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Texas Water Resources Institute
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Economic and Conservation Evaluation of Capital Renovation Projects: Hidalgo County Irrigation District No. 2 (San Juan) – Rehabilitation of Alamo Main Canal – Final

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Texas A&M University

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Authors' Note:

The original *Preliminary TR-276* report was published in October 2004, with that economic and conservation analysis subsequently reviewed by the Texas Water Development Board (TWDB) and the U.S. Bureau of Reclamation (USBR) during October, 2004 - March, 2005. The revision process did result in slightly-revised construction-cost values. Thus, the reported results between the original *Preliminary* and this revised *Final* report do vary some.

This and the aforementioned TR-276 report were developed to assist Hidalgo County Irrigation District No. 2 (HCID #2) in their submitting of project materials to the USBR. Distribution of this report will initially be limited to the HCID #2 and their consulting engineer, the USBR, and the TWDB. Only after the USBR has scored and finalized the next grouping of irrigation districts' proposed capital-rehabilitation projects will the final results for HCID #2s project be made available to other stakeholders and the public. This is anticipated to occur sometime in mid 2005.

This research was supported by the "Rio Grande Basin Initiative" which is administered by the Texas Water Resources Institute of the Texas A&M University System with funds provided by the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, under Agreement Numbers 2001-45049-01149 and 2003-34461-13278.

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, evaluation, and financing are necessary, however, before these projects may be constructed. The U. S. Bureau of Reclamation (USBR) is the agency tasked with administering the Act and it has issued a set of guidelines for preparing and reviewing such proposed capital renovation projects.

Based on language in the Act, the "Guidelines for Preparing and Reviewing Proposals for Water Conservation and Improvement Projects Under Public Law 106-576 (Guidelines)" require three economic measures as part of the USBRs 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 of these 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 USBR, and the Texas Water Development Board to perform economic and energy evaluations of the proposed capital improvement 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 from pumping less water, in association with 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 USBR for evaluation prior to being approved for funding appropriations from Congress.

The USBR, in a letter dated July 24, 2002 (Walkoviak), stated that RGIDECON© satisfies the legislation authorizing projects and that the USBR will use the results for economic and energy evaluation.

About the Authors

M. Edward Rister
Ronald D. Lacewell
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The authors are **Rister**, Professor and Associate Head, Department of Agricultural Economics, Texas A&M University and Texas Agricultural Experiment Station, College Station, TX.; **Lacewell**, Professor, Assistant Vice Chancellor, and Associate Director, Department of Agricultural Economics, Texas Agricultural Experiment Station, and Texas Cooperative Extension, College Station, TX.; and **Sturdivant**, Extension Associate, Department of Agricultural Economics, Texas Cooperative Extension, Agricultural Research and Extension Center, Weslaco, TX.

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:

- ***Sonny Hinojosa, Sonia Kaniger, Roy Cooley, Jesus Reyes, Joe Barrera, Wayne Halbert, George Carpenter, Bill Friend, Rick Smith, Tito Nieto, Nora Zapata, Edd Fifer, and Max Phillips***. These irrigation district managers have been and are a continual source of information and assistance as we develop an accurate, consistent, efficient, and practical analytical approach for these investigations;

- ***Dee Purkeypile, Jim Holdar, Larry Smith, and Al Blair.*** These private consulting engineers have strengthened the rigor of our methodology and enhanced the integrity of the data;

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

- ***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 and helpful in many ways;

- ***Bob Hamilton and Randy Christopherson.*** These economists affiliated with the U. S. Bureau of Reclamation (USBR) have served as reviewers of our methodology. They have also identified appropriate means of satisfying the data requirements specified in the legislative-mandated USBR 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;

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

- ***Thomas Michalewicz, Larry Walkoviak, Mike Irlbeck, Debbie Blackburn, and James Allard.*** These individuals are with the USBR in various management, engineering, and environmental roles. They have been instrumental in fostering a collaborative environment among several agencies and have taken the lead in bringing the Texas Water Development Board into planning and facilitating cooperation across State and Federal agencies;

- ***Rick Clark.*** Formerly in a management role with the USBR, Rick was a great friend to Rio Grande irrigation district rehabilitation efforts and largely responsible for successful collaborative efforts of involved stakeholders.

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

- ***Allan Jones, B. L. Harris, Ellen Weichert, and Rosemary Payton.*** As Director, Associate Director, Business Administrator, and Senior Administrative Coordinator of the Texas Water Resources Institute, respectively, they provide leadership 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.*** As a graduate student with the Bush School at Texas A&M University, Megan has contributed useful insight and commentary while reviewing our work and during development of related materials on Rio Grande Basin irrigation districts;

- ***Michael C. Popp.*** As a former graduate student in the Department of Agricultural Economics at Texas A&M University, and as a former co-author on related economic studies, Michael provided significant input and a rigorous review of analyses and reports, as well as leadership in efforts which extended economic analyses by incorporating risk and uncertainty associated with data-input; and

- ***Michele Zinn and Angela Catlin.*** In a variety of administrative-assisting roles at Texas A&M in College Station, these ladies are an absolutely essential component to our efforts. Their daily accomplishments are multi-faceted and just as impressive as their personalities!

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©.

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Abstract

Initial construction costs and net annual changes in operating and maintenance expenses are identified for a two-component capital renovation project proposed by Hidalgo County Irrigation District No. 2, to the U. S. Bureau of Reclamation (USBR). The proposed project primarily consists of relining the Alamo Main canal and installing a flow-management system in the Alamo Main canal. Both nominal and real estimates of water and energy savings and expected economic and financial costs of those savings are identified throughout the anticipated useful life for the proposed project. Sensitivity results for both the cost of water savings and cost of energy savings are presented for several important parameters.

Annual water and energy savings forthcoming from the total project are estimated, using amortization procedures, to be **876 ac-ft of water** per year and **331,389,647 BTUs (97,125 kwh) of energy** per year. The calculated economic and financial cost of water savings is estimated to be **$201.50 per ac-ft**. The calculated economic and financial cost of energy savings is estimated to be **$0.0005592 per BTU ($1.908 per kwh)**.

In addition, expected real (vs nominal) values are indicated for the USBRs 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 $182.98 per ac-ft of water savings. The aggregate initial construction cost per BTU (kwh) of energy savings measure is $0.0004837 per BTU ($1.650 per kwh). The aggregate ratio of initial construction costs per dollar of total annual economic savings is estimated to be -20.74.

U. S. 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: Hidalgo County Irrigation District No. 2 (San Juan) – Rehabilitation of Alamo Main Canal - Final

Executive Summary

Introduction

Recognizing the seriousness of the water crisis in South Texas, the U. S. Congress enacted Public Law (PL) 106-576, entitled "The Lower Rio Grande Valley Water Conservation and Improvement Act of 2000 (Act)." 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. Subsequent legislation (i.e., PL 107-351, or "Lower Rio Grande Valley Water Resources Conservation and Improvement Act of 2002") amended the previous Act by adding 15 conservation projects. *Authorization* of these projects does not guarantee federal funding (i.e., appropriations) as several phases of planning and evaluation are necessary before these projects may be approved for financing and construction. In July 2003, Hidalgo County Irrigation District No. 2 (i.e., the District) submitted two project proposals authorized in PL 107-351. The project analyzed herein is not authorized in either PL 106-576 or PL 107-351, but it is anticipated to be formally incorporated into amending legislation in 2005.

With a proactive approach and anticipation of its pursuing a future rehabilitation project (i.e., currently non-authorized), the District requested assistance with the preparation of an economic analysis from the authors. Similar to their efforts on the legislative-authorized projects, Texas Agricultural Experiment Station (TAES) and Texas Cooperative Extension (TCE) economists are utilizing RGIDECON©, and collaborating with the District, its consulting engineer, and the USBR.[1] The methodology employed has been accepted, as the USBR, in a letter dated July 24, 2002, stated that RGIDECON© satisfies the legislative-authorized projects and that the USBR will use the results for economic and energy evaluation of proposed projects.

This report documents the analysis conducted for an anticipated project proposal to the USBR. That is, the District anticipates future legislation authorizing additional projects similar to those found in PL 106-576 and PL 107-351, and wishes to be pro-active in the preparation of project materials. Although the project analyzed and reported on herein is currently non-authorized, it is reasonable to assume the consistency in methodology provided by RGIDECON© would continue to satisfy any future related legislative-authorized project(s) overseen by the

[1] This report contains economic and financial analysis results for a capital rehabilitation project proposed by the Hidalgo County Irrigation District No. 2 (a.k.a. San Juan). Readers interested in the methodology and/or prior reports are directed to pages 36-38 which identify related publications.

USBR.[2] 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.[3]

District Description

The District delivers water to over 30,000 acres of agricultural cropland each year with its 137,675 ac-ft of irrigation water rights, with the actual water available varying from year to year. In addition, the District holds municipal/domestic/industrial water rights of 12,732 ac-ft per year, municipal water rights of 12,318.5 ac-ft per year, and mining water rights of 100 ac-ft per year. The District contracts for delivery of water to the North Alamo Water Supply Corporation (1,907.8 ac-ft per year), with its municipal customers including the City of McAllen (7,640 ac-ft per year), the City of Pharr (5,454.6 ac-ft per year), the City of San Juan (2,390.5 ac-ft per year), the City of Alamo (1,650.2 ac-ft per year), and the City of Edinburg (511.7 ac-ft per year). The District does not deliver to a major industrial customer. The District is currently the only source of water for the cities of Pharr, San Juan, and Alamo.

Recent agricultural water use during fiscal years 1999-2003 for the District has ranged from 43,780 to 53,107 ac-ft, with the five-year average at 48,871 ac-ft. Municipal and industry (M&I) water use during 1999-2003 has been fairly consistent, ranging from 19,407 to 22,832 ac-ft, with the five-year average at 20,905 ac-ft. Although the District relies upon the Rio Grande for its water, the District's agricultural water diversions during recent years have not been significantly hampered by deficit allocations. Thus, the five-year water use figures are considered appropriate for use in forecasting future diversions.

Proposed Project Components

The capital improvement project anticipated to be proposed by the District to the USBR consists of two components. Specifically, it includes:

- relining 5.34 miles of Alamo Main canal with a geomembrane lining and shotcrete cover, removing 17 unused farm turnout gates from the side of the canal (and filling the resulting holes with grout), and replacing 30-35 of the side-of-canal farm turnout gates with "short-wells" (i.e., 36" vertical concrete pipe) about 30-feet from the canal to facilitate a new farm turnout method – this will reduce seepage in the concrete-lined canal, and reduce water losses from leaking gates by a total of 644 ac-ft per year; and

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2 Though currently non-authorized, this project's analysis (and the methodology behind it) is consistent with and comparable to other publications as found in the *Related Rio Grande Basin Irrigation District Capital Rehabilitation Publications and Other Reports* section of this report.

3 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.

- installing a flow-management system (i.e., flow meters, automated gates, and telemetry equipment) in the Alamo Main canal – this will reduce spillage by an estimated 280 ac-ft per year in the canal as improved water-management information will allow for a closer match of water supply with water demand in the area.

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 analyses of up to five individual components comprising a project; it reports on individual components, and the total aggregate over all components comprising the 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.[4]

Anticipated Water and Energy Savings

Annual water and energy savings are calculated for each component separately and also as a combined total across all components, if applicable. 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 can result from reduced diversions, reduced relift pumping, and/or efficiency improvements with new pumps and motors, and are comprised of (a) the amount of energy used for pumping and (b) the cost (value) of such energy.[5]

Cost of Water and Energy Savings

The estimated cost per ac-ft of water saved and the estimated cost of energy saved resulting from a component's purchase, installation, and implementation is analyzed to gauge

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4 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.

5 A major assumption made by the authors and embedded in this and other related analyses is that only the local IDs perspective is considered. In addition, all marginal water and energy savings are recognized, not withstanding that in actuality, the "savings" may continue to be utilized within (or outside) the District. The existence of "on-allocation" status for a District does not alter this assumption.

each 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, if applicable.

Project Components

Discussion pertaining to costs (initial construction and subsequent annual O&M) and savings for both water and energy is presented below for each component of HCID No. 2s 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: Relining Alamo Main Canal

Component #1 of the District's proposed USBR project is commonly referred to as relining the Alamo Main canal and consists of (a) relining 5.34 miles of Alamo Main canal with a geomembrane lining and shotcrete cover, (b) removing 17 unused farm turnout gates from the side of the canal (and then filling the resulting holes with grout), and (c) replacing 30-35 of the side-of-canal farm turnout gates with "short-wells" (i.e., 36" vertical concrete pipe) about 30-feet from the canal to facilitate a new farm turnout method. 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 $2,500,000 ($468,165 per mile). Although the Alamo Main canal project replaces a leaky concrete-lined canal with a new geomembrane and shotcrete-lined canal, annual reductions in annual O&M expenditures are not anticipated; i.e., maintenance operations and costs will not change with relining the lateral. Therefore, a net change in annual O&M costs of $0 is expected.

Anticipated Water and Energy Savings

Only off-farm water savings are predicted to be forthcoming from the Alamo Main canal relining, with the nominal total being 31,556 ac-ft over the 49-year productive life of this component and the real 2005 total being 13,556 ac-ft. The annual *off-farm* water-savings estimate of 644.0 ac-ft per year are based on 638.0 ac-ft seepage savings and 6.0 ac-ft of reduced gate leaks. With no on-farm savings, combined water savings are thus the off-farm value of 644.0 ac-ft per year. Associated energy savings estimates are 11,937,812,868 BTU (3,498,773 kwh) in nominal terms over the 49-year productive life and 4,999,421,096 BTU (1,465,247 kwh) in real 2005 terms. Energy savings are based on reduced diversions at the Rio Grande, and reduced relifting within the delivery system.

Cost of Water and Energy Savings

The economic and financial cost of water savings forthcoming from the Alamo Main canal component is estimated to be $251.87 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 $154,945 by the annuity equivalent of the total net water savings of 615 ac-ft (in 2005 terms). The economic and financial cost of energy savings are estimated at $0.0006935 per BTU ($2.366 per kwh). This value is obtained by dividing the annuity equivalent of the total net cost stream for energy savings from all sources of $161,385 by the annuity equivalent of the total net energy savings of 232,724,054 BTU (68,208 kwh) (in 2005 terms).

Component #2: Installing Flow-Management System

Component #2 of the District's proposed USBR project is termed the flow-management system project and consists of installing a flow-management system (i.e., flow meters, new automated gates, and telemetry equipment) in the Alamo Main canal. The installation period is projected to take one year with an ensuing expected useful life of 20 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 $570,000. Annual increases in O&M expenditures of $18,000 are expected. Also, decreases in annual O&M expenses of $40,294 associated with dis-employment of one canal rider (i.e., salary, fringes, and vehicle) are expected. Therefore, a net decrease in annual O&M costs of $22,294 (basis 2005) is expected.

Anticipated Water and Energy Savings

Only off-farm water savings are predicted to be forthcoming from installing the flow-management system, with the nominal total being 5,600 ac-ft over the 20-year productive life of this component and the real 2005 total being 3,659 ac-ft. The annual *off-farm* water-savings estimate is based on 280.0 ac-ft of prevented spillage. With no on-farm savings, combined water savings are thus the off-farm value of 280.0 ac-ft per year, with associated energy savings estimates of 2,118,511,600 BTU (620,900 kwh) in nominal terms over the 20-year productive life and 1,384,195,385 BTU (405,684 kwh) in real 2005 terms. Energy savings are based on reduced diversions at the Rio Grande and reduced relifting within the delivery system.

Cost of Water and Energy Savings

The economic and financial cost of water savings forthcoming from the Flow-Management System component is estimated to be $82.69 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 $21,565 by the annuity equivalent of the total net water savings of 261 ac-ft (in 2005 terms). The economic and financial cost of energy savings are estimated at $0.0002426 per BTU ($0.828 per kwh). This value is obtained by dividing the annuity equivalent of the total net cost stream for energy savings from all sources of $23,938 by the annuity equivalent of the total net energy savings of 98,665,593 BTU (28,917 kwh) (in 2005 terms).

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 projects 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 $3,070,000. 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 $176,511 cost per year for water savings associated with the total project. The similar measure for costs of energy savings is $185,323 per year.

Anticipated Water and Energy Savings

Only off-farm water savings are expected from the two components with the nominal total being 37,156 ac-ft over their expected productive lives and the real 2005 total being 16,874 ac-ft. On an average annual basis (or annuity equivalent basis), this amounts to 876 ac-ft across the two project components, representing **1%** of the current average water diversion by the District. Annual water savings estimates are based on reduced canal seepage, reduced gate leaks, and reduced spillage. Associated energy savings estimates are 14,056,324,468 BTU (4,119,673 kwh) in nominal terms over their lives and 6,383,616,482 BTU (1,870,931 kwh) in real 2005 terms. On an average annual basis (or annuity equivalent), this amounts to 331,389,647 BTU (97,125 kwh) across the two components. Combined energy savings are based on net reduced diversions at the Rio Grande and reduced relift pumping in the District's delivery-system.

Cost of Water and Energy Savings

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 **$201.50 per ac-ft** cost of water savings and **$0.0005592 per BTU ($1.908 per kwh)** cost of energy savings.

Summary

The following table summarizes key information regarding each of the components of HCID No. 2s project, with a more complete discussion provided in the main report.

Table ES1. Summary of Data and Economic and Conservation Analysis Results for Rehabilitation of Alamo Main Canal, HCID No. 2, 2005.

