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Economic and Conservation Evaluation of Capital Renovation Projects: Maverick County Water Control and Improvement District No. 1 (Eagle Pass) – Lining Main Canal – Preliminary

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Texas A&M University

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Authors' Note:

This preliminary report was developed to assist the Maverick County Water Control and Improvement District No. 1 (MCWCID #1) in their submitting of project materials to the Bureau of Reclamation (BOR), Border Environment Cooperation Commission, and the North American Development Bank. Distribution of this report will initially be limited to the MCWCID #1 and their consulting engineer, the BOR, and the Texas Water Development Board (TWDB). After the BOR and TWDB have reviewed MCWCID #1s Project Plan and provided comments, a final economic analysis and report will be prepared incorporating those review comments affecting the economic analysis. Initially, distribution of the final report will be kept to the same limited group of stakeholders. Only after the BOR has scored and finalized the next grouping of irrigation districts' proposed capital-rehabilitation projects will the final results for MCWCID #1s project be made available to other stakeholders and the public. This is anticipated to occur sometime in mid 2004.

M. Edward Rister
Ronald D. Lacewell
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Rio Grande Basin Initiative is administered by the Texas Water Resources Institute of the Texas A&M University System with funds provided through a federal initiative, "Rio Grande Basin Initiative," administered 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, development, evaluation, prioritization, financing, and fund appropriation are necessary, however, before these projects may be constructed. The Bureau of Reclamation 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 Bureau of Reclamation's evaluation of proposed projects:

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

South Texas irrigation districts have an extensive system of engineered networks – including 24 major pumping stations, 800 miles of main 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 Bureau of Reclamation (BOR), 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.

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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).

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 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 BOR for evaluation prior to being approved for funding appropriations from Congress.

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

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

About the Authors

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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 and Assistant Vice Chancellor, Department of Agricultural Economics, Texas Agricultural Experiment Station and Texas Cooperative Extension, College Station, TX.; **Sturdivant**, Extension Associate, Department of Agricultural Economics, Texas Cooperative Extension, Agricultural Research and Extension Center, Weslaco, TX.; **Robinson**, Extension Economist and Associate Professor, Department of Agricultural Economics, Texas Cooperative Extension, Agricultural Research and Extension Center, Weslaco, TX.; and **Popp**, Graduate Research Assistant, Department of Agricultural Economics, Texas Cooperative Extension, College Station, 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:

- ***Roy Cooley, Jesus Reyes, Joe Barrera, Sonny Hinojosa, Wayne Halbert, George Carpenter, Sonia Kaniger, 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 support as we work to develop an accurate, consistent, logical, efficient, and practical analytical approach for these investigations;

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

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

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

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

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

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

- ***Thomas Michalewicz, Larry Walkoviak, Mike Irlbeck, Debbie Blackburn, and James Allard.*** These individuals are with the Bureau of Reclamation 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 U.S. Bureau of Reclamation, Rick was a great friend to Rio Grande irrigation district rehabilitation efforts and largely responsible for successful collaborative efforts of involved stakeholders. We wish him well with his new endeavors with the Montana Forestry Service;

- ***Danny Fox, Debbie Helstrom, Jeff Walker, and Nick Palacios.*** These engineers and managers with the Texas Water Development Board (TWDB) have provided valuable feedback on the methodology and data, as well as insights on accommodating the requirements 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 and B. L. Harris.*** As Director and Executive Director of the Texas Water Resources Institute, respectively, they provide leadership and oversight for the Rio Grande Basin Initiative funded through a grant from Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture;

- ***Megan Stubbs and David Derry.*** As graduate students with the Bush School and Department of Agricultural Economics, respectively, at Texas A&M University, Megan and David have contributed useful insight and commentary while reviewing our work and during development of related materials on Rio Grande Basin irrigation districts;

- ***Jason Morris.*** A Student Technician in the Department of Agricultural Economics at Texas A&M University, Jason provides helpful computer support, data searches, etc.;

- ***Angela Catlin.*** An Administrative Secretary in the Department of Agricultural Economics at Texas A&M University, Angela provides background support for several of the team members involved in the Rio Grande Basin Task One activities. Her responsibilities and accomplishments are seamless, facilitating the team's efforts; and

