio measure is -1.70 (**Table A4**), however, signifying construction costs are higher than the expected real values of economic savings in O&M during the planning period.

## Summary of Legislated Criteria Results for the Individual Components

Notably, the legislated criteria results differ for the two components comprising the District's proposed NADBank and Bureau of Reclamation project. The numbers are dissimilar to the results presented in the main body of this report due to the difference in mathematical approaches, i.e., construction costs and O&M expenditures are not comprehensively evaluated per ac-ft of water savings and per BTU (kwh) of energy savings here.

In the main body of this report, the comprehensive assessment indicates the interconnect is a more economical source of *water savings* than the pumping plant (**Table 29**). The comprehensive costs of *energy savings* yielded, however, opposite rankings (**Table 30**), i.e., the pumping plant energy savings are cheaper than those associated with the interconnect.

Here, in the legislated criteria results, the interconnect <u>is</u> the most economical in terms of dollars of initial construction costs per ac-ft of *water savings*, with the pumping plant ranked second (**Tables A2** and **A4**). With respect to cost of *energy savings*, the interconnect again is the most economical, out-performing the pumping plant in terms of dollars of initial construction costs per BTU of energy saved (**Tables A2** and **A4**). Finally, for the construction costs per dollar of economic savings in annual O&M criterion, the anticipated net savings in O&M for both the pumping plant and the interconnect components appear to be less than the initial construction costs for both investments when evaluated in real (i.e., discounted) terms (**Tables A2** and **A4**). Between the two components, however, the pumping plant appears to be the most economical as the interconnect requires more real initial construction cost per dollar of economic O&M savings. It is difficult to determine the absolute rank order of these two components, however, since either a low construction cost requirement and/or a high increase in O&M expenditures result in a low ratio of the two designated calculated values. Similarly, a high construction cost requirement and/or a low increase in O&M expenditures result in a high ratio of the two designated calculated values. The resulting paradox is apparent.

Recall, however, that according to the legislated guidelines, a project proposed by a District is to be evaluated in its entirety, rather than on the merits of individual components. **Appendix B** contains a <u>commentary</u> addressing the <u>likely</u> aggregate performance of the total project proposed by the District, using the legislated criteria modified to account, somewhat but not completely, for the differences in useful lives of the respective project components.

## Appendix B: Legislated Criteria Results Aggregated Across Components

As noted in Rister et al. (2002a), aggregation of evaluation results for independent projects into an appraisal of one comprehensive project is not a common occurrence. Adaptations in analytical methods are necessary to account for the variations in useful lives of the individual components. The approach used in aggregating the legislated criteria results presented in **Appendix A** into one set of uniform measures utilizes the present value methods followed in the calculation of the economic and financial results reported in the main body of the text, but does not include the development of annuity equivalent measures. These compromises in approaches are intended to maintain the spirit of the legislated criteria's intentions. Here in Appendix B, only real, present value measures are presented and discussed, thereby designating all values in terms of 2003 equivalents. **Differences in useful lives across project components are not fully represented, however, in these calculated values.**

**Table B1** contains the summary measures for the two respective individual components (i.e., interconnect and pumping plant replacement) and also a summed aggregate value for each measure. The project as a whole requires an initial capital construction investment of $13,300,300. In total, 242,747 ac-ft of real water savings are estimated. Real energy savings are anticipated to be 75,099,749,441 BTU (22,010,478 kwh). The net change in real total annual O&M expenditures is a decrease of $6,077,145.

Derivation of the aggregate legislated-criteria measures for the project as a whole entails use of the Aggregate column values presented in **Table B1** and calculations similar to those used to arrive at the measures for the independent project components. The resulting aggregate initial construction costs per ac-ft of water savings measure is $157.07 per ac-ft of water savings (**Table B2**). Note that this amount is substantially higher than the comprehensive economic and financial value of **$41.26 per ac-ft** identified in **Table 29** and discussed in the main body of this report. The difference in these values is attributable both to the incorporation of both initial capital costs and changes in operating expenses in the latter value and its treatment of the differences in the useful lives of the respective components of the proposed project.

The resulting aggregate initial construction costs per BTU (kwh) of energy savings measure is $0.0001777 per BTU ($0.606 per kwh) (**Table B2**). These cost estimates are higher than the **$0.0001586 per BTU ($0.541 per kwh)** comprehensive economic and financial cost estimates identified in **Table 30** for reasons similar to those noted above with respect to the estimates of costs of water savings.

The final aggregate legislated criterion of interest is the amount of initial construction costs per dollar of total annual economic savings. The estimate for this ratio measure is -3.80, indicating that (a) the net change in annual O&M expenditures is negative, i.e., a reduction in O&M expenditures is anticipated; and (b) $3.80 of initial construction costs are expended for each such dollar reduction in O&M expenditures, with the latter represented in total real dollars accrued across the two project components' respective planning periods.