	Project Component		
	Relining Alamo Main Canal	Installing Flow-Management System	Aggregate
Initial Investment Cost ($)	$ 2,500,000	$ 570,000	$ 3,070,000
Expected Useful Life (years)	49	20	n/a
Net Changes in Annual O&M ($)	$ 0	($ 22,294)	($ 22,294)
Annuity Equivalent of Net Cost Stream – Water Savings ($/yr)	$ 154,945	$ 21,565	$ 176,511
Annuity Equivalent of Water Savings (ac-ft)	615	261	876
Calculated Cost of Water Savings ($/ac-ft)	**$ 251.87**	**$ 82.69**	**$ 201.50**
Annuity Equivalent of Net Cost Stream – Energy Savings ($/yr)	$ 161,385	$ 23,938	$ 185,323
Annuity Equivalent of Energy Savings (BTU)	232,724,054	98,665,593	331,389,647
Annuity Equivalent of Energy Savings (kwh)	68,208	28,917	97,125
Calculated Cost of Energy Savings ($/BTU)	**$ 0.0006935**	**$ 0.0002426**	**$ 0.0005592**
Calculated Cost of Energy Savings ($/kwh)	**$ 2.366**	**$ 0.828**	**$ 1.908**

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 analyses 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 (and the amending legislation U. S. Public Law 107-351) requires three economic measures be calculated and included as part of the information prepared for the USBRs (USBR 2001) evaluation of the proposed projects. According to the USBR, 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 costs relative to the anticipated water and energy savings. The approach used in aggregating the legislated criteria results presented in Appendix B 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 2005 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 $182.98 per ac-ft of water savings which is much lower than the comprehensive economic and financial value of **$201.50 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 component(s) of the proposed project.

The aggregate initial construction cost per BTU (kwh) of energy savings measure is $0.0004837 per BTU ($1.650 per kwh). These cost estimates are much lower than the **$0.0005592 per BTU ($1.908 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 -20.74, 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) $20.74 of initial construction costs are expended for each such dollar reduction in O&M expenditures, with the latter represented in total real 2005 dollars accrued across the two project components' respective planning periods.

Economic and Conservation Evaluation of Capital Renovation Projects: Hidalgo County Irrigation District No. 2 (San Juan) – Rehabilitation of Alamo Main Canal - Final

Introduction

This report, for Hidalgo County Irrigation District No. 2 (i.e., the District), is for a project the District anticipates proposing to the U. S. Bureau of Reclamation (USBR) at some future date and that is not included among the nineteen irrigation-district capital rehabilitation projects authorized in Public Laws (PL) 106-576 and 107-351. With a proactive approach and anticipation of its pursuing a future rehabilitation project (i.e., currently non-authorized), the District requested assistance with the preparation of an economic analysis from the authors. That is, the District anticipates future legislation authorizing additional projects beyond PL 106-576 and 107-351, and wishes to be pro-active in the preparation of project materials. Though this project is currently non-authorized, this analysis (and the methodology behind it) is consistent with and comparable to the legislative-authorized analyses under PL 106-576 and PL 107-351.[1]

Similar to their efforts on the legislative-authorized projects, Texas Agricultural Experiment Station (TAES) and Texas Cooperative Extension (TCE) economists are utilizing RGIDECON©, and collaborating with the District, its consulting engineer, and the USBR in the same manner exhibited with previous legislative-authorized project analyses for Rio Grande Basin irrigation-district projects. In those nineteen legislative-authorized projects, the methodology employed by the authors was accepted, as the USBR, in a letter dated July 24, 2002, stated that RGIDECON© satisfied the legislative-authorized projects and that the USBR would use the results for economic and energy evaluations. Although the project analyzed and reported on herein is currently non-authorized, it is reasonable to assume the consistency in methodology provided by RGIDECON© would continue to satisfy any future related legislative-authorized project(s) overseen by the USBR. Thus, this report provides documentation of an economic and conservation analysis conducted for the two-component project which is anticipated to be proposed by the District to the USBR (and possibly others) at some future date.

Irrigation District Description[2]

Twenty-eight irrigation districts exist in the Texas Lower Rio Grande Valley (**Exhibit 1**).[3] The Hidalgo County Irrigation District No. 2 office is located in downtown San Juan, Texas (**Exhibits 2** and **3**). The District boundary covers approximately 72,000 acres of Hidalgo County

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1 These results are for a project anticipated to be proposed by the District to USBR. Readers interested in the methodology and/or prior reports are directed to pages 36-38 which identify related publications.

2 The general descriptive information presented was assimilated from several sources, including documents provided by Sonny Hinojosa (the District manager), 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 Glossary and before the Appendices.

(**Exhibit 4**). Postal and street addresses are P. O. Box 6, 326 Standard Street, San Juan, TX 78589. Telephone contact information is 956/787-1422 and the fax number is 956/781-7622. Sonny Hinojosa is the District Manager, with Thomas Michalewicz of the USBR, Oklahoma City, OK., serving as the lead consulting engineer for this project.

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, and ponds.

Irrigated Acreage and Major Crops

The District delivers water to approximately 36,000 acres of agricultural cropland within its district. Furrow irrigation accounts for approximately 79% of irrigation deliveries. Special turnout connections are provided for a fee, as requested, to 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 vegetables, citrus, corn, sugarcane, etc. The crop mix distribution within a particular irrigation district may vary considerably depending on output prices and the relative available local water supplies. 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 holds 17,646.9 acre feet (ac-ft) of water rights for M&I diversions to the cities of McAllen, Edinburg, Pharr, San Juan, and Alamo, and an additional 1,907.8 ac-ft of water rights for North Alamo Water Supply Corporation (**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, thereby providing "push water" to facilitate delivery of municipal water. When on an "allocation status" and when individual irrigation district water supplies (including account balances) are inadequate for charging an irrigation district's delivery system to facilitate municipal water delivery, however, Rio Grande 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

A recent five-year period (i.e., 1999-2003) shows a range of water use in the District (**Table 2**). Agricultural use has ranged from 43,780 to 53,107 ac-ft, with an average of 48,871 ac-ft. M&I water use has ranged from 19,407 to 22,832 ac-ft, with the average at 20,905 ac-ft. The average total water diverted within the District during this time period is 81,823 ac-ft, with a range from 77,476 to 87,860 ac-ft. Although the District relies upon the Rio Grande for its water, the District's agricultural water diversions during recent years have not been significantly hampered by deficit allocations forthcoming from the Rio Grande. Thus, the five-year water use figures are considered appropriate for use in forecasting future diversions (Hinojosa).[5]

Assessment of Technology and Efficiency Status

The District's pumping plant diverts water from the Rio Grande near the city of Pharr (**Exhibit 5**). The current pumping plant was built in 1983 and has a typical operating capacity of 165 cfs and a maximum of 680 cfs. More than 23 miles of lined canal, 47 miles of earthen canal, 239 miles of pipeline, 3 relift pumping stations, and one 1,700 ac-ft storage reservoir 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 incorporated a computerized 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. Acceptance of volumetric pricing for agriculture irrigation water delivery has not increased within the District. This is evidenced by the fact that only about 1% of current agricultural water use is volumetrically measured. Producers' use of water-conserving methods and equipment is encouraged, however, by the District (Hinojosa).

Water Rights Ownership and Sales

The District holds seven Certificates of Adjudication (i.e., No's. 0808-000 through 0808-004, 0808-500, and 0808-008) (**Table 3**). The District does not divert/deliver, on an on-going basis, towards other Certificates of Adjudication which may belong to other municipal and/or industrial entities. Further, users interested in acquiring additional water beyond their available allocations may acquire such water from parties interested in selling or leasing rights. Such purchases and/or leases are subject to a transportation delivery loss charged by the District; that

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5 The supply/demand balance within irrigation districts varies. In recent years, some districts have had appropriations matching their demands, while others have not. Having an extreme short water supply was identified with previous irrigation-district analyses reports (i.e., those for Cameron County Irrigation District No. 2 (a.k.a. San Benito)) completed thus far by the authors. Other Districts' analyses (i.e., Cameron County Irrigation District No. 1 (a.k.a. Harlingen) and Hidalgo County Irrigation District No. 1 (a.k.a. Edinburg)) did not advise of incurring extreme water unavailability. In fact, one of the two recently had an excess supply and was able to make a one-time sale of water (external to the District).

is, purchase or lease of one ac-ft of water from sources inside or 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 $8.25 per irrigated acre (which is paid for by the landowner) (**Table 3**). An additional $7.50 per acre per irrigation is assessed (either to the landowner-operator, or tenant-producer) (**Table 3**), with such irrigations approximated at 0.5 ac-ft per acre. On an ac-ft basis, this equates to a variable charge of $15.00 per acre. Also, the District charges a delivery fee of $0.085 per 1,000 gallons for Municipal water. Volumetric-priced irrigation water is assessed at $13.50 per ac-ft in the District (Hinojosa).

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 (Hinojosa). 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 rehabilitation of the Alamo Main canal consists of two project components. Though often referred to as components within this report, they are sometimes referred to (locally and or in this report) as the " Relining Alamo Main Canal Project" and the "Flow-Management System Project" (Hinojosa).[6]

Component #1: Relining Alamo Main Canal

The 5.34 miles of Alamo Main canal to be relined in this component service an 11,000 acre area within the District. Summary data for this component of the District's proposed project, are presented in **Tables 4, 5,** and **6**, with discussion of that data following.

<u>Description</u>

This project consists of (a) relining 5.34 miles of Alamo Main canal with a geomembrane lining and shotcrete cover, (b) removing 17 unused farm turnout gates from the side of the canal (and then filling the resulting holes with grout), and (c) replacing 30-35 of the side-of-canal farm turnout gates with "short-wells" (i.e., 36" vertical concrete pipe) about 30-feet from the canal to facilitate a new farm turnout method. Once installed and brought on-line, this project is expected to (**Table 4**):

a) reduce seepage estimated at 638.0 ac-ft per year; and
b) reduce water losses from leaking gates estimated at 6.0 ac-ft per year.

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6 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.

Installation Period

It is anticipated that it will take one year after purchase and project initiation for the new lining to be installed and fully implemented (**Table 5**). No loss of operations or otherwise adverse impacts are anticipated during the installation period since it will occur in the off-season.

Productive Period

A useful life of 49 years[7] for the relining is expected and assumed in the baseline analysis (**Table 5**). A shorter period is possible, but 49 years is considered reasonable and consistent with engineering expectations for the lining system being installed (Michalewicz). 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.

Initial. Based on discussions with USBR management, expenses associated with design, engineering, and other preliminary development of this project'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.

A summary of project construction costs, changes in O&M and other project attributes are indicated in **Table 5**. Detailed capital investment costs (i.e., excavate, purchase, and install the lining) for the 5.34 miles of new lining total $2,500,000 (in 2005 nominal dollars) are provided in **Table 6** (Michalewicz). Sensitivity analysis 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.

Recurring. Annual operating and maintenance (O&M) expenditures associated with the new lining are expected to be the same as those presently occurring for the leaky concrete-lined Alamo Main canal (Hinojosa). Thus, changes in annual O&M expenditures associated with the newly-lined Alamo Main canal project are anticipated to be zero (**Table 5**).

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 as a result of this project component's installation and

[7] 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©.

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.[8]

Off-farm savings include those occurring in the District's canal delivery system as a result of reduced seepage after Alamo Main canal is relined. Recent ponding tests in three segments of Alamo Main canal by Leigh and Fipps documented an annual average water seepage loss rate of 1.17 gal/ft^2/day (USBR 2004). USBR engineers incorporated this and other information to estimate 638.0 ac-ft per year of water savings forthcoming from reduced seepage with the future relining of Alamo Main canal (**Table 4**). Existing estimates of these water losses via seepage are applicable to canals/laterals in their present state. It is highly likely that additional deterioration and increased water loss and associated O&M expenses should be expected as canals/laterals age (Carpenter; Halbert). While estimates of ever-increasing seepage losses over time could be developed, the analysis conservatively maintains a constant water savings (Michalewicz), consistent with assumptions embedded in previous analyses (e.g.; Rister et al. 2004a-b).

Also, it is estimated 6.0 ac-ft of water will be saved by removing and replacing (with "short wells") the farm turnout gates in the Alamo Main canal (which are currently installed on the side of the canal). Further, since this project is only relining the canal (versus enclosing with pipe), additional *off-farm* water savings from reducing evaporation are not expected. There are no *on-farm* water savings anticipated. Thus the combined annual estimated *off-farm* water savings being analyzed for this project are 644.0 ac-ft (**Table 4**) (i.e., 638.0 + 6.0). As with other estimated water savings, this value is held constant during each year of the new Alamo Main canal lining's productive life to provide for a conservative analysis. Sensitivity analyses are performed on all water savings to examine the implications of this estimate. Annual *off-farm* water savings for this project are expected to result in reduced Rio Grande diversions.

Estimates of *off-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 turnout gates. Thus, all noted water savings are based on a "delivered" basis, which is the same as the "diverted" basis for this project analysis.[9]

Energy. In a general sense, energy savings may occur as a result of less water being pumped at the Rio Grande diversion site and also because of lower relift pumping requirements at one or more points throughout the canal delivery system. The amount of such energy savings

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8 A major assumption made by the authors and embedded in this and other analyses of irrigation districts' (IDs) proposed projects is that only the local IDs' perspectives are considered, i.e., activities external to the ID are ignored. Also, all marginal water and energy savings are recognized, not withstanding that in actuality, the "savings" may continue to be utilized within (or outside) the District. The existence of "on-allocation" status for an ID does not alter this assumption.

9 The District's system-wide conveyance loss is estimated to be 23% (Fipps and Pope), as determined by considering total diversions and total sales (Hinojosa). For the component analyzed, additional savings, beyond the local project-area savings 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 affect 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 project site(s) (Michalewicz).

and the associated monetary savings are detailed below. Energy savings associated with reduced diversions and reduced relift pumping are expected with this project. That is, water delivered with the Alamo Main canal is diverted from the Rio Grande and is also relifted within the water-delivery system.

Factors constituting energy savings associated with lessened diversion/relift pumping are twofold: (a) less energy used for pumping and (b) the cost (or value) of such energy. Recent historic records for calendar years 1999-2003 are presented in **Table 7** (diversion energy) and **Table 8** (relift energy) with electricity representing 100% of the District's total diversion-energy and relift-energy expense. The District's average lift at the Rio Grande diversion site is 33 feet (**Table 3**). On average, 213,290 BTU were used to pump each ac-ft of water diverted (**Table 7**). Multiplying this value by the anticipated 644.0 ac-ft of annual *off-farm* water savings results in anticipated annual irrigation energy savings of 137,358,643 BTU (40,257 kwh) (**Table 4**). Assuming the historical average cost of \$0.068 per kwh (i.e., 1999-2003),[10] the estimated annual *off-farm* irrigation energy cost savings (associated with water savings) are \$2,736 (i.e., \$2,711 + \$25) in 2005 dollars (**Table 4**).

Additional *off-farm* energy savings due to reduced relift pumping are expected to be forthcoming from the relining project.[11] After completion and installation of the lining, there will be a reduction in relift pumping due to water savings at the project component site. The net amount of relift-energy reduction associated with this component is estimated to be 106,270,191 BTU (31,146 kwh), which, using the average historical (i.e., 1999-2003) relift-energy cost of \$0.068/kwh equates to an annual relift-pumping energy savings of \$2,125 (**Tables 4** and **8**).

Since there are no *on-farm* water savings, the combined *off-farm* water savings results in total anticipated irrigation energy cost savings of 243,628,834 BTU (71,404 kwh) or the equivalent of \$4,861 in 2005 dollars (**Table 4**). 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 relifted) and the cost per unit of energy.

Operating and Maintenance. Annual O&M expenditures are not expected to change with the new lining project (Hinojosa). Thus, across the total 5.34 miles of Alamo Main canal proposed for relining, a reduction in O&M expense is not anticipated (**Table 5**).

Reclaimed Property. No real property will be reclaimed in association with this project (**Table 5**). Consequently, there is no realizable cash income to claim as a credit against the costs of this project.

10 This estimated value is calculated using District information provided by Sonny Hinojosa which incorporates recognition of the sole source of pumping power (i.e., electric) and its costs.

11 Eliminating the need to relift water saves energy, but not water; i.e., since the water savings realized at the project site area results in reduced Rio Grande diversions, that amount of water is not relifted within the District's water-conveyance system, in addition to not being diverted from the Rio Grande.

Component #2: Installing a Flow-Management System

Water management improvements in the Alamo Main canal (which services an approximate 11,000 acre area within the District) are anticipated from the installation of a flow-management system. Summary data for this component of the District's proposed project, are presented in **Tables 4, 5,** and **6**, with discussion of that data following.

Description

This project consists of installing a flow-management system (i.e., consisting of flow meters, automated gates, and telemetry equipment) in the Alamo Main. Once installed and brought on-line, this project is expected to (**Table 4**):

a) reduce spillage by an estimated 280 ac-ft per year with improved water management.

Installation Period

It is anticipated that it will take one year after purchase and project initiation for the new system to be installed and fully implemented (**Table 5**). No loss of operations or otherwise adverse impacts are anticipated during the installation period since it will occur in the off-season.

Productive Period

A useful life of 20 years for the flow-management system is expected and assumed in the baseline analysis (**Table 5**). A shorter period is possible, but 20 years is considered reasonable and consistent with engineering expectations for the system being installed (Michalewicz). 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 21-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 USBR management, expenses associated with design, engineering, and other preliminary development of this project'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.

A summary of project construction costs, changes in O&M and other project attributes are indicated in **Table 5**. Detailed capital investment costs (i.e., excavate, purchase, and install the lining) for the new flow-management system total $570,000 in 2005 nominal dollars are provided in **Table 6** (Michalewicz). Sensitivity analysis 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) expenses associated with the new system are expected to be very different than those presently occurring since there is currently no similar system in place. That is, implementation of the new system will necessarily cause for new and additional O&M expenses previously not incurred. The estimated increase in annual O&M expenditures associated with this component is $18,000 (basis 2005 dollars) (**Table 5**) (Hinojosa).