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

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

MER, RDL, AWS, JRCR, MCP

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Economic and Conservation Evaluation of Capital Renovation Projects: Maverick County Water Control and Improvement District No. 1 (Eagle Pass) – Lining Main Canal – Preliminary

Abstract

Initial construction costs and net annual changes in operating and maintenance expenses are identified for a capital renovation project proposed by Maverick County Water Control and Improvement District No. 1 to the Bureau of Reclamation and North American Development Bank. The proposed project involves lining 3 miles of the "Main Canal" with a urethane lining and a concrete anchor and ballast system. Both nominal and real estimates of water and energy savings and expected economic and financial costs of those savings are identified throughout the anticipated 49-year 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 **8,084 ac-ft of water** per year and **2,041,095,338 BTUs (598,211 kwh) of energy** per year. The calculated economic and financial cost of water savings is estimated to be **$33.37 per ac-ft**. The calculated economic and financial cost of energy savings is estimated to be **$0.0001322 per BTU ($0.451 per kwh)**.

In addition, expected real (rather than nominal) values are indicated for the Bureau of Reclamation's three principal evaluation measures specified in the United States Public Law 106-576 legislation. The initial construction cost per ac-ft of water savings measure is $25.97 per ac-ft of water savings. The initial construction cost per BTU (kwh) of energy savings measure is $0.0001029 per BTU ($0.351 per kwh). The ratio of initial construction costs per dollar of total annual economic savings is estimated to be -13.65.

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,

Larry Walkoviak
Area Manager

A Century of Water for the West
1902-2002

Economic and Conservation Evaluation of Capital Renovation Projects: Maverick County Water Control and Improvement District No. 1 (Eagle Pass) – Lining Main Canal – Preliminary

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 entitled "Lower Rio Grande Valley Water Resources Conservation and Improvement Act of 2002" (i.e., PL 107-351) amended the previous Act by adding 15 irrigation-district conservation projects. Maverick County Water Control and Improvement District No. 1's "Lining Main Canal" project is included among those fifteen projects. Project authorization does not guarantee federal funding as several phases of planning, evaluation, etc. are necessary before these projects may be approved for financing and construction.

Subsequent to the noted original legislation (i.e., PL 106-576) and approval process developed by the U.S. Bureau of Reclamation (BOR) for evaluating legislation-authorized projects being proposed by Rio Grande Basin irrigation districts, the bi-national North American Development Bank (NADB) announced the availability of an $80 million Water Conservation Investment Fund for funding irrigation projects on both sides of the U.S.-Mexico border. The NADB also announced a merging of its board with that of the Border Environment Cooperation Commission (BECC), resulting in the latter assuming a facilitation role in assisting U.S. irrigation districts and other entities in applying for and being certified for the $40 million available on the U.S. side of the border. The Maverick County Water Control and Improvement District No. 1 (MCWCID #1) has submitted its BOR project as a component of a larger project proposed to BECC/NADB. The District has received preliminary notification of a $406,941 grant from NADB, pending final certification of its total project proposal. Thus, the analysis reported herein supports the MCWCID #1's BOR project proposal and one component of its multi-component BECC/NADB project proposal.

Similar to their efforts on the legislative-authorized projects, Texas Agricultural Experiment Station (TAES) and Texas Cooperative Extension (TCE) economists and engineers are collaborating with Rio Grande Basin irrigation district managers, their consulting engineers, the BECC, and NADB and using RGIDECON© to develop supportive materials documenting the sustainability of the projects being proposed by Texas Irrigation Districts to BECC, NADB, and

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

This report provides documentation of the economic and conservation analysis conducted for the Maverick County Water Control and Improvement District No. 1's Lining Main Canal project proposal to the BOR. The report also provides documented support for the same component included in the District's BECC/NADB project proposal. TAES/TCE agricultural economists have developed this analysis report as facilitated by the Rio Grande Basin Initiative and administered by the Texas Water Resources Institute of the Texas A&M University System.[2]