# Appendix Tables

Table A1. Summary of Calculated Values, Cameron County Irrigation District No. 2, Interconnect Component of NADBank and Bureau of Reclamation Project, 2003.

| Item | Nominal PV | Real NPV |
|---|---|---|
| Dollars of Initial Construction Costs | $3,585,300 | $3,585,300 |
| Ac-Ft of Water Saved | 468,267 | 196,105 |
| BTU of Energy Saved | 52,977,046,976 | 22,186,188,476 |
| kwh of Energy Saved | 15,526,684 | 6,502,400 |
| $ of Annual Economic Savings (costs are + values and benefits [i.e., savings] are -) | $(1,587,569) | $(378,419) |

Table A2. Legislated Evaluation Criteria, Cameron County Irrigation District No. 2, Interconnect Component of NADBank and Bureau of Reclamation Project, 2003.

| Criteria | Nominal PV | Real NPV |
|---|---|---|
| Dollar of Initial Construction Costs per Ac-Ft of Water Saved | $7.66 | $18.28 |
| | | |
| Dollar of Initial Construction Costs per BTU of Energy Saved | $0.0000677 | $0.0001616 |
| | | |
| Dollar of Initial Construction Costs per kwh of Energy Saved | $0.231 | $0.551 |
| | | |
| $ of Initial Construction Costs per $ of Annual Economic Savings (costs are + values and benefits [i.e., savings] are -) | -2.26 | -9.47 |

Table A3. Summary of Calculated Values, Cameron County Irrigation District No. 2, Replacement of Pumping Plant Component of NADBank and Bureau of Reclamation Project, 2003.

| Item | Nominal PV | Real NPV |
|---|---|---|
| Dollars of Initial Construction Costs | $9,715,000 | $9,715,000 |
| Ac-Ft of Water Saved | 114,250 | 46,643 |
| BTU of Energy Saved | 129,610,087,207 | 52,913,560,965 |
| kwh of Energy Saved | 37,986,544 | 15,508,078 |
| $ of Annual Economic Savings (costs are + values and benefits [i.e., savings] are -) | $(13,407,827) | $(5,698,726) |

Table A4. Legislated Evaluation Criteria, Cameron County Irrigation District No. 2, Replacement of Pumping Plant Component of NADBank and Bureau of Reclamation Project, 2003.

| Criteria | Nominal PV | Real NPV |
|---|---|---|
| Dollar of Construction Costs per Ac-Ft of Water Saved | $85.03 | $208.29 |
| | | |
| Dollar of Construction Costs per BTU of Energy Saved | $0.0000750 | $0.0001836 |
| | | |
| Dollar of Construction Costs per kwh of Energy Saved | $0.256 | $0.626 |
| | | |
| $ of Initial Construction Costs per $ of Annual Economic Savings (costs are + values and benefits [i.e., savings] are -) | -0.72 | -1.70 |

Table B1. Summary of Calculated Values, Cameron County Irrigation District No. 2, Aggregated Across Interconnect Between Canals 39 and 13-A1, and Replacement of Pumping Plant, 2003.

| | Project Component | | |
|---|---|---|---|
| **Economic / Conservation Measures** | **Interconnect Between Canals 39 and 13-A1** | **Replacement of Pumping Plant** | **Aggregate** |
| Dollars of Initial Construction Costs ($) | $3,585,300 | $9,715,000 | $13,300,300 |
| Ac-Ft of Water Saved (ac-ft) | 196,105 | 46,643 | 242,747 |
| BTU of Energy Saved (BTU) | 22,186,188,476 | 52,913,560,965 | 75,099,749,441 |
| kwh of Energy Saved (kwh) | 6,502,400 | 15,508,078 | 22,010,478 |
| $ of Annual Economic Savings (- represents net savings and + represents net added costs) ($) | $(378,419) | $(5,698,726) | $(6,077,145) |

Table B2. Legislated Results Criteria, Real Values, Cameron County Irrigation District No. 2, Aggregated Across Interconnect Between Canals 39 and 13-A1, and Replacement of Pumping Plant, 2003.

| Economic Measures | Project Component | | Aggregate |
|---|---|---|---|
| | Interconnect Between Canals 39 and 13-A1 | Replacement of Pumping Plant | |
| Dollar of Initial Construction Costs per Ac-Ft of Water Saved ($/ac-ft) | $18.28 | $208.29 | $157.068 |
| | | | |
| Dollar of Initial Construction Costs per BTU of Energy Saved ($/BTU) | $0.0001616 | $0.0001836 | $0.0001777 |
| | | | |
| Dollar of Initial Construction Costs per kwh of Energy Saved ($/kwh) | $0.551 | $0.626 | $0.606 |
| | | | |
| Dollar of Initial Construction Costs per Dollar of Annual Economic Savings (- represents net savings and + represents net added costs) [a] | -9.47 | -1.70 | -3.80 |

[a] Negative values are indicative of expected net reductions in O&M expenditures during the planning horizon to current practices and capital installations.

## — Notes —