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 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.[12]

Off-farm savings are those occurring in the District's canal delivery system as a result of reduced spillage after the flow-management system is installed in the Alamo Main canal. Using information provided by the District, USBR engineers estimated a total of 280.0 ac-ft per year will be saved by reducing spills (**Table 4**). This amount is based on a 90% effectiveness in the system's ability to affect savings and is thus considered a conservative estimate (Michalewicz). Other water-savings are not anticipated; thus, the 280.0 ac-ft of annual *off-farm* savings represent total savings for this project (**Table 4**). As with other estimated water savings, this value is held constant during each year of the new flow-management system's productive life to provide for a conservative analysis. Sensitivity analyses are performed on all water savings to examine the implications of this estimate. Annual *off-farm* water savings for this project are expected to result in reduced Rio Grande diversions.

Estimates of *off-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 turnout gates. Thus, all noted water savings are based on a "delivered" basis, which is the same as the "diverted" basis for this project analysis.[13]

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12 A major assumption made by the authors and embedded in this and other related analyses is that only the local IDs' perspectives are considered. Also, all marginal water and energy savings are recognized, not withstanding that in actuality, the "savings" may continue to be utilized within (or outside) the District. The existence of "on-allocation" status for an ID does not alter this assumption.

13 The District's system-wide conveyance loss is estimated to be 23% (Fipps and Pope), as determined by considering total diversions and total sales (Hinojosa). For the component analyzed, additional savings, beyond the local project-area savings 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) (Michalewicz).

Energy. In a general sense, energy savings may occur as a result of less water being pumped at the Rio Grande diversion site and also because of lower relift pumping requirements 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 reduced diversions and reduced relift pumping are expected with this project. That is, water delivered with the Alamo Main canal is diverted from the Rio Grande and is also relifted within the water-delivery system.

Factors constituting energy savings associated with lessened diversion/relift pumping are twofold: (a) less energy used for pumping and (b) the cost (or value) of such energy. Recent historic records for calendar years 1999-2003 are presented in **Table 7** (diversion energy) and **Table 8** (relift energy) with electricity representing 100% of the District's total diversion-energy and relift-energy expense. The District's average lift at the Rio Grande diversion site is 33 feet (**Table 3**). On average, 213,290 BTU were used to pump each ac-ft of water diverted (**Table 7**). Multiplying this value by the anticipated 280.0 ac-ft of annual *off-farm* water savings results in anticipated annual irrigation energy savings of 59,721,149 BTU (17,503 kwh) (**Table 4**). Assuming the historical average cost of $0.068 per kwh (i.e., 1999-2003), the estimated annual off-farm irrigation energy cost savings (associated with water savings) are $1,190 in 2005 dollars (**Table 4**).

Additional off-farm energy savings due to reduced relift pumping are expected to be forthcoming from the flow-management project. After completion and installation of the system, there will be a reduction in relift pumping due to water savings at the project component site. The net amount of relift-energy reduction associated with this component is estimated to be 46,204,431 BTU (13,542 kwh), which, using the average historical (i.e., 1999-2003) relift-energy cost of $0.068/kwh equates to an annual relift-pumping energy savings of $924 (**Tables 4** and **8**).

Since there are no *on-farm* water savings, the combined *off-farm* water savings results in total anticipated irrigation energy cost savings of 105,925,580 BTU (31,045 kwh) or the equivalent of $2,114 in 2005 dollars (**Table 4**). 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 relifted) and the cost per unit of energy.

Operating and Maintenance. Annual O&M expenditures associated with the new flow-management system will be different than those presently occurring. That is, implementation of the new system will necessarily allow for the dis-employment of one canal rider. The estimated decrease in annual O&M expenses for a fully-laden canal rider (i.e., salary, fringes, and vehicle) are $40,294 (Hinojosa) (**Table 5**).

Reclaimed Property. No real property will be reclaimed in association with this project (**Table 5**). Consequently, there is no realizable cash income to claim as a credit against the costs of this project.

Abbreviated Discussion of Methodology[14]

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 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© is also capable of providing valuable information towards 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 anticipated energy savings from pumping less water caused by reducing leaks and from improving the efficiency of pumping plants.

RGIDECON©'s economic and energy savings analysis 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 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 (USBR 2001). In addition, all calculations are performed on a nominal rather than real basis (Hamilton).

Detailed results for the economic and financial analysis following the methodology presented in Rister et al. 2002 appear in subsequent sections of the main body of this report. Results for the legislative criteria appear in Appendices A and B.

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14 The publication, "Economic Methodology for South Texas Irrigation Projects – RGIDECON©," Texas Water Resources Institute TR-203 (Rister et al. 2002), provides an extensive documentation of the methodology used in conducting the analysis 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. 2002 was endorsed in July, 2002, as expressed by Larry Walkoviak, Area Manager of the Oklahoma-Texas Office of the USBR, "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."

Assumed Values for Critical Parameters

This section presents the values assumed for several parameters which are considered critical in their effects on the results. This discussion emphasizes the importance of these parameters and highlights the values used.[15]

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 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 finance, 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, 2004 and 2005.

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. 2002, 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. 2002). Thus, a 2.043269% rate is used to compound 2005 nominal dollar cost estimates forward for years in the planning period beyond 2005. Rationale for assuming this rate is based both on

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15 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. 2002.

the mathematical relationship presented above and analyses of several pertinent price index series and discussions with selected professionals.[16]

Pre-Project Annual Water Use by the District

Water availability and use in the District has varied in recent years. **Table 2** contains the District's historic water use among agricultural irrigation and M&I along with an indication of the total use for a recent five-year period (1999-2003). Rather than isolate one particular year as the baseline on which to base estimates of future water savings, USBR, Texas Water Development Board, 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 agricultural irrigation use has averaged 48,871 ac-ft during the designated 5-year period. M&I use averages 20,905 ac-ft. The average total water use within the District (including conveyance losses of 12,040 ac-ft) during 1999-2003 is 81,823 ac-ft. These values are perceived as appropriate for gauging future use during this project's planning period (Hinojosa).

Value of Water Savings per Acre-Foot of Water

This analysis/report focuses 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 cost-benefit analysis.[17] 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

This analysis includes calculating the cost of energy savings and applying the value of such savings as a credit to the project's construction cost when evaluating the cost of water

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16 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. 2002, assuming the noted values for risk and time value.

17 RGIDECON© allows for the value of agricultural irrigation water and the incremental differential value for M&I water to be specified, thereby facilitating full cost-benefit analyses. For this study, however, such values are set at $0.00, thereby meeting the assessment requirements specified in P. L. 106-576.

savings associated with the project.[18] The historic average *diversion-energy* usage level of 213,290 BTU per ac-ft of water diverted by the District for calendar years 1999-2003 are used to estimate energy savings resulting when less water is diverted from the Rio Grande due to implementation of the proposed project (**Table 7**). In similar fashion, the historic average *relift-energy* usage level of 165,016 BTU per ac-ft of water relifted by the District for calendar years 1999-2003 are used to estimate energy savings when less water is relifted within the Districts' water-delivery infrastructure system (**Table 8**). Thus, it is anticipated that 213,290 BTU will be saved when diversions from the Rio Grande are lessened by one ac-ft, and for each ac-ft of water not relifted within the District, an additional 165,016 BTU will be saved. 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

Corresponding to the amount of energy saved, historic average pumping costs (diversion and relift) are used to determine the dollar value of the expected energy savings. Records for calendar years 1999-2003 indicate *diversion-energy* costs have ranged from $0.0000163 per BTU ($0.056 per kwh) to $0.0000230 per BTU ($0.078 per kwh). Multiplying the 5-year average cost by the average amount of energy used to divert an ac-ft of water for those years, and the average cost to divert an ac-ft has ranged from $3.96 to $4.71 per ac-ft; with the overall 5-year average of $4.25 per ac-ft used in this analysis (**Table 7**). Similarly, district records indicate *relift-energy* costs have ranged from $0.0000164 per BTU ($0.056 per kwh) to $0.0000227 per BTU ($0.078 per kwh). Multiplying the 5-year average cost by the average amount of energy used to relift an ac-ft of water for those years, and the average cost to relift an ac-ft has ranged from $2.81 to $3.71 per ac-ft; with the overall 5-year average of $3.30 per ac-ft used in this analysis (**Table 8**). Sensitivity analyses are utilized to examine the implications of these estimates.

Results – by Component

The economic and financial analysis results of the afore-mentioned data for each individual component, using RGIDECON© (Rister et al. 2002), are presented here. Aggregated results across the two components are provided in a subsequent section.

Component #1: Relining Alamo Main Canal

The first component evaluated in this analysis is primarily the relining of 5.34 miles of Alamo Main canal. Results of the analysis for this component follow (**Table 9**).

18 "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 ... – they are single measures, representing different perspectives of the proposed projects and their component(s)." (Rister et al. 2002).

Quantities of Water and Energy Savings

Critical values in the analysis are the quantities of water and energy anticipated being saved during the 49-year productive life of the new lining.[19] On a nominal (i.e., non-discounted) basis, 31,556 ac-ft of irrigation water are projected to be saved; no M&I water savings are expected. Thus, the total nominal water savings anticipated are 31,556 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 13,215 ac-ft of real irrigation savings and 0.0 ac-ft of real M&I water savings, representing a total real water savings of 13,215 ac-ft (**Table 9**).

On a nominal (i.e., non-discounted) basis, 11,937,812,868 BTU (3,498,773 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. Using the 4% discount rate previously discussed, those nominal savings translate into 4,999,421,096 BTU (1,465,247 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 component's merit is the estimated cost per ac-ft of water saved as a result of its installation and implementation. Both deterministic results based on the expected values for all parameters integrated into the RGIDECON© assessment and sets of sensitivity analyses for several pairs of data parameters are presented below for component #1.

NPV of Net Cost Stream. Accounting for all capital purchase and construction costs, changes in O&M expenditures, and credits for energy savings, the nominal total cost of the 50-year planning period for the new lining project is $2,080,272 (**Table 9**). Using the previously-identified discount rate of 6.125%, these nominal cost dollars translate into present-day, real costs of $2,400,243 (**Table 9**). This amount represents, across the total 50-year planning period, the total net costs, in 2005 dollars, of purchasing and installing the geomembrane and shotcrete-covered lining as well as payment of the net changes in O&M expenditures. Note that the positive real-value amount of costs is greater than the positive nominal-value amount. This result occurs because in the nominal-value amount, the savings accruing from reduced energy use in the lengthy planning period offset a large portion of the initial investment cost, while the real (i.e., "discounted) dollars of energy savings offset a smaller portion of the initial investment cost. In the case of the real-value amount, 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 31,556 ac-ft (**Table 9**). The corresponding total real water savings expressed in

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19 As noted previously, the estimated useful life is 50 years instead of 49 years. RGIDECON© was developed to consider a maximum 50-year planning horizon, with the perspectives that projections beyond that length of time are largely discounted and 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©.

2005 water quantities are 13,215 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 $2,400,243 correlates with the real water savings projection of 13,215 ac-ft; the respective annuity equivalents are $154,945 and 615 ac-ft (**Table 9**). The estimated cost of saving one ac-ft of water using the new lining comprising this project is $251.87 (**Table 9**). This value can be interpreted as the cost of leasing one ac-ft of water in year 2005. 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. 2002, 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 new lining system 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 installation and implementation of the new lining in the water-delivery system. Thus, the cost per ac-ft of water-saved sensitivity analysis consist of varying the off-farm water-savings dimension of that factor across a range of 325 to 900 ac-ft (including the baseline 638 ac-ft) for the new lining[20] 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 $175.50 to $1,070.12 cost per ac-ft of savings around the baseline estimate of $251.87. These calculated values were derived by varying the reduction in Rio Grande diversions arising from off-farm water savings for the new lining from as low as 325 ac-ft up to 900 ac-ft about the expected 638 ac-ft and by investigating a range of useful lives of the lining system 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 water savings than the predicted 638 ac-ft also increased cost estimates, and higher-than-expected water savings contributed to lower cost estimates.

20 All sources of water savings are interconnected within the RGIDECON© analysis such that total savings are incorporated into the pertinent sensitivity tables. That is, as one area (e.g., seepage) is varied in the sensitivity analyses, so are the other areas (e.g., spillage, percolation, etc.), on a proportional basis.

Similarly, **Table 11** is a presentation of a range of cost estimates varying from $212.70 to $401.53 per ac-ft of savings around the baseline estimate of $251.87. These calculated values were derived by varying the reduction in Rio Grande diversions arising from off-farm water savings from the new lining from as low as 325 ac-ft up to 900 ac-ft about the expected 638 ac-ft and by considering variations in the cost of the capital investment in the new lining system varying from $500,000 less than the expected $2,500,000 up to $500,000 more than the expected amount. As should be expected, both lower-than-the-anticipated $2,500,000 capital costs and/or higher-than-expected water savings contributed to lower cost estimates, while both higher investment costs and/or lower off-farm water savings than the predicted amounts increased the cost estimates.

The final set of sensitivity analysis conducted for the costs of water savings accounted for varying both the reduction in Rio Grande diversions arising from investment in the new lining and the cost of energy. **Table 12** is an illustration of the results of varying those parameters from as low as 325 ac-ft up to 900 ac-ft about the expected 638 ac-ft of off-farm water savings and across a range of $0.0350 to $0.1025 per kwh energy costs about the expected $0.0680 per kwh level. The resulting cost of water-savings estimates ranged from a high of $509.60 per ac-ft down to a low of $170.18 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 new lining 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 lining's installation and implementation, another issue of interest is the cost of energy savings. Reduced water diversions from the Rio Grande will result as seepage is reduced, and as improved water management (as facilitated by the flow-management system) minimizes spillage. These reduced diversions associated with the proposed Alamo Main's capital renovation will result in less water being pumped (i.e., diverted and relifted), translating into energy savings. Both deterministic results based on the expected values for all parameters integrated into the RGIDECON© assessment and sets of sensitivity analyses for several pairs of data parameters are presented below for the proposed project.

NPV of Net Cost Stream. Accounting for all capital purchase and construction costs, and changes in O&M expenditures, the nominal total cost of the 50-year planning period for the Alamo Main canal relining project is $2,500,000 (**Table 9**). Using the previously-identified discount rate of 6.125%, these nominal cost dollars translate into a present-day, real cost of $2,500,000 (**Table 9**). This amount represents, across the total 50-year planning period, the total net costs, in 2005 dollars, of purchasing and installing the lining system 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. Note that since construction costs are assumed to be incurred immediately and because there are no net changes to annual O&M expenses for this component, the nominal and real total costs are equal.

NPV of All Energy Savings. As detailed above, the total nominal energy savings anticipated are 11,937,812,868 BTU (3,498,773 kwh) (**Table 9**). The corresponding total real energy savings expressed in 2005 energy quantities are 4,999,421,096 BTU (i.e., 1,465,247 kwh) over the 49-year productive life of this component, assuming the previously-identified discount rate of 4.00% (**Table 9**).

Cost per BTU & kwh Saved. The real net cost estimate of $2,500,000 correlates with the real energy savings projection of 4,999,421,096 BTU (1,465,247 kwh); the respective annuity equivalents are $161,385 and 232,724,054 BTU (68,208 kwh) (**Table 9**). The estimated cost of saving one BTU of energy using the new lining system comprising this project is $0.0006935 ($2.366 per kwh) (**Table 9**). An interpretation of this value is that it is the cost of saving one BTU (kwh) of energy in year 2005. Following through with the economic and capital budgeting methodology presented in Rister et al. 2002, 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 geomembrane and shotcrete-covered lining system 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 is considered to be that pertaining to the amount of energy savings that will result from the installation and implementation of the new geomembrane and shotcrete lining system in the water-delivery infrastructure 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 213,290 BTU (62.51 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 lining system. 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 $0.0004623 to $0.0018386 cost per BTU (and $1.577 to $6.273 per kwh) of energy savings around the baseline estimate of $0.0006935 per BTU ($2.366 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 213,290 BTU (62.51 kwh) current average usage per ac-ft of water savings and by investigating a range of useful lives of the capital investment in the lining system 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 $0.0003698 to $0.0010402 per BTU (and $1.262 to $3.549 per kwh) of energy savings around the baseline estimate of $0.0006935 per BTU ($2.366 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 213,290 BTU (62.51 kwh) current average usage per ac-ft of water savings and by considering variations in the cost of the capital investment in the lining system from $500,000 less than the expected $2,500,000 up to $500,000 more than the expected amount. As should be expected, both lower-than-the-anticipated $2,500,000 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 expected 213,290 BTU (62.51 kwh) increased the cost estimates.

The final set of sensitivity analysis 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 relining of Alamo Main canal. **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 213,290 BTU (62.51 kwh) current average usage per ac-ft of water savings and from as low as 325 ac-ft up to 900 ac-ft about the expected 638 ac-ft off-farm water savings for the relining of Alamo Main canal. The resulting costs of energy savings estimates ranged from a high of $0.0017016 per BTU ($5.806 per kwh) down to a low of $0.0003277 per BTU ($1.118 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.

Component #2: Installing a Flow-Management System

The second component evaluated in this analysis is the installing of a flow-management system in the Alamo Main canal. Results of the analysis for this component follow (**Table 19**).

<u>Quantities of Water and Energy Savings</u>

Critical values in the analysis are the quantities of water and energy anticipated being saved during the 20-year productive life of the new flow-management system. On a nominal (i.e., non-discounted) basis, 5,600 ac-ft of irrigation water are projected to be saved; no M&I water savings are expected. Thus, the total nominal water savings anticipated are 5,600 ac-ft over the 20-year productive life of this component (**Table 19**). Using the 4% discount rate previously discussed, those nominal savings translate into 3,659 ac-ft of real irrigation savings and 0.0 ac-ft of real M&I water savings, representing a total real water savings of 3,659 ac-ft (**Table 19**).

On a nominal (i.e., non-discounted) basis, 2,118,511,600 BTU (620,900 kwh) of energy savings are projected to be saved in association with the forecast irrigation water savings (**Table 19**). Since there are no M&I-related energy savings, these values represent the total energy savings for this project. Using the 4% discount rate previously discussed, those nominal savings translate into 1,384,195,385 BTU (405,684 kwh) of real irrigation-related energy savings over the 20-year productive life of this component (**Table 19**).

Cost of Water Saved

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

NPV of Net Cost Stream. Accounting for all capital purchase and construction costs, changes in O&M expenditures, and credits for energy savings, the nominal total cost of the 21-year planning period for the new flow-management system project is ($50,189) (**Table 19**). Using the previously-identified discount rate of 6.125%, these nominal cost dollars translate into present-day, real costs of $251,052 (**Table 19**). This amount represents, across the total 21-year planning period, the total net costs, in 2005 dollars, of purchasing and installing the flow-management system 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 and a net reduction in annual O&M, in the lengthy planning period, more than offset the initial investment cost, while the real (i.e., "discounted) dollars of energy savings offset a smaller portion of the initial investment cost. In the case of the real-value amount, 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 5,600 ac-ft (**Table 19**). The corresponding total real water savings expressed in 2005 water quantities are 3,659 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 $251,052 correlates with the real water savings projection of 3,659 ac-ft; the respective annuity equivalents are $21,565 and 261 ac-ft (**Table 19**). The estimated cost of saving one ac-ft of water using the new flow-management system comprising this project is $82.69 (**Table 19**). This value can be interpreted as the cost of leasing one ac-ft of water in year 2005. 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. 2002, 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 new flow-management system 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 installation and implementation of the new flow-management system. Thus, the cost per ac-ft of water-saved sensitivity analysis consist of varying the off-farm water-savings dimension of that factor across a range of 150 to 400 ac-ft (including the baseline 280 ac-ft) for the new flow-management system 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 $55.15 to $439.83 cost per ac-ft of savings around the baseline estimate of $82.69. These calculated values were derived by varying the reduction in Rio Grande diversions arising from off-farm water savings for the new lining from as low as 150 ac-ft up to 400 ac-ft about the expected 280 ac-ft and by investigating a range of useful lives of the lining system down from the expected 20 years to as short as only 5 years. As should be expected, shorter-useful lives than the anticipated 20-year productive life resulted in higher cost estimates, lower off-farm water savings than the predicted 280 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 $32.10 to $223.71 per ac-ft of savings around the baseline estimate of $82.69. These calculated values were derived by varying the reduction in Rio Grande diversions arising from off-farm water savings from the new flow-management system from as low as 150 ac-ft up to 400 ac-ft about the expected 280 ac-ft and by considering variations in the cost of the capital investment in the new flow-management system varying from $100,000 less than the expected $570,000 up to $100,000 more than the expected amount. As should be expected, both lower-than-the-anticipated $570,000 capital costs and/or higher-than-expected water savings contributed to lower cost estimates, while both higher investment costs and/or lower off-farm water savings than the predicted amounts increased the cost estimates.

The final set of sensitivity analysis conducted for the costs of water savings accounted for varying both the reduction in Rio Grande diversions arising from investment in the new flow-management system and the cost of energy. **Table 22** is an illustration of the results of varying those parameters from as low as 150 ac-ft up to 400 ac-ft about the expected 280 ac-ft of off-farm water savings and across a range of $0.0350 to $0.1025 per kwh energy costs about the expected $0.0680 per kwh level. The resulting cost of water-savings estimates ranged from a high of $166.64 per ac-ft down to a low of $50.53 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 new flow-management system 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 flow-management system's installation and implementation, another issue of interest is the cost of energy savings. Reduced water diversions from the Rio Grande will result as spillage is reduced as the new flow-management system helps to more closely match water demand with water supply in the project area. These reduced diversions associated with the proposed flow-management system capital addition will result in less water being pumped (i.e., diverted and relifted), translating into energy savings. Both deterministic results based on the expected values for all parameters integrated into the RGIDECON© assessment and sets of sensitivity analyses for several pairs of data parameters are presented below for the proposed project.

NPV of Net Cost Stream. Accounting for all capital purchase and construction costs, and changes in O&M expenditures, the nominal total cost of the 21-year planning period for the flow-management system project is $3,517 (**Table 19**). Using the previously-identified discount rate of 6.125%, these nominal cost dollars translate into a present-day, real cost of $278,671 (**Table 19**). This amount represents, across the total 21-year planning period, the total net costs, in 2005 dollars, of purchasing and installing the flow-management system 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. Note that the positive real-value amount of costs is substantially greater than the positive nominal-value amount. This result occurs because in the nominal-value amount, the savings accruing from a net reduction in annual O&M, across the planning period, offset the majority of the initial investment cost, while the real (i.e., "discounted) dollars of energy savings offset a smaller portion of the initial investment cost. In the case of the real-value amount, 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 Energy Savings. As detailed above, the total nominal energy savings anticipated are 2,118,511,600 BTU (620,900 kwh) (**Table 19**). The corresponding total real energy savings expressed in 2005 energy quantities are 1,384,195,385 BTU (405,684 kwh) over the 20-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 $278,671 correlates with the real energy savings projection of 1,384,195,385 BTU (405,684 kwh); the respective annuity equivalents are $23,938 and 98,665,593 BTU (28,917 kwh) (**Table 19**). The estimated cost of saving one BTU of energy using the new flow-management system comprising this project is $0.0002426 ($0.828 per kwh) (**Table 19**). An interpretation of this value is that it is the cost of saving one BTU (kwh) of energy in year 2005. Following through with the economic and capital budgeting methodology presented in Rister et al. 2002, 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 flow-management system 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 is considered to be that pertaining to the amount of energy savings that will result from the installation and implementation of the new flow-management system in the water-delivery infrastructure 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 213,290 BTU (62.51 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 lining system. 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 $0.0001617 to $0.0008222 cost per BTU (and $0.552 to $2.805 per kwh) of energy savings around the baseline estimate of $0.0002426 per BTU ($0.828 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 213,290 BTU (62.51 kwh) current average usage per ac-ft of water savings and by investigating a range of useful lives of the capital investment in the lining system down from the expected 20 years to as short as only 5 years. As should be expected, shorter-useful lives than the anticipated 20-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 $0.0004121 to $0.0001037 per BTU (and $1.406 to $0.354 per kwh) of energy savings around the baseline estimate of $0.0002426 per BTU ($0.828 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 213,290 BTU (62.51 kwh) current average usage per ac-ft of water savings and by considering variations in the cost of the capital investment in the flow-management system from $100,000 less than the expected $570,000 up to $100,000 more than the expected amount. As should be expected, both lower-than-the-anticipated $570,000 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 expected 213,290 BTU (62.51 kwh) increased the cost estimates.

The final set of sensitivity analysis 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 installing the flow-management system in the Alamo Main canal. **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 expected 213,290 BTU (62.51 kwh) current average usage per ac-ft of water savings and from as low as 150 ac-ft up to 400 ac-ft about the expected 280 ac-ft off-farm water savings for the flow-management system. The resulting costs of energy savings estimates ranged from a high of $0.0005661 per BTU ($1.932 per kwh) down to a low of $0.0001132 per BTU ($0.386 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.

Results – Aggregated Across Components

According to USBR management, a comprehensive, aggregated measure is required to assess the overall potential performance of a proposed project consisting of multiple components (Shaddix). 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. 2002, 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 project components 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 two 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 **$201.50 per ac-ft**.

Relining Alamo Main Canal

The initial capital investment associated with this component is $2,500,000 in 2005 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 $2,400,243 value noted at the top of the ‘Reline Alamo Main Canal’ column in **Table 29**. The nominal water savings anticipated during the 50-year planning period total 31,556 ac-ft; discounted into a real 2005 value, those savings are estimated to be 13,215 ac-ft (**Table 9**). Converting both of the real 2005 values into annuity equivalents per the methodology presented in Rister et al. 2002 results in an annual cost estimate of $154,945 to achieve 615.0 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 $251.87 per ac-ft of water savings for the relining of Alamo Main canal (**Table 29**).

<u>Installing a Flow-Management System</u>

The initial capital investment associated with this component is $570,000 in 2005 nominal dollars (**Table 6**). Combining that cost with the changes in O&M expenditures over the 21-year planning horizon and calculating the net present value (NPV) of that flow of funds contributes to the $251,052 value noted at the top of the ‘Install Flow-Management System’ column in **Table 29**. The nominal water savings anticipated during the 21-year planning period total 5,600 ac-ft; discounted into a real 2005 value, those savings are estimated to be 3,659 ac-ft (**Table 19**). Converting both of the real 2005 values into annuity equivalents per the methodology presented in Rister et al. 2002 results in an annual cost estimate of $21,565 to achieve 261.0 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 $82.69 per ac-ft of water savings for the flow-management system (**Table 29**).

<u>Aggregate Measure of Cost of Water Savings</u>

Combining the costs of the two components 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 $2,651,294 which translates into an annuity cost equivalent of **$176,511 per year** (**Table 29**). The total NPV of water savings is 16,874 ac-ft, representing an annuity equivalent of **876 ac-ft of water savings** (**Table 29**), representing **1%** of the current average water diversion by the District. 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 **$201.50 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 two components. The individual component measures are displayed in the table and then aggregated in the far-right column, indicating that the overall cost of energy saved is **$0.0005592 per BTU (or $1.908 per kwh)**.

<u>Relining Alamo Main Canal</u>

The initial capital investment associated with this component is $2,500,000 in 2005 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 $2,500,000 value noted at the top of the 'Reline Alamo Main Canal' column in **Table 30.** This value is again higher than the corresponding $2,400,243 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 11,937,812,868 BTU (3,498,773 kwh) (**Table 9**). Discounted into a real 2005 value, those savings are estimated to be 4,999,421,096 BTU (1,465,247 kwh) (**Table 9**). Converting both of the real 2005 values into annuity equivalents per the methodology presented in Rister et al. 2002 results in an annual cost estimate of $161,385 to achieve 232,724,054 BTU (68,208 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 $0.0006935 per BTU ($2.366 per kwh) of energy savings for the relining of Alamo Main canal (**Table 30**).

Installing a Flow-Management System

The initial capital investment associated with this component is $570,000 in 2005 nominal dollars (**Table 6**). Combining that cost with the changes in O&M expenditures over the 21-year planning horizon and calculating the net present value (NPV) of that flow of funds contributes to the $278,671 value noted at the top of the 'Install Flow-Management System' column in **Table 30.** This value is again higher than the corresponding $251,052 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 21-year planning period total 2,118,511,600 BTU (620,900 kwh) (**Table 19**). Discounted into a real 2005 value, those savings are estimated to be 1,384,195,385 BTU (405,684 kwh) (**Table 19**). Converting both of the real 2005 values into annuity equivalents per the methodology presented in Rister et al. 2002 results in an annual cost estimate of $23,938 to achieve 98,665,593 BTU (28,917 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 $0.0002426 per BTU ($0.083 per kwh) of energy savings for the flow-management system (**Table 30**).

Aggregate Measure of Cost of Energy Savings

Combining the costs of the two components results in a total NPV net cost (i.e., both initial investments and changes in O&M expenditures) estimate of $2,778,671 which translates into an annuity cost equivalent of $185,323 per year (**Table 30**). The total NPV of energy savings is 6,383,616,482 BTU, representing an annuity equivalent of **331,389,647 BTU (97,125 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 **$0.0005592 per BTU ($1.908 per kwh)** of energy savings aggregate cost measure (**Table 30**).

Limitations

The protocol and implementation of the analysis reported herein 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 analysis is 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 ignored.

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

- Limited financial resources and data availability, and a defined time horizon prohibit (a) extensive field experiments to document all 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 and elaborate evaluation process.

- Though the analysis framework is deterministic, sensitivity analyses are included for several of the dominant parameters (in recognition of the prior two limitations). Beyond the sensitivity analyses, however, there is no accounting for risk in this analysis.

- 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, 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.

- 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. 2002.

- 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 analysis 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, or anticipated to be authorized, by 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 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 and Public Law 107-351 legislation. 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

This analysis report is conditioned on the best information available, subject to the array of resource limitations and other problematic issues previously mentioned. Nonetheless, the results are highly useful for the USBRs appraisal and prioritization of the several Rio Grande Basin projects already or potentially authorized by Congress or submitted in a formal manner. Nonetheless, there are opportunities for additional research efforts 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 0.25 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.

- An effort to confirm and validate the water and energy savings estimated forthcoming from each proposed project component is needed to confirm the economic and financial cost effectiveness of each.

- 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 highlight potential efficiency gains.

- Integration of risk would be useful in future analyses, including incorporation of stochastic elements for and correlation among the numerous parameters affecting the costs of saving water and energy.

- Identifying a prioritization process for ranking projects competing for limited funds could distinguish between project components, as well as consider other potential components besides those proposed by individual IDs (i.e., whereby such latter projects are identified in a regional context). Development of an economic mixed-integer programming model (Agrawal and Heady) is suggested as a reasonable and useful complement to ongoing and 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.

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 in addressing current and emerging issues in the area.

Summary and Conclusions

The District's proposed project consists of two components: relining the Alamo Main canal and installing a flow-management system (in the Alamo Main canal). Their required respective capital investment costs are $2,500,000 and $570,000, which total $3,070,000. A one-year installation period is anticipated for both components, with component #1 expected to have a 49-year useful life, while component #2 is expected to be useful for 20-years. Net annual O&M expenditures are expected to remain consistent for the relining component, but decrease substantially for the flow-management system component, resulting in an overall decrease in annual O&M for the total project (**Table 5**).

Only *off-farm* water savings are predicted to be forthcoming from component #1 as its nominal water savings anticipated during its 49-year useful life total 31,556 ac-ft; discounted into a real 2005 value, those savings are estimated to be 13,215 ac-ft (**Table 9**). Only *off-farm* water savings are predicted to be forthcoming from component #2 as its nominal water savings anticipated during its 20-year useful life total 5,600 ac-ft; discounted into a real 2005 value, those savings are estimated to be 3,659 ac-ft (**Table 19**). Across the total project, nominal water savings are 37,156 ac-ft (**Tables 9** and **19**) and real 2005 savings are 16,874 ac-ft. On an average, annual, real basis, this totals **876 ac-ft** across both components (**Table 29)**.

Energy savings estimates associated with component #1 are 11,937,812,868 BTU (3,498,773 kwh) in nominal terms and 4,999,421,096 BTU (1,465,247 kwh) in real 2005 terms (**Table 9**). Similar estimates associated with component #2 are 2,118,511,600 BTU (620,900 kwh) in nominal terms and 1,384,195,385 BTU (405,684 kwh) in real 2005 terms (**Table 19**). For the total project, nominal energy savings are 14,056,324,468 BTU (4,119,673 kwh) and real 2005 savings are 6,383,616,482 BTU (1,870,931 kwh) (**Table 9**, **19**, and **30**). On an average, annual, real basis, this totals **331,389,647 BTU (97,125 kwh)** across both components (**Table 30)**.

Economic and financial costs of *water* savings forthcoming from component #1 are estimated at $251.87 per ac-ft; while those for component #2 are estimated at $82.69 (**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 installation and implementation of the project components; (b) the expected useful lives of the components; (c) the initial capital investment costs of the components; and (d) the value of BTU savings (i.e., cost of energy).

Economic and financial costs of *energy* savings forthcoming from component #1 are estimated at \$0.0006935 per BTU (\$2.366 per kwh); while those for component #2 are estimated at \$0.0002426 per BTU (\$0.828 per kwh) (**Tables 9**, **19**, and **30**). Sensitivity analyses indicate factors of importance are (a) the amount of energy savings resulting from the 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 **\$201.50 per ac-ft** cost of water savings (**Table 29**) and **\$0.0005592 per BTU (\$1.908 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. 2002.

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Glossary

Acre-feet: A measure of water contained in an area of one acre square and one foot deep which is equal to 325,851 gallons.

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/analysis, 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, resulting in reduced seepage and/or increased 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 or pipeline where end users appropriate 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.

No-Charge Water: An amount of water, considered as excess flow, which can be diverted, quantified, and added to improve a District's water supply without being counted against its Watermaster-controlled allocation.

Nominal basis: Refers to non-inflation adjusted values (e.g., dollars).

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

Off-farm savings: Conserved units of water or energy occurring in the water-delivery infrastructure system of an irrigation district; in this report, derived from capital improvement projects designed to improve pumping operations or conveyance and/or delivery of raw water.

On-farm savings: Conserved units of water or energy realized at the farm level; in this report, indirect savings forthcoming from irrigation districts' capital improvement projects.

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.

Rio Grande Valley: A geographic region in the southern tip of Texas which is considered to include Cameron, Hidalgo, Starr, and Willacy counties.

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

Telemetry: Involving a wireless means of data transfer of water flow rates, volume, levels, etc.

Turnout: Refers to the diversion point (or gate) where water is diverted from the irrigation district's canal/lateral to the farmer's field.

Volumetric pricing: Method of pricing raw irrigation water based on the precise quantity of water delivered/used, as opposed to pricing on an assumed/estimated amount (e.g., 6 acre inches) and applying a specified rate to a per-acre or per-irrigation basis.

Watermaster: An employee for the Texas Commission on Environmental Quality who is responsible for the allocation and accounting of Rio Grande water flows and compliance of water rights.

Water Right: A right acquired under the laws of the State of Texas to impound, divert, or use state water.

Exhibits

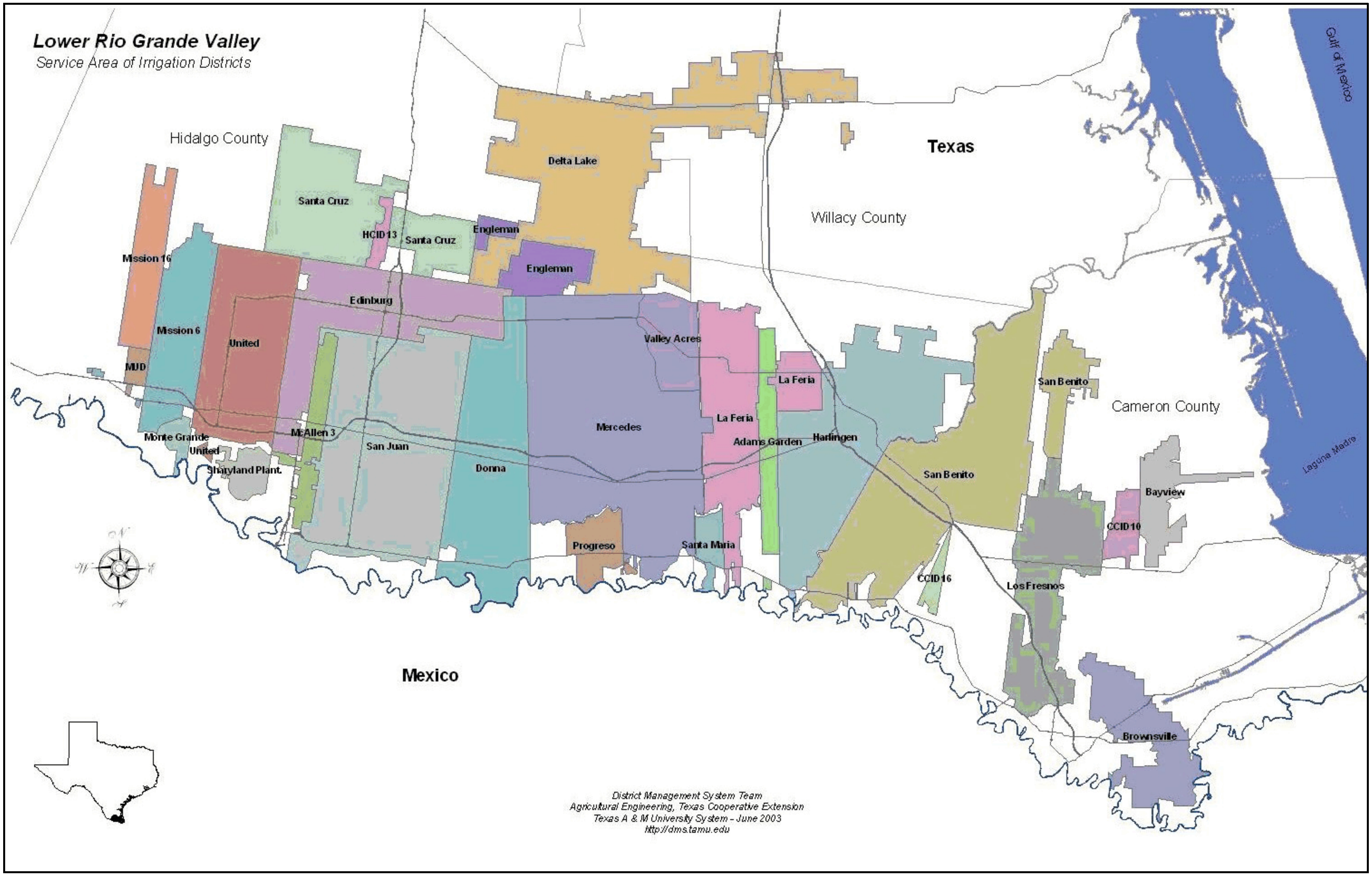

Exhibit 1. Illustration of Twenty-Eight Irrigation Districts in the Texas Lower Rio Grande Valley (Fipps et al.).

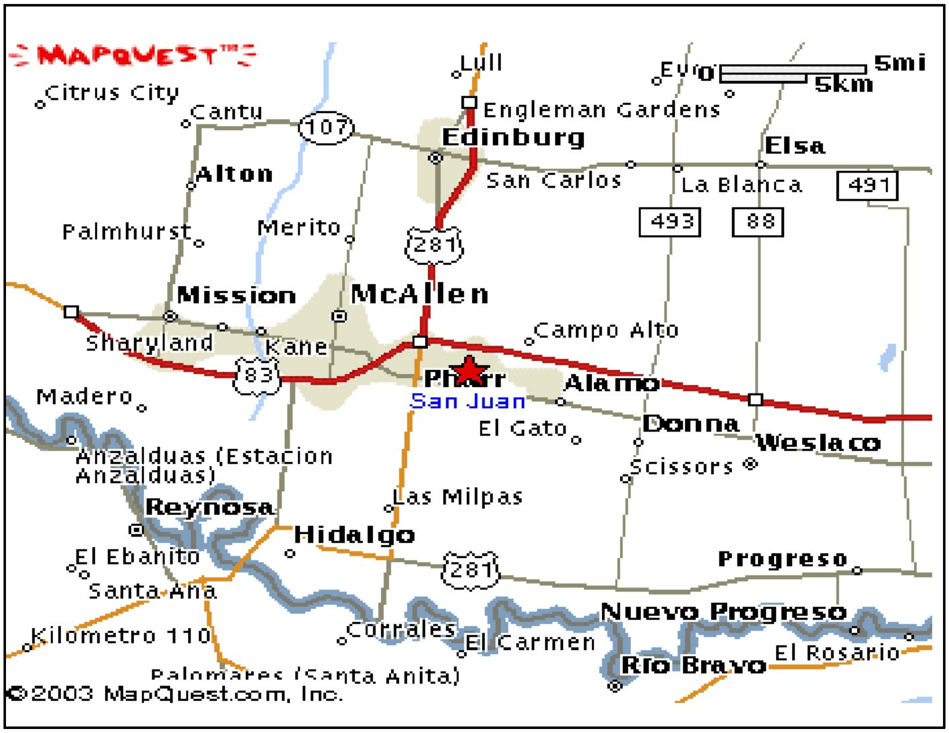

Exhibit 2. San Juan, TX – Location of Hidalgo County Irrigation District No. 2 Office (MapQuest).

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

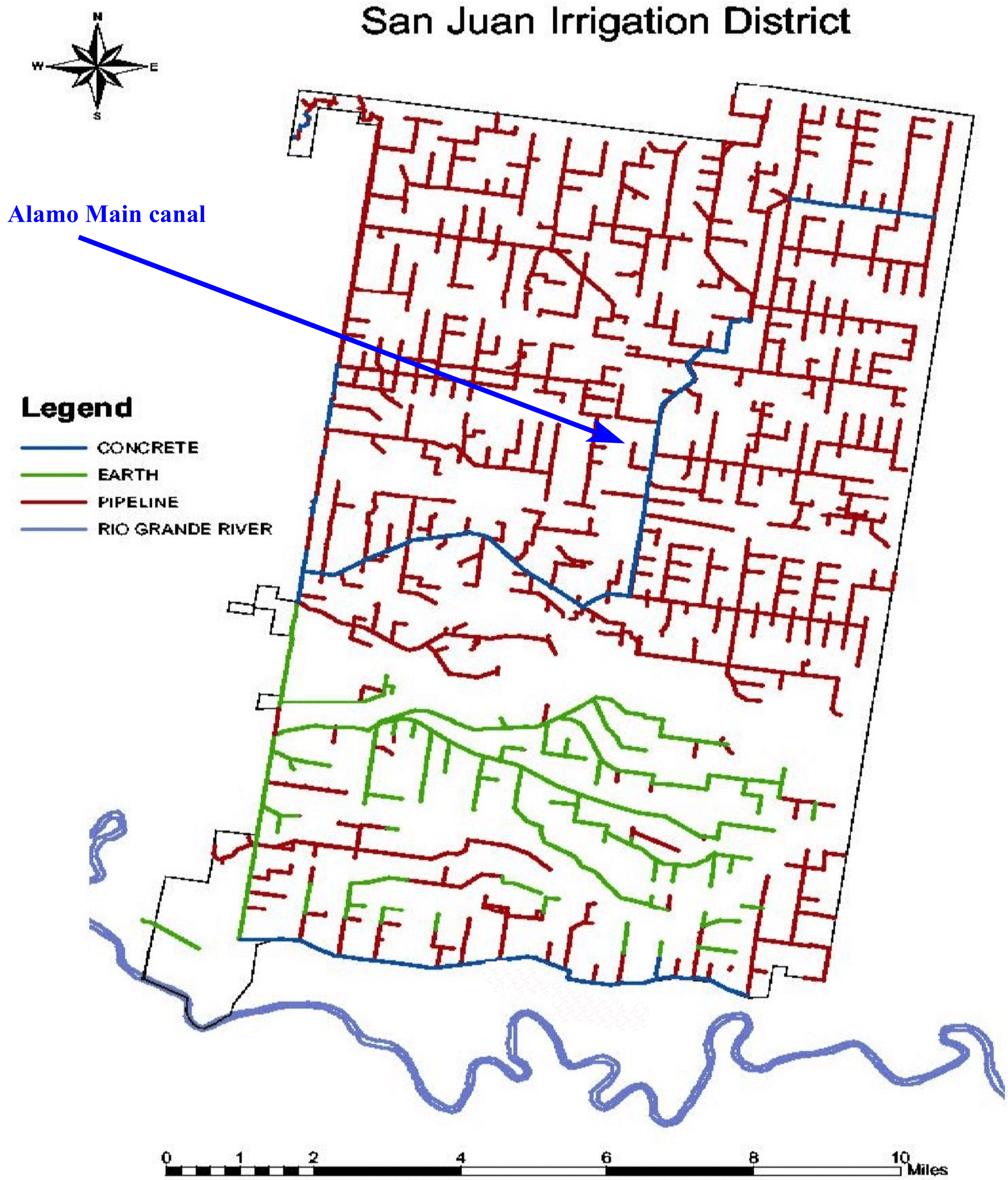

Exhibit 4. Illustrated Layout of Hidalgo County Irrigation District No. 2 (Fipps et al.).

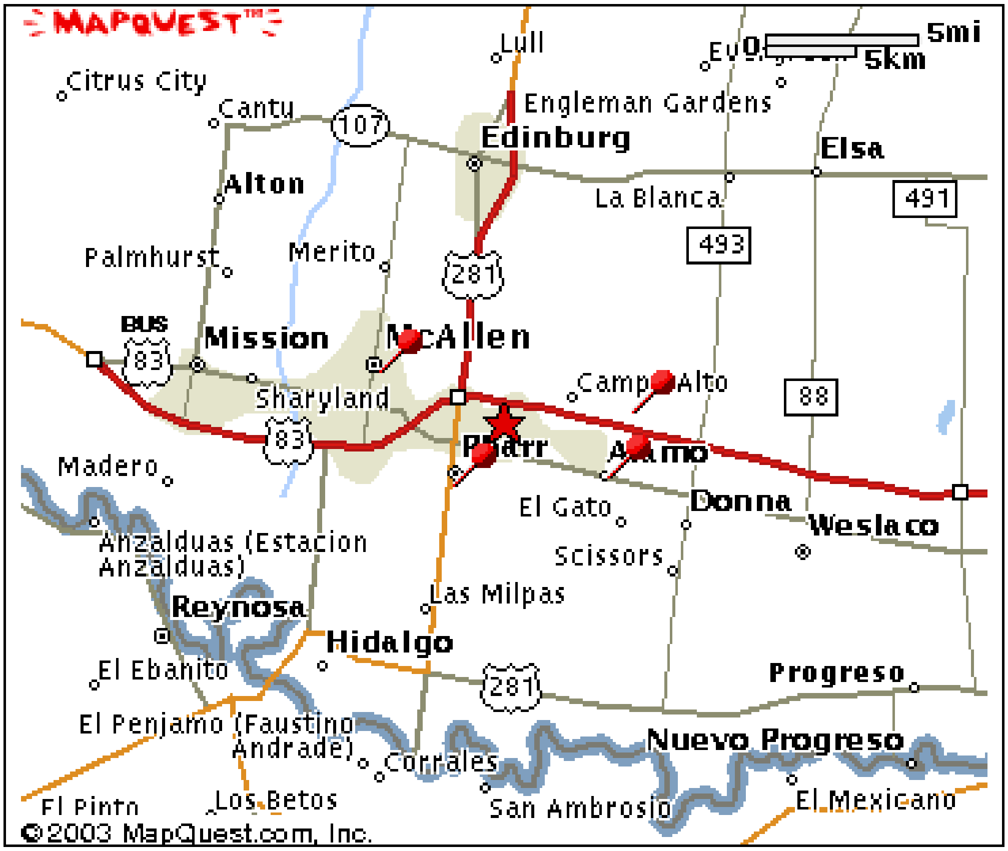

Exhibit 5. Location of Municipalities, Water Supply Corporations, and Irrigation Districts Served by Hidalgo County Irrigation District No. 2 (MapQuest).

Tables

Table 1. Average Acreage Irrigated by HCID No. 2 During 1999-2003.

Category / Enterprise	crop year 1999	2000	2001	2002	2003	5-year average acres	%
Field crops - annual							
SORGHUM	6,854.0	7,047.0	6,779.0	7,298.0	6,414.0	6,878.4	19.12 %
COTTON	6,246.0	4,093.0	4,716.0	3,221.0	3,358.0	4,326.8	12.03 %
CORN	3,612.0	3,736.0	3,547.0	2,606.0	2,992.0	3,298.6	9.17 %
MISC. FIELD CROPS	5.0	34.0	90.0	10.0	4.0	28.6	0.08 %
OATS	-	-	4.0	-	-	0.8	0.00 %
						14,533.2	40.40 %
Vegetables							
ONIONS	2,901.0	3,512.0	3,467.0	3,202.0	3,482.0	3,312.8	9.21 %
CABBAGE	1,438.0	1,181.0	1,660.0	1,524.0	1,988.0	1,558.2	4.33 %
CARROTS	1,789.0	1,374.0	1,362.0	1,060.0	899.0	1,296.8	3.61 %
GREENS	1,174.0	1,037.0	1,047.0	1,256.0	1,469.0	1,196.6	3.33 %
PICKLES	1,253.0	1,232.0	1,171.0	1,193.0	850.0	1,139.8	3.17 %
PEPPERS	99.0	117.0	137.0	218.0	141.0	142.4	0.40 %
TOMATOES	108.0	144.0	177.0	123.0	96.0	129.6	0.36 %
BEETS	153.0	85.0	135.0	136.0	38.0	109.4	0.30 %
BROCCOLI	132.0	94.0	149.0	102.0	70.0	109.4	0.30 %
SQUASH	89.0	53.0	60.0	156.0	138.0	99.2	0.28 %
OTHER VEGETABLES	101.0	87.0	162.0	75.0	61.0	97.2	0.27 %
CUCUMBERS	13.0	-	156.0	143.0	65.0	75.4	0.21 %
CILANTRO	16.0	50.0	34.0	58.0	124.0	56.4	0.16 %
LEEKS	-	-	-	68.0	125.0	38.6	0.11 %
LETTUCE	-	58.0	75.0	30.0	8.0	34.2	0.10 %
CAULIFLOWER	34.0	9.0	10.0	12.0	25.0	18.0	0.05 %
CELERY	-	5.0	29.0	29.0	12.0	15.0	0.04 %
BEANS	15.0	18.0	-	23.0	-	11.2	0.03 %
						9,440.2	26.24 %
Pasture / Open							
OPEN LAND	6,805.0	5,090.0	4,032.0	3,626.0	1,910.0	4,292.6	11.93 %
PASTURE	1,000.0	996.0	1,102.0	1,257.0	760.0	1,023.0	2.84 %
						5,315.6	14.78 %
Fruit							
CITRUS	1,672.0	1,575.0	1,512.0	1,522.0	1,410.0	1,538.2	4.28 %
OTHER FRUITS	3.0	4.0	18.0	12.0	5.0	8.4	0.02 %
						1,546.6	4.30 %
Hay							
OTHER HAY	481.0	913.0	614.0	790.0	422.0	644.0	1.79 %
ALFALFA HAY	479.0	468.0	549.0	484.0	486.0	493.2	1.37 %
OTHER GRASSES	292.0	286.0	281.0	380.0	250.0	297.8	0.83 %
						1,435.0	3.99 %
Field Crops - perennial							
SUGAR CANE	1,462.0	1,442.0	1,380.0	1,165.0	1,049.0	1,299.6	3.61 %
						1,299.6	3.61 %
Melons							
CANTALOUPES	781.0	375.0	1,183.0	1,055.0	814.0	841.6	2.34 %
WATERMELONS	542.0	191.0	188.0	201.0	218.0	268.0	0.75 %
HONEYDEW, ETC.	264.0	139.0	38.0	281.0	40.0	152.4	0.42 %
						1,262.0	3.51 %
Other							
YARD-ACRES	613.0	615.0	558.0	479.0	361.0	525.2	1.46 %
YARD-LOTS	361.0	317.0	313.0	281.0	243.0	303.0	0.84 %
PALM-TREES	48.0	73.0	231.0	170.0	134.0	131.2	0.36 %
OTHER TREES	106.0	99.0	77.0	91.0	71.0	88.8	0.25 %
LAKE	71.0	75.0	121.0	86.0	82.0	87.0	0.24 %
GOLF COURSE	6.0	2.0	3.0	10.0	-	4.2	0.01 %
						1,139.4	3.17 %
Total	41,018.0	36,626.0	37,167.0	34,433.0	30,614.0	35,971.6	100.00 %

Source: As per district records (Hinojosa).

Table 2. Historic Water Use (acre-feet) for HCID No. 2, 1999-2003.

	Calendar Year (values in annual ac-ft)					
Use	1999	2000	2001	2002	2003	5 year average
DMI	21,094	22,832	20,035	21,159	19,407	20,905
Ag Irrigation	53,107	47,736	47,896	51,836	43,780	48,871
Conveyance Loss	8,108	10,203	12,764	14,837	14,288	12,040
Total	82,310	80,772	80,696	87,860	77,476	81,823

Source: Hinojosa, via email data received August 19, 2004.

Table 3. Selected Summary Information for HCID No. 2 and the Alamo Main Rehabilitation Project, 2005.

Item	Description / Data
Certificates of Adjudication (Type Use \\ ac-ft):	0808-000 (Domestic/Municipal/Industrial, \\ 12,732.0 ac-ft); 0808-001 (Municipal (McAllen) \\ 6,140 ac-ft); 0808-002 (Municipal (Pharr) \\ 2,946 ac-ft); 0808-003 (Municipal (San Juan) \\ 2,030 ac-ft); 0808-004 (Municipal (Alamo) \\ 1,202.5 ac-ft); 0808-500 (Irrigation \\ 137,675 ac-ft); 0808-008 (Mining \\ 100 ac-ft).
Municipalities Served (Total Delivery in ac-ft):	City of Pharr (8,302.442 ac-ft); City of McAllen (7,640 ac-ft); North Alamo Water Supply Corp (3,399.8 ac-ft); City of San Juan (2,706.737 ac-ft); City of Alamo (1,650.234 ac-ft); City of Edinburg (1,556.652 ac-ft).
District Water Rates:	Flat Rate - ($8.25 per acre) Irrigation - ($7.50 per acre) Lawn Water - ($11.50 per year) Municipal - ($0.085 per 1,000 gal)
Average Lift at Rio Grande:	33 ’
Project Name:	Rehabilitation of Alamo Main canal
Proposed Work:	Reline 5.34 miles of concrete-lined canal and install a flow management system, consisting of Flow Control, Gate Automation, and Telemetry.

Source: Hinojosa, Michalewicz, and draft of "Project Report - Rehabilitation of Alamo Main Canal, Hidalgo County Irrigation District #2, June 2004," as received via email, August 10, 2004 from Michalewicz.

Table 4. Summary of Annual Water and Energy Savings Data for Rehabilitating the Alamo Main, HCID No. 2, 2005. [a]

Component / Water Savings Category	Amount of Annual Water Savings, by Type			Total Water Savings (ac-ft)	Associated Annual Energy Savings		
	Reduced Seepage (ac-ft)	Reduced Gate Leak (ac-ft)	Reduced Spillage (ac-ft)		BTU	kwh	$
Agricultural Irrigation Use:							
Component #1 - reline Alamo Main							
Off-farm (reduced seepage)	638.0	-	-	638.0	136,078,904	39,882	$2,711
Off-farm (reduced gate leaks)	-	6.0	-	6.0	1,279,739	375	25
Off-farm (relift pumping)	-	-	-	-	106,270,191	31,146	2,125
sub-total	638.0	6.0	0.0	644.0	243,628,834	71,404	$4,861
Component #2 - flow management system							
Off-farm (reduced spillage)	-	-	280.0	280.0	59,721,149	17,503	$1,190
Off-farm (relift pumping)	-	-	-	-	46,204,431	13,542	924
sub-total	-	-	280.0	280.0	105,925,580	31,045	$2,114
Municipal and Industrial Use:							
Off-farm	-	-	-	-	-	-	-
On-farm	-	-	-	-	-	-	-
sub-total	-	-	-	-	-	-	-
Total	638.0	6.0	280.0	924.0	349,554,414	102,449	$6,975

Source: Hinojosa, Michalewicz, and draft of "Project Report - Rehabilitation of Alamo Main Canal, Hidalgo County Irrigation District #2, June 2004," as received via email, August 10, 2004 from Michalewicz.

[a] All values are basis calendar year 2005. This project is anticipated to be proposed to the USBR if/when authorized by federal legislation.

Table 5. Summary of Project Cost and Expense Data for Rehabilitation of Alamo Main Canal, HCID No. 2, 2005. [a]

Item	Component #1 (Reline Alamo Main) [b]			Component #2 (Flow-Management System) [c]			Aggregate
		Expenses / Revenues			Expenses / Revenues		
	years	total $	$/mile	years	total $	$/mile	total $
Installation Period	1			1			
Productive Period	49			20			
Planning Period	50			21			
Initial Capital Investment Costs		$ 2,500,000	$ 468,165		$ 570,000	n/a	$ 3,070,000
Annual Increases in O&M Expenses		n/a	n/a		$ 18,000	n/a	$ 18,000
Annual Decreases in O&M Expenses		n/a	n/a		$ 40,294	n/a	$ 40,294
Net Changes in Annual O&M Expenses		$ 0	$ 0		($ 22,294)	n/a	($ 22,294)
Value of Economic Benefit – Reclaimed Property (revenue)		$ 0			$ 0		$ 0

Source: Hinojosa, Michalewicz email of March 15, 2005, and draft of "Project Report - Rehabilitation of Alamo Main Canal, Hidalgo County Irrigation District #2, June 2004," as received via email, August 10, 2004 from Michalewicz.

[a] All costs, expenses, and revenues are based on 2005 dollars. This project is anticipated to be proposed to the USBR if/when authorized by federal legislation.

[b] Component #1 is primarily relining 5.34 miles of Alamo Main canal with a geomembrane lining and a shotcrete cover.

[c] Component #2 is installing a flow-management system (i.e., flow meters, automated gates, and telemetry) in the Alamo Main canal.

Table 6. Details of Cost Estimates for the Alamo Main Canal Rehabilitation Project, HCID No. 2, 2005.[a]

Item	- - Component #1 - - Reline Alamo Main	- - Component #2 - - Flow Management System	Aggregate
Cost to purchase, mobilize, and install	$1,816,706	$372,500	$2,189,206
Unlisted items	195,894	77,500	273,394
Contingencies	220,000	92,000	312,000
Construction management	130,000	28,000	158,000
District in-kind contribution	137,400	0	137,400
Total	$2,500,000	$570,000	$3,070,000

Source: Michalewicz email of March 15, 2005, and draft of "Project Report - Rehabilitation of Alamo Main Canal, Hidalgo County Irrigation District #2, June 2004," as received via email, August 10, 2004 from Michalewicz.

[a] All values are based on 2005 dollars. Based on discussions with USBR management (April 9, 2002; Austin, TX), expenses associated with design, engineering, and other preliminary development of similar and previously-authorized project's (i.e., P. L. 106-576 and 107-351) are ignored. To maintain consistency for projects authorized at different time periods, preliminary development costs for this analysis are also ignored.

Table 7. Summary of Water Diversions, and Energy Use and Expenses (1999-2003) for HCID No. 2s Rio Grande Diversion Pumping Plant.

Item	Calendar Year 1999	2000	2001	2002	2003	5-year Average
Electricity - Diverted:						
- kwh used	5,844,000	5,364,000	4,850,400	5,001,600	4,514,400	5,114,880
- Btu equivalent	19,939,728,000	18,301,968,000	16,549,564,800	17,065,459,200	15,403,132,800	17,451,970,560
- total electric expense	$325,833	$336,095	$380,463	$367,858	$328,052	$347,660
Natural Gas - Diverted:						
- kwh used	0	0	0	0	0	0
- Btu equivalent	0	0	0	0	0	0
- total natural gas expense	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total Energy - Diverted:						
- kwh used	5,844,000	5,364,000	4,850,400	5,001,600	4,514,400	5,114,880
- Btu equivalent	19,939,728,000	18,301,968,000	16,549,564,800	17,065,459,200	15,403,132,800	17,451,970,560
- total energy expense	$325,833	$336,095	$380,463	$367,858	$328,052	$347,660
Water - Diverted:						
- CFS pumped	41,495	40,720	40,681	44,293	39,058	41,250
- ac-ft equivalent	82,310	80,772	80,696	87,860	77,476	**81,823**
Calculations (diverted water):						
- kwh / ac-ft	71.00	66.41	60.11	56.93	58.27	62.51
- Btu / ac-ft	242,253	226,588	205,086	194,234	198,812	**213,290**
- avg. cost per kwh ($/kwh)	$0.056	$0.063	$0.078	$0.074	$0.073	$0.068
- avg. cost per Btu ($/Btu)	$0.0000163	$0.0000184	$0.0000230	$0.0000216	$0.0000213	$0.0000199
- avg. energy cost of water pumped ($/ac-ft)	$3.96	$4.16	$4.71	$4.19	$4.23	**$4.25**

Source: Per district records (Hinojosa).

Table 8. Summary of Water Relifting, and Energy Use and Expenses (1999-2003) for HCID No. 2s Relift Pumping Plant.

Item	Calendar Year 1999	2000	2001	2002	2003	5-year Average
Electricity - Relifted:						
- kwh used	2,664,000	2,581,200	2,532,000	2,719,691	2,118,360	2,523,050
- Btu equivalent	9,089,568,000	8,807,054,400	8,639,184,000	9,279,585,692	7,227,844,320	8,608,647,282
- total electric expense	$148,919	$160,004	$196,371	$190,434	$164,972	$172,140
Water - Relifted:						
- CFS pumped	26,706	26,961	26,707	28,628	22,497	26,300
- ac-ft equivalent	52,974	53,480	52,977	56,786	44,626	**52,169**
Calculations (relifted water):						
- kwh / ac-ft	50.29	48.26	47.79	47.89	47.47	48.36
- Btu / ac-ft	171,586	164,680	163,075	163,412	161,965	**165,016**
- avg. cost per kwh ($/kwh)	$0.056	$0.062	$0.078	$0.070	$0.078	$0.068
- avg. cost per Btu ($/Btu)	$0.0000164	$0.0000182	$0.0000227	$0.0000205	$0.0000228	$0.0000200
- avg. energy cost of water pumped ($/ac-ft)	$2.81	$2.99	$3.71	$3.35	$3.70	**$3.30**

Source: Per district records (Hinojosa).

Table 9. Economic and Financial Evaluation Results Across Component #1's Useful Life, HCID No. 2 – Relining 5.34 Miles of Alamo Main Canal, 2005.

Results	Nominal	Real [a]
Water Savings (ac-ft)		
Agriculture Irrigation	31,556	13,215
M&I	0	0
Total ac-ft	31,556	13,215
annuity equivalent		615
Energy Savings (BTU)		
Agriculture Irrigation	11,937,812,868	4,999,421,096
M&I	0	0
Total BTU	11,937,812,868	4,999,421,096
annuity equivalent		232,724,054
Energy Savings (kwh)		
Agriculture Irrigation	3,498,773	1,465,247
M&I	0	0
Total kwh's	3,498,773	1,465,247
annuity equivalent		68,208
NPV of Initial Capital Investment Costs and Changes in O&M Expenditures, Including Energy Cost Savings	$2,080,272	$2,400,243
annuity equivalent		$154,945
Cost of Water Savings ($/ac-ft)		$251.87
NPV of Initial Capital Investment Costs and Changes in O&M Expenditures, Ignoring Both Energy Cost Savings and Value of Water Savings	$2,500,000	$2,500,000
annuity equivalent		$161,385
Cost of Energy Savings ($/BTU)		$0.0006935
Cost of Energy Savings ($/kwh)		$2.366

[a] **Determined using a 4% discount factor.**

Table 10. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings Obtained by Relining 5.34 Miles of Alamo Main Canal and Expected Useful Life of the Capital Investment, HCID No. 2, 2005.

		annual ac-ft of water loss (seepage) prevented by lining 5.34 miles of Alamo Main canal									
		325	375	450	500	575	**638**	700	775	825	900
Expected Useful life of Investment (years)	10	$1,070.12	$924.48	$766.70	$687.81	$595.20	$534.23	$484.95	$435.87	$408.11	$372.25
	20	$688.50	$594.79	$493.28	$442.52	$382.94	$343.72	$312.01	$280.43	$262.57	$239.50
	25	$618.37	$534.21	$443.04	$397.45	$343.93	$308.71	$280.23	$251.87	$235.82	$215.10
	30	$574.74	$496.52	$411.78	$369.41	$319.67	$286.92	$260.45	$234.09	$219.18	$199.93
	40	$526.38	$454.74	$377.13	$338.33	$292.77	$262.78	$238.54	$214.40	$200.74	$183.10
	49	$504.53	$435.86	$361.47	$324.28	$280.62	**$251.87**	$228.64	$205.50	$192.41	$175.50

Table 11. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings Obtained by Relining 5.34 Miles of Alamo Main Canal and Initial Cost of the Capital Investment, HCID No. 2, 2005.

		annual ac-ft of water loss (seepage) prevented by lining 5.34 miles of Alamo Main canal									
		325	375	450	500	575	**638**	700	775	825	900
Initial Capital Investment Cost ($)	$(500,000)	$401.53	$346.59	$287.08	$257.33	$222.40	$199.40	$180.82	$162.30	$151.83	$138.31
	$(250,000)	$453.03	$391.23	$324.28	$290.80	$251.51	$225.64	$204.73	$183.90	$172.12	$156.90
	$(100,000)	$483.93	$418.01	$346.59	$310.89	$268.97	$241.38	$219.07	$196.86	$184.29	$168.06
	$ -	$504.53	$435.86	$361.47	$324.28	$280.62	**$251.87**	$228.64	$205.50	$192.41	$175.50
	$100,000	$525.13	$453.71	$376.35	$337.67	$292.26	$262.37	$238.20	$214.14	$200.52	$182.94
	$250,000	$556.02	$480.49	$398.67	$357.75	$309.72	$278.11	$252.55	$227.09	$212.70	$194.10
	$500,000	$607.52	$525.13	$435.86	$391.23	$338.83	$304.34	$276.46	$248.69	$232.98	$212.70

Table 12. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings Obtained by Relining 5.34 Miles of Alamo Main Canal and Value of Energy Savings, HCID No. 2, 2005.

	annual ac-ft of water loss (seepage) prevented by lining 5.34 miles of Alamo Main canal										
		325	375	450	500	575	**638**	700	775	825	900
Value of Energy Savings ($/kwh)	$0.0350	$509.60	$440.94	$366.55	$329.36	$285.69	$256.95	$233.71	$210.57	$197.49	$180.58
	$0.0475	$507.68	$439.01	$364.62	$327.43	$283.77	$255.02	$231.79	$208.65	$195.56	$178.65
	$0.0600	$505.75	$437.09	$362.70	$325.51	$281.84	$253.10	$229.86	$206.72	$193.64	$176.73
	$0.0680	$504.53	$435.86	$361.47	$324.28	$280.62	**$251.87**	$228.64	$205.50	$192.41	$175.50
	$0.0750	$503.44	$434.78	$360.39	$323.20	$279.53	$250.79	$227.55	$204.41	$191.33	$174.42
	$0.0900	$501.13	$432.47	$358.08	$320.88	$277.22	$248.48	$225.24	$202.10	$189.02	$172.11
	$0.1025	$499.21	$430.54	$356.15	$318.96	$275.30	$246.55	$223.32	$200.18	$187.09	$170.18

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, HCID No. 2, Relining Alamo Main Canal, 2005.

		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									
		170,632	191,961	202,625	207,958	**213,290**	218,622	223,954	234,619	266,612	319,935
Expected Useful life of Investment (years)	10	$0.0018386	$0.0016343	$0.0015483	$0.0015086	$0.0014709	$0.0014350	$0.0014008	$0.0013371	$0.0011767	$0.0009806
	20	$0.0011829	$0.0010515	$0.0009961	$0.0009706	$0.0009463	$0.0009232	$0.0009013	$0.0008603	$0.0007571	$0.0006309
	25	$0.0010624	$0.0009444	$0.0008947	$0.0008717	$0.0008499	$0.0008292	$0.0008095	$0.0007727	$0.0006799	$0.0005666
	30	$0.0009875	$0.0008777	$0.0008315	$0.0008102	$0.0007900	$0.0007707	$0.0007523	$0.0007182	$0.0006320	$0.0005266
	40	$0.0009044	$0.0008039	$0.0007616	$0.0007421	$0.0007235	$0.0007059	$0.0006890	$0.0006577	$0.0005788	$0.0004823
	49	$0.0008668	$0.0007705	$0.0007300	$0.0007112	**$0.0006935**	$0.0006765	$0.0006604	$0.0006304	$0.0005548	$0.0004623

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, HCID No. 2, Relining Alamo Main Canal, 2005.

		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									
		170,632	191,961	202,625	207,958	**213,290**	218,622	223,954	234,619	266,612	319,935
Expected Useful life of Investment (years)	10	$6.273	$5.576	$5.283	$5.147	$5.019	$4.896	$4.780	$4.562	$4.015	$3.346
	20	$4.036	$3.588	$3.399	$3.312	$3.229	$3.150	$3.075	$2.935	$2.583	$2.153
	25	$3.625	$3.222	$3.053	$2.974	$2.900	$2.829	$2.762	$2.636	$2.320	$1.933
	30	$3.369	$2.995	$2.837	$2.764	$2.695	$2.630	$2.567	$2.450	$2.156	$1.797
	40	$3.086	$2.743	$2.599	$2.532	$2.469	$2.408	$2.351	$2.244	$1.975	$1.646
	49	$2.958	$2.629	$2.491	$2.427	**$2.366**	$2.308	$2.253	$2.151	$1.893	$1.577

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, HCID No. 2, Relining Alamo Main Canal, 2005.

		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									
		170,632	191,961	202,625	207,958	**213,290**	218,622	223,954	234,619	266,612	319,935
Initial Capital Investment Cost ($)	$(500,000)	$0.0006935	$0.0006164	$0.0005840	$0.0005690	$0.0005548	$0.0005412	$0.0005284	$0.0005043	$0.0004438	$0.0003698
	$(250,000)	$0.0007801	$0.0006935	$0.0006570	$0.0006401	$0.0006241	$0.0006089	$0.0005944	$0.0005674	$0.0004993	$0.0004161
	$(100,000)	$0.0008322	$0.0007397	$0.0007008	$0.0006828	$0.0006657	$0.0006495	$0.0006340	$0.0006052	$0.0005326	$0.0004438
	$ -	$0.0008668	$0.0007705	$0.0007300	$0.0007112	**$0.0006935**	$0.0006765	$0.0006604	$0.0006304	$0.0005548	$0.0004623
	$100,000	$0.0009015	$0.0008013	$0.0007592	$0.0007397	$0.0007212	$0.0007036	$0.0006869	$0.0006556	$0.0005770	$0.0004808
	$250,000	$0.0009535	$0.0008476	$0.0008030	$0.0007824	$0.0007628	$0.0007442	$0.0007265	$0.0006935	$0.0006102	$0.0005085
	$500,000	$0.0010402	$0.0009246	$0.0008760	$0.0008535	$0.0008322	$0.0008119	$0.0007925	$0.0007565	$0.0006657	$0.0005548

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, HCID No. 2, Relining Alamo Main Canal, 2005.

		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									
		170,632	191,961	202,625	207,958	**213,290**	218,622	223,954	234,619	266,612	319,935
Initial Capital Investment Cost ($)	$(500,000)	$2.366	$2.103	$1.992	$1.941	$1.893	$1.847	$1.803	$1.721	$1.514	$1.262
	$(250,000)	$2.662	$2.366	$2.242	$2.184	$2.129	$2.078	$2.028	$1.936	$1.704	$1.420
	$(100,000)	$2.839	$2.524	$2.391	$2.330	$2.271	$2.216	$2.163	$2.065	$1.817	$1.514
	$ -	$2.958	$2.629	$2.491	$2.427	**$2.366**	$2.308	$2.253	$2.151	$1.893	$1.577
	$100,000	$3.076	$2.734	$2.590	$2.524	$2.461	$2.401	$2.344	$2.237	$1.969	$1.640
	$250,000	$3.253	$2.892	$2.740	$2.669	$2.603	$2.539	$2.479	$2.366	$2.082	$1.735
	$500,000	$3.549	$3.155	$2.989	$2.912	$2.839	$2.770	$2.704	$2.581	$2.271	$1.893

Table 17. Costs per BTU of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Reduced Water Losses By Relining 5.34 Miles of the Alamo Main Canal, HCID No. 2, 2005.

		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									
		170,632	191,961	202,625	207,958	**213,290**	218,622	223,954	234,619	266,612	319,935
annual ac-ft of water loss prevented by lining 5.34 miles of Alamo Main	325	$0.0017016	$0.0015126	$0.0014330	$0.0013962	$0.0013613	$0.0013281	$0.0012965	$0.0012376	$0.0010891	$0.0009075
	375	$0.0014748	$0.0013109	$0.0012419	$0.0012101	$0.0011798	$0.0011510	$0.0011236	$0.0010726	$0.0009438	$0.0007865
	450	$0.0012290	$0.0010924	$0.0010349	$0.0010084	$0.0009832	$0.0009592	$0.0009364	$0.0008938	$0.0007865	$0.0006554
	500	$0.0011061	$0.0009832	$0.0009314	$0.0009075	$0.0008849	$0.0008633	$0.0008427	$0.0008044	$0.0007079	$0.0005899
	575	$0.0009618	$0.0008549	$0.0008099	$0.0007892	$0.0007694	$0.0007507	$0.0007328	$0.0006995	$0.0006156	$0.0005130
	638	$0.0008668	$0.0007705	$0.0007300	$0.0007112	**$0.0006935**	$0.0006765	$0.0006604	$0.0006304	$0.0005548	$0.0004623
	700	$0.0007900	$0.0007023	$0.0006653	$0.0006482	$0.0006320	$0.0006166	$0.0006019	$0.0005746	$0.0005056	$0.0004214
	775	$0.0007136	$0.0006343	$0.0006009	$0.0005855	$0.0005709	$0.0005570	$0.0005437	$0.0005190	$0.0004567	$0.0003806
	825	$0.0006703	$0.0005959	$0.0005645	$0.0005500	$0.0005363	$0.0005232	$0.0005107	$0.0004875	$0.0004290	$0.0003575
	900	$0.0006145	$0.0005462	$0.0005175	$0.0005042	$0.0004916	$0.0004796	$0.0004682	$0.0004469	$0.0003933	$0.0003277

Table 18. Costs per kwh of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Reduced Water Losses By Relining 5.34 Miles of the Alamo Main Canal, HCID No. 2, 2005.

		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									
		170,632	191,961	202,625	207,958	**213,290**	218,622	223,954	234,619	266,612	319,935
annual ac-ft of water loss prevented by lining 5.34 miles of Alamo Main	325	$5.806	$5.161	$4.889	$4.764	$4.645	$4.532	$4.424	$4.223	$3.716	$3.097
	375	$5.032	$4.473	$4.237	$4.129	$4.026	$3.927	$3.834	$3.660	$3.220	$2.684
	450	$4.193	$3.727	$3.531	$3.441	$3.355	$3.273	$3.195	$3.050	$2.684	$2.236
	500	$3.774	$3.355	$3.178	$3.097	$3.019	$2.945	$2.875	$2.745	$2.415	$2.013
	575	$3.282	$2.917	$2.764	$2.693	$2.625	$2.561	$2.500	$2.387	$2.100	$1.750
	638	$2.958	$2.629	$2.491	$2.427	**$2.366**	$2.308	$2.253	$2.151	$1.893	$1.577
	700	$2.696	$2.396	$2.270	$2.212	$2.157	$2.104	$2.054	$1.960	$1.725	$1.438
	775	$2.435	$2.164	$2.050	$1.998	$1.948	$1.900	$1.855	$1.771	$1.558	$1.299
	825	$2.287	$2.033	$1.926	$1.877	$1.830	$1.785	$1.743	$1.663	$1.464	$1.220
	900	$2.097	$1.864	$1.766	$1.720	$1.677	$1.636	$1.597	$1.525	$1.342	$1.118

Table 19. Economic and Financial Evaluation Results Across Component #2's Useful Life, HCID No. 2 – Installing a Flow-Management System, 2005.

Results	Nominal	Real [a]
Water Savings (ac-ft)		
Agriculture Irrigation	5,600	3,659
M&I	0	0
Total ac-ft	5,600	3,659
annuity equivalent		261
Energy Savings (BTU)		
Agriculture Irrigation	2,118,511,600	1,384,195,385
M&I	0	0
Total BTU	2,118,511,600	1,384,195,385
annuity equivalent		98,665,593
Energy Savings (kwh)		
Agriculture Irrigation	620,900	405,684
M&I	0	0
Total kwh's	620,900	405,684
annuity equivalent		28,917
NPV of Initial Capital Investment Costs and Changes in O&M Expenditures, Including Energy Cost Savings	($50,189)	$251,052
annuity equivalent		$21,565
Cost of Water Savings ($/ac-ft)		$82.69
NPV of Initial Capital Investment Costs and Changes in O&M Expenditures, Ignoring Both Energy Cost Savings and Value of Water Savings	$3,517	$278,671
annuity equivalent		$23,938
Cost of Energy Savings ($/BTU)		$0.0002426
Cost of Energy Savings ($/kwh)		$0.828

[a] **Determined using a 4% discount factor.**

Table 20. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings Obtained by Installing a Flow-Management System and Expected Useful Life of the Capital Investment, HCID No. 2, 2005.

		annual ac-ft of water loss (spillage) prevented by installing a flow-management system									
		150	175	200	225	250	**280**	300	325	375	400
Expected Useful life of Investment (years)	5	$439.83	$373.47	$323.71	$285.00	$254.03	$224.17	$207.58	$189.72	$161.13	$149.52
	10	$252.15	$214.11	$185.58	$163.39	$145.64	$128.52	$119.01	$108.77	$92.38	$85.72
	12	$221.50	$188.08	$163.02	$143.53	$127.93	$112.89	$104.54	$95.54	$81.15	$75.30
	15	$191.36	$162.49	$140.84	$124.00	$110.52	$97.53	$90.32	$82.54	$70.11	$65.05
	18	$171.78	$145.86	$126.43	$111.31	$99.21	$87.55	$81.07	$74.10	$62.93	$58.40
	20	$162.23	$137.76	$119.40	$105.12	$93.70	**$82.69**	$76.57	$69.98	$59.43	$55.15

Table 21. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings Obtained by Installing a Flow-Management System and Initial Cost of the Capital Investment, HCID No. 2, 2005.

		annual ac-ft of water loss (spillage) prevented by installing a flow-management system									
		150	175	200	225	250	**280**	300	325	375	400
Initial Capital Investment Cost ($)	$(100,000)	$100.75	$85.06	$73.29	$64.14	$56.81	$49.75	$45.83	$41.60	$34.84	$32.10
	$(75,000)	$116.12	$98.23	$84.82	$74.38	$66.03	$57.98	$53.51	$48.70	$40.99	$37.86
	$(50,000)	$131.49	$111.41	$96.34	$84.63	$75.26	$66.22	$61.20	$55.79	$47.14	$43.62
	$ -	$162.23	$137.76	$119.40	$105.12	$93.70	**$82.69**	$76.57	$69.98	$59.43	$55.15
	$50,000	$192.97	$164.11	$142.46	$125.62	$112.14	$99.15	$91.94	$84.17	$71.73	$66.68
	$75,000	$208.34	$177.28	$153.98	$135.86	$121.37	$107.39	$99.62	$91.26	$77.88	$72.44
	$100,000	$223.71	$190.45	$165.51	$146.11	$130.59	$115.62	$107.31	$98.35	$84.03	$78.21

Table 22. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings Obtained by Installing a Flow-Management System and Value of Energy Savings, HCID No. 2, 2005.

	annual ac-ft of water loss (spillage) prevented by installing a flow-management system										
		150	175	200	225	250	**280**	300	325	375	400
Value of Energy Savings ($/kwh)	$0.0350	$166.64	$142.17	$123.81	$109.54	$98.11	$87.10	$80.98	$74.39	$63.85	$59.56
	$0.0475	$164.97	$140.50	$122.14	$107.86	$96.44	$85.43	$79.31	$72.72	$62.17	$57.89
	$0.0600	$163.30	$138.82	$120.47	$106.19	$94.77	$83.75	$77.63	$71.04	$60.50	$56.22
	$0.0680	$162.23	$137.76	$119.40	$105.12	$93.70	**$82.69**	$76.57	$69.98	$59.43	$55.15
	$0.0750	$161.29	$136.82	$118.46	$104.18	$92.76	$81.75	$75.63	$69.04	$58.49	$54.21
	$0.0900	$159.28	$134.81	$116.45	$102.17	$90.75	$79.74	$73.62	$67.03	$56.49	$52.20
	$0.1025	$157.61	$133.14	$114.78	$100.50	$89.08	$78.07	$71.95	$65.36	$54.81	$50.53

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, Installing a Flow-Management System, HCID No. 2, 2005.

		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									
		170,632	191,961	202,625	207,958	**213,290**	218,622	223,954	234,619	266,612	319,935
Expected Useful life of Investment (years)	5	$0.0008222	$0.0007308	$0.0006924	$0.0006746	$0.0006578	$0.0006417	$0.0006264	$0.0005980	$0.0005262	$0.0004385
	10	$0.0004714	$0.0004190	$0.0003969	$0.0003868	$0.0003771	$0.0003679	$0.0003591	$0.0003428	$0.0003017	$0.0002514
	12	$0.0004141	$0.0003681	$0.0003487	$0.0003397	$0.0003312	$0.0003232	$0.0003155	$0.0003011	$0.0002650	$0.0002208
	15	$0.0003577	$0.0003180	$0.0003012	$0.0002935	$0.0002862	$0.0002792	$0.0002726	$0.0002602	$0.0002289	$0.0001908
	18	$0.0003211	$0.0002854	$0.0002704	$0.0002635	$0.0002569	$0.0002506	$0.0002447	$0.0002335	$0.0002055	$0.0001713
	20	$0.0003033	$0.0002696	$0.0002554	$0.0002488	**$0.0002426**	$0.0002367	$0.0002311	$0.0002206	$0.0001941	$0.0001617

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, Installing a Flow-Management System, HCID No. 2, 2005.

		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									
		170,632	191,961	202,625	207,958	**213,290**	218,622	223,954	234,619	266,612	319,935
Expected Useful life of Investment (years)	5	$2.805	$2.494	$2.362	$2.302	$2.244	$2.190	$2.137	$2.040	$1.795	$1.496
	10	$1.608	$1.430	$1.354	$1.320	$1.287	$1.255	$1.225	$1.170	$1.029	$0.858
	12	$1.413	$1.256	$1.190	$1.159	$1.130	$1.103	$1.076	$1.027	$0.904	$0.753
	15	$1.221	$1.085	$1.028	$1.001	$0.976	$0.953	$0.930	$0.888	$0.781	$0.651
	18	$1.096	$0.974	$0.923	$0.899	$0.877	$0.855	$0.835	$0.797	$0.701	$0.584
	20	$1.035	$0.920	$0.871	$0.849	**$0.828**	$0.808	$0.788	$0.753	$0.662	$0.552

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, Installing a Flow-Management System, HCID No. 2, 2005.

		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									
		170,632	191,961	202,625	207,958	**213,290**	218,622	223,954	234,619	266,612	319,935
Initial Capital Investment Cost ($)	$(100,000)	$0.0001944	$0.0001728	$0.0001637	$0.0001595	$0.0001556	$0.0001518	$0.0001481	$0.0001414	$0.0001244	$0.0001037
	$(75,000)	$0.0002217	$0.0001970	$0.0001867	$0.0001819	$0.0001773	$0.0001730	$0.0001689	$0.0001612	$0.0001419	$0.0001182
	$(50,000)	$0.0002489	$0.0002212	$0.0002096	$0.0002042	$0.0001991	$0.0001942	$0.0001896	$0.0001810	$0.0001593	$0.0001327
	$ -	$0.0003033	$0.0002696	$0.0002554	$0.0002488	**$0.0002426**	$0.0002367	$0.0002311	$0.0002206	$0.0001941	$0.0001617
	$50,000	$0.0003577	$0.0003179	$0.0003012	$0.0002935	$0.0002861	$0.0002792	$0.0002725	$0.0002601	$0.0002289	$0.0001908
	$75,000	$0.0003849	$0.0003421	$0.0003241	$0.0003158	$0.0003079	$0.0003004	$0.0002933	$0.0002799	$0.0002463	$0.0002053
	$100,000	$0.0004121	$0.0003663	$0.0003470	$0.0003381	$0.0003297	$0.0003216	$0.0003140	$0.0002997	$0.0002637	$0.0002198

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, Installing a Flow-Management System, HCID No. 2, 2005.

		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									
		170,632	191,961	202,625	207,958	**213,290**	218,622	223,954	234,619	266,612	319,935
Initial Capital Investment Cost ($)	$(100,000)	$0.663	$0.590	$0.559	$0.544	$0.531	$0.518	$0.505	$0.483	$0.425	$0.354
	$(75,000)	$0.756	$0.672	$0.637	$0.621	$0.605	$0.590	$0.576	$0.550	$0.484	$0.403
	$(50,000)	$0.849	$0.755	$0.715	$0.697	$0.679	$0.663	$0.647	$0.618	$0.543	$0.453
	$ -	$1.035	$0.920	$0.871	$0.849	**$0.828**	$0.808	$0.788	$0.753	$0.662	$0.552
	$50,000	$1.220	$1.085	$1.028	$1.001	$0.976	$0.953	$0.930	$0.888	$0.781	$0.651
	$75,000	$1.313	$1.167	$1.106	$1.078	$1.051	$1.025	$1.001	$0.955	$0.840	$0.700
	$100,000	$1.406	$1.250	$1.184	$1.154	$1.125	$1.097	$1.071	$1.023	$0.900	$0.750

Table 27. Costs per BTU of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Reduced Water Losses By Installing a Flow-Management System, HCID No. 2, 2005.

		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									
		170,632	191,961	202,625	207,958	**213,290**	218,622	223,954	234,619	266,612	319,935
annual ac-ft of water loss prevented by lining 5.34 miles of Alamo Main	150	$0.0005661	$0.0005032	$0.0004767	$0.0004645	$0.0004529	$0.0004418	$0.0004313	$0.0004117	$0.0003623	$0.0003019
	175	$0.0004852	$0.0004313	$0.0004086	$0.0003981	$0.0003882	$0.0003787	$0.0003697	$0.0003529	$0.0003106	$0.0002588
	200	$0.0004246	$0.0003774	$0.0003575	$0.0003484	$0.0003397	$0.0003314	$0.0003235	$0.0003088	$0.0002717	$0.0002264
	225	$0.0003774	$0.0003355	$0.0003178	$0.0003097	$0.0003019	$0.0002946	$0.0002875	$0.0002745	$0.0002415	$0.0002013
	250	$0.0003397	$0.0003019	$0.0002860	$0.0002787	$0.0002717	$0.0002651	$0.0002588	$0.0002470	$0.0002174	$0.0001812
	280	$0.0003033	$0.0002696	$0.0002554	$0.0002488	**$0.0002426**	$0.0002367	$0.0002311	$0.0002206	$0.0001941	$0.0001617
	300	$0.0002831	$0.0002516	$0.0002384	$0.0002322	$0.0002264	$0.0002209	$0.0002157	$0.0002059	$0.0001812	$0.0001510
	325	$0.0002613	$0.0002322	$0.0002200	$0.0002144	$0.0002090	$0.0002039	$0.0001991	$0.0001900	$0.0001672	$0.0001393
	375	$0.0002264	$0.0002013	$0.0001907	$0.0001858	$0.0001812	$0.0001767	$0.0001725	$0.0001647	$0.0001449	$0.0001208
	400	$0.0002123	$0.0001887	$0.0001788	$0.0001742	$0.0001698	$0.0001657	$0.0001617	$0.0001544	$0.0001359	$0.0001132

Table 28. Costs per kwh of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Reduced Water Losses By Installing a Flow-Management System, HCID No. 2, 2005.

		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									
		170,632	191,961	202,625	207,958	**213,290**	218,622	223,954	234,619	266,612	319,935
annual ac-ft of water loss prevented by lining 5.34 miles of Alamo Main	150	$1.932	$1.717	$1.627	$1.585	$1.545	$1.508	$1.472	$1.405	$1.236	$1.030
	175	$1.656	$1.472	$1.394	$1.358	$1.324	$1.292	$1.261	$1.204	$1.060	$0.883
	200	$1.449	$1.288	$1.220	$1.189	$1.159	$1.131	$1.104	$1.054	$0.927	$0.773
	225	$1.288	$1.145	$1.084	$1.057	$1.030	$1.005	$0.981	$0.937	$0.824	$0.687
	250	$1.159	$1.030	$0.976	$0.951	$0.927	$0.905	$0.883	$0.843	$0.742	$0.618
	280	$1.035	$0.920	$0.871	$0.849	**$0.828**	$0.808	$0.788	$0.753	$0.662	$0.552
	300	$0.966	$0.858	$0.813	$0.792	$0.773	$0.754	$0.736	$0.702	$0.618	$0.515
	325	$0.891	$0.792	$0.751	$0.731	$0.713	$0.696	$0.679	$0.648	$0.571	$0.475
	375	$0.773	$0.687	$0.651	$0.634	$0.618	$0.603	$0.589	$0.562	$0.494	$0.412
	400	$0.724	$0.644	$0.610	$0.594	$0.579	$0.565	$0.552	$0.527	$0.464	$0.386

Table 29. Summary of Economic and Financial Results for the Cost of Saving Water, by Project Component and Aggregated, HCID No. 2, 2005.

Economic / Conservation Measure	Project Component: #1 Reline Alamo Main Canal	Project Component: #2 Install Flow-Management System	Aggregate
NPV of Net Cost Stream ($) [a]	$ 2,400,243	$ 251,052	$ 2,651,294
- annuity equivalent ($/yr)	$ 154,945	$ 21,565	$ 176,511
NPV of All Water Savings (ac-ft)	13,215	3,659	16,874
- annuity equivalent (ac-ft/yr)	615	261	876
Costs of Saving Water ($/ac-ft) [b]	$ 251.872	$ 82.687	$ 201.500

[a] Includes both initial investment cost and changes in O&M expenditures, including energy cost savings.

[b] An annuity equivalent, assuming perpetuity, zero salvage values, and replacement with identical technology.

Table 30. Summary of Economic and Financial Results for the Cost of Saving Energy, by Project Component and Aggregated, HCID No. 2, 2005.

Economic / Conservation Measure	Project Component: #1 Reline Alamo Main Canal	Project Component: #2 Install Flow-Management System	Aggregate
NPV of Net Cost Stream ($) [a]	$ 2,500,000	$ 278,671	$ 2,778,671
- annuity equivalent ($/yr)	$ 161,385	$ 23,938	$ 185,323
NPV of All Energy Savings (BTU)	4,999,421,096	1,384,195,385	6,383,616,482
- annuity equivalent (BTU/yr)	232,724,054	98,665,593	331,389,647
- annuity equivalent (kwh/yr)	68,208	28,917	97,125
Cost of Saving Energy ($/BTU) [b]	$ 0.0006935	$ 0.0002426	$ 0.0005592
Cost of Saving Energy ($/kwh) [b]	$ 2.366	$ 0.828	$ 1.908

[a] Includes initial investment cost and net changes in O&M expenses, but ignores energy savings ($'s) and value of water.

[b] An annuity equivalent, assuming perpetuity, and replacement with identical technology.

Appendices

Appendix A: Results – Legislated Criteria, by Component

United States Public Law 106-576 legislation requires three economic measures be calculated and included as part of the information prepared for USBR evaluations of proposed projects (USBR 2001):

- 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 USBR 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 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 cost 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. 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. 2002 for more information regarding the issues associated with comparing capital investments having differences in length of planning periods.

Component #1: Relining Alamo Main Canal

Component #1 of the District's USBR project primarily consists of relining 5.34 miles of Alamo Main canal. Details on the cost estimates and related projections of associated water and energy savings are presented in the main body of this report (**Tables 4, 5, 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 Public Law 106-576 legislation, transformed according to Hamilton, are presented in **Table A2** (which are 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 $2,500,000. 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 31,556 ac-ft of nominal *off-farm* water savings are projected to occur during the productive life of the new lining, with associated energy savings of 11,937,812,868 BTU (3,498,773 kwh). Using the 4% discount rate, the present or real value of such anticipated savings become 13,215 ac-ft and 4,999,421,096 BTU (1,465,247 kwh) (**Table A1**).

The accrued annual net changes in O&M expenditures over the new lining's productive life are a total decrease of $419,728. Using the 2002 Federal discount rate of 6.125%, this anticipated net decrease in expenditures represents a real cost reduction of $99,757 (**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 $79.22 in a nominal sense and $189.17 in real terms, while the initial construction costs per BTU (kwh) of energy saved are $0.0002094 ($0.715) in a nominal sense and $0.0005001 ($1.706) 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 new lining result in anticipated net decreases in annual costs (**Table A2**). Dividing the initial construction costs by the decreases in operating costs results in a ratio measure of -5.96 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 lining. On a real basis, this ratio measure is -25.06 (**Table A2**), signifying construction costs are substantially higher than the expected real value of economic savings in O&M during the planning period.

Component #2: Installing a Flow-Management System

Component #2 of the District's USBR project consists of installing a flow-management system in the Alamo Main canal. Details on the cost estimates and related projections of associated water and energy savings are presented in the main body of this report (**Tables 4, 5, 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 component #2 amount to $570,000. 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 5,600 ac-ft of nominal *off-farm* water savings are projected to occur during the productive life of the new flow-management system, with associated energy savings of 2,118,511,600 BTU (620,900 kwh). Using the 4% discount rate, the present or real value of such anticipated savings become 3,659 ac-ft and 1,384,195,385 BTU (405,684 kwh) (**Table A3**).

The accrued annual net changes in O&M expenditures over the new system's productive life are a total decrease of $620,189. Using the 2002 Federal discount rate of 6.125%, this anticipated net decrease in expenditures represents a real cost reduction of $318,948 (**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 $101.79 in a nominal sense and $155.78 in real terms, while the initial construction costs per BTU (kwh) of energy saved are $0.0002691 ($0.918) in a nominal sense and $0.0004118 ($1.405) 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 new flow-management system 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 -0.92 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 system. On a real basis, this ratio measure is -1.787

(**Table A4**), 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 project anticipated to be proposed to the USBR. 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 component #2, the flow-management system is a more economical source of *water savings* than component #1, relining of Alamo Main canal (**Tables 29** and **A5**). The comprehensive costs of *energy savings* yielded the same rankings (**Tables 30** and **A5**), i.e., the flow-management system's energy savings are cheaper than those associated with relining the canal.

Here, in the legislated criteria results, the flow-management system also is the most economical in terms of dollars of initial construction costs per ac-ft of *water savings*, with the canal lining ranked second (**Tables A2**, **A4**, and **A5**). With respect to cost of *energy savings*, the flow-management system again is the most economical, out-performing the canal lining in terms of dollars of initial construction costs per BTU of energy saved (**Tables A2**, **A4**, and **A5**). 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 canal lining and the flow-management system components appear to be more 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 flow-management system appears to be the most economical as the canal relining requires more real initial construction cost per dollar of economic O&M savings (**Tables A2**, **A4**, and **A5**). 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.[21]

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 commentary addressing the likely 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.

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21 See the next sub-section entitled *Caveat to Interpretation of Legislated Criteria Results* for more discussion.

Caveat to Interpretation of Legislated Criteria Results

The proper interpretation of the third legislated ratio (i.e., dollars of initial construction cost divided by dollars of economic savings) for any component can be somewhat difficult and involves recognition that the most desired value is negative and close to zero (**Exhibit A1**). That is, a negative ratio signifies a net real reduction in future expenses (i.e., O&M and energy), while a positive ratio signifies a net real increase in future expenses. Also, whether the value of the ratio is *less than* or *greater than* negative 1 makes a difference. That is, if less than negative one (e.g., -3.45), it infers that construction costs are *greater than* the sum of real expected annual economic savings (which are on a "current dollar basis"). Likewise, if the value is greater than negative one and less than zero (e.g., -.74), it infers construction costs are *less than* the sum of real expected annual economic savings. Of course, if the value is positive (i.e., greater than zero), it infers that in addition to initial construction costs, the project component will incur net increases in real future operating and maintenance costs (i.e., not realize net real economic savings over the life of the project). Finally, a negative value close to zero indicates a relatively low required investment to achieve a dollar of savings in O&M expenses.

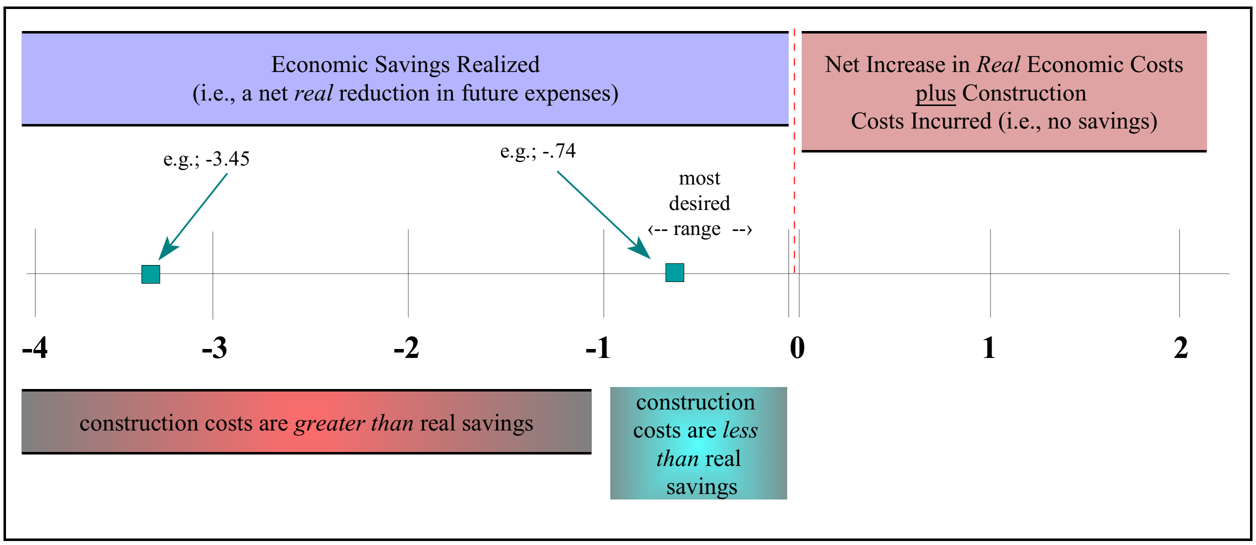

Exhibit A1. Graphical Interpretation of the Ratio "Dollars of Initial Construction Cost" Divided by "Dollars of Economic Savings" as Required by Federal Legislation.

Although an interpretation of the third legislative criteria is provided above, ranking and/or comparing this ratio measure across project components (either within or across irrigation districts' projects) solely by this ratio should be approached with caution due to criticisms of the ratio's very nature. That is, it is difficult to determine the rank order of components since either a low initial construction cost and/or a high increase in O&M expenses result in a low ratio of the calculated values. Similarly, a high construction cost requirement and/or a low increase in O&M expenditures result in a high ratio of the calculated values. The resulting paradox is apparent. Furthermore, the reader is reminded that the legislative criteria does not reflect differences in useful lives of the respective project components.

Appendix B: Results – Legislated Criteria, Aggregated Across Components

As noted in Rister et al. 2002, 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 2005 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 and a summed aggregate value for each measure. The project as a whole requires an initial capital construction investment of $3,070,000. In total, 16,874 ac-ft of real water savings are estimated. Real energy savings are anticipated to be 6,383,616,482 BTU (1,870,931 kwh). The net change in real total annual O&M expenditures is a decrease of $418,706.

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 $182.98 per ac-ft of water savings (**Table B2**). Note that this amount is much less than the comprehensive economic and financial value of **$201.50 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 $0.0004837 per BTU ($1.650 per kwh) (**Table B2**). These cost estimates are less than the **$0.0005592 per BTU ($1.908 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 -20.74, 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) $20.74 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, Relining Alamo Main Canal, HCID No. 2, 2005.

Item	Nominal PV	Real NPV
Dollars of Initial Construction Costs	$ 2,500,000	$ 2,500,000
Ac-Ft of Water Saved	31,556	13,215
BTU of Energy Saved	11,937,812,868	4,999,421,096
kwh of Energy Saved	3,498,773	1,465,247
$ of Annual Economic Savings [a]	($ 419,728)	($ 99,757)

a Positive (+) values indicate net added costs, while negative (-) values indicate net savings.

Table A2. Legislated Evaluation Criteria, Relining Alamo Main Canal, HCID No. 2, 2005.

Criteria	Nominal PV	Real NPV
Dollar of Initial Construction Costs per Ac-Ft of Water Saved	$ 79.22	$ 189.17
Dollar of Initial Construction Costs per BTU of Energy Saved	$ 0.0002094	$ 0.0005001
Dollar of Initial Construction Costs per kwh of Energy Saved	$ 0.715	$ 1.706
$ of Initial Construction Costs per $ of Annual Economic Savings [a]	-5.956	-25.061

a Negative values indicate expected net reductions in O&M expenditures over the planning horizon, while positive values indicate expected net increases in O&M expenditures over the planning horizon.

Table A3. Summary of Calculated Values, Installing a Flow-Management System, HCID No. 2, 2005.

Item	Nominal PV	Real NPV
Dollars of Initial Construction Costs	$ 570,000	$ 564,000
Ac-Ft of Water Saved	5,600	3,659
BTU of Energy Saved	2,118,511,600	1,384,195,385
kwh of Energy Saved	620,900	405,684
$ of Annual Economic Savings [a]	($ 620,189)	($ 318,948)

[a] Positive (+) values indicate net added costs, while negative (-) values indicate net savings.

Table A4. Legislated Evaluation Criteria, Installing a Flow-Management System, HCID No. 2, 2005.

Criteria	Nominal PV	Real NPV
Dollar of Initial Construction Costs per Ac-Ft of Water Saved	$ 101.79	$ 155.78
Dollar of Initial Construction Costs per BTU of Energy Saved	$ 0.0002691	$ 0.0004118
Dollar of Initial Construction Costs per kwh of Energy Saved	$ 0.918	$ 1.405
$ of Initial Construction Costs per $ of Annual Economic Savings [a]	-0.919	-1.787

[a] Negative values indicate expected net reductions in O&M expenditures over the planning horizon, while positive values indicate expected net increases in O&M expenditures over the planning horizon.

Table A5. Summary of Ranked Order of Project Components, by Comprehensive Economic Criteria and Individual Legislative Criteria, HCID No. 2, 2005.

	Ranking Measure / Ranked Order				
	Composite Economic Criteria		Individual Legislative Criteria		
Project Component	**Water Savings**	**Energy Savings**	**$ ICC per ac-ft[a] Water Saved**	**$ ICC per BTU Energy Saved**	**$ ICC per $ Annual Economic Savings**
#1 Reline Alamo Main Canal	2nd	2nd	2nd	2nd	2nd
#2 Install Flow-Management System	1st	1st	1st	1st	1st

[a] Note that the abbreviation ICC stands for 'Initial Construction Cost'; the abbreviation allows for a more user-friendly table heading.

Table B1. Summary of Calculated Values, by Project Component and Aggregated, HCID No. 2, 2005.

Economic / Conservation Measures	Project Component: Relining Alamo Main Canal	Project Component: Install Flow-Management System	Aggregate
Dollars of Initial Construction Costs ($)	$ 2,500,000	$ 570,000	$ 3,070,000
Ac-Ft of Water Saved (ac-ft)	13,215	3,659	16,874
BTU of Energy Saved (BTU)	4,999,421,096	1,384,195,385	6,383,616,482
kwh of Energy Saved (kwh)	1,465,247	405,684	1,870,931
$ of Annual Economic Savings [a]	($ 99,757)	($ 318,948)	($ 418,706)

[a] Positive (+) values indicate net added costs, while negative (-) values indicate net savings.

Table B2. Legislated Results Criteria, Real Values, by Project Component and Aggregated, HCID No. 2, 2005.

Economic Measures	Project Component: Reline Alamo Main Canal	Project Component: Install Flow-Management System	Aggregate
Dollar of Initial Construction Costs per Ac-Ft of Water Saved ($/ac-ft)	$ 189.17	$ 155.78	$ 182.98
Dollar of Initial Construction Costs per BTU of Energy Saved ($/BTU)	$ 0.0005001	$ 0.0004118	$ 0.0004837
Dollar of Initial Construction Costs per kwh of Energy Saved ($/kwh)	$ 1.706	$ 1.405	$ 1.650
Dollar of Initial Construction Costs per Dollar of Annual Economic Savings [a, b]	-25.061	-1.787	-20.740

[a] Negative values indicate expected net reductions in O&M expenditures over the planning horizon, while positive values indicate expected net increases in O&M expenditures over the planning horizon.

[b] Interpretation and discussion of these values are provided in the sub-section of Appendix A entitled: *Caveat to Interpretation of Legislated Criteria Results* on page 74.

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