District Description

The District delivers water to about 38,500 acres of agricultural cropland, pasture, and orchards each year with its 135,895.0 ac-ft of irrigation water rights (i.e., 134,900.0 ac-ft irrigation, plus 725.0 ac-ft Quemado Creek, plus 270.0 ac-ft Canon Grande Creek), with the actual water available varying each year. In addition, the District holds municipal/domestic water rights of 2,049.0 ac-ft per year, recreation water rights of 100.0 ac-ft per year, and 1,085,966.0 ac-ft of non-consumptive hydro-electric water rights. The District contracts for delivery of water to Maverick County and the City of Eagle Pass. The District does not contract to deliver water to any industrial customer other than the AEP/Central Power and Light Hydro-electric Power Plant (with the non-consumptive hydro-electric water mentioned above). Currently, the District is the only source of water for the City of Eagle Pass and the towns of Quemado and El Indio.

Recent agricultural water use during calendar years 1994-1998 for the District has ranged from 42,677 ac-ft to 105,893 ac-ft, with the five-year average at 71,657 ac-ft.[3] Since the District's agricultural water diversions during recent years have been significantly hampered by deficit allocations, the cited five-year water use figures are not considered appropriate for use in forecasting future diversions. Since water savings are based on other criteria (i.e., not a % of diversions), future projected diversions have no impact on the expected water savings anticipated forthcoming from this project and are thus ignored in this analysis.

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[1] This report contains economic and financial analysis results for a capital rehabilitation project proposed by the MCWCID #1 in the Rio Grande Basin. Readers interested in the methodological background and/or prior reports are directed to pp. 29-31 which identify related publications.

[2] This analysis report is based on the best information available at the time and is subject to an array of resource limitations. At times, District management's best educated estimates (and/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.

[3] Information for municipal and industry (M&I) water use was not made available.

Proposed Project Components

The capital improvement project proposed by the District to BOR consists of one component.[4] Specifically, it includes:

- lining 3 miles of the Main Canal with a urethane lining and concrete anchor and ballast system – this will reduce seepage and blow-out losses in the earthen canal.

Economic and Conservation Analysis Features of RGIDECON©

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

Cost Considerations: Initial & Changes in O&M

Two principal types of costs are analyzed for each component: (a) initial capital outlays and (b) changes in annual operating and maintenance (O&M) expenses. Results related to each type of expenditure for each component are presented in following sections.[5]

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. In general, 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.[6]

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4 This component is one of several included in a larger proposal to BECC/NADB. The scope of the economic analysis discussed in this report is limited to the one component common to both proposals.

5 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.

6 A major assumption made by the authors and embedded in this and other economic and conservation analyses of irrigation districts' (IDs) proposed capital rehabilitation 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

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 are analyzed to gauge each component's merit. Results related to each type of cost for each component are presented in following sections, as well as totals across all 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 the single component contained in both the MCWCID #1's BOR and BECC/NADB projects. With only one component comprising this project, aggregation of component results is not necessary/possible. With regards to water and energy savings, areas or sources are first identified, with the subsequent discussion quantifying estimates for those sources.

Component #1: Main Canal

The District's proposed BOR and NADB project, commonly called the "Main Canal" project, consists of lining 3 miles of the Main Canal with a urethane lining and a concrete anchor and ballast system. The installation period is projected to take one year with an ensuing expected useful life of 49 years. It is expected water deliveries to the AEP/Central Power and Light Hydro-electric Power Plant (AEP Power Plant hereafter) will be interrupted for 4 months, resulting in an estimated loss of $320,000 in District revenues during the forecasted installation period. Other adverse impacts, such as to agriculture production, are not anticipated during the installation period since it will occur in the off-season.

<u>Initial and O&M Costs</u>

Estimated initial capital investment costs total $4,509,819 ($1,503,273 per mile). Annual increases in O&M expenditures for the new lining of $1,500 ($500 per mile) are expected. Additionally, reductions in annual O&M expenditures of $24,711 ($8,237 per mile) are anticipated from discontinued maintenance associated with the existing earthen canal. Therefore, a net decrease in annual O&M costs of $23,211 ($7,737 per mile) is expected (2003 dollars).[7]

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within (or outside) the ID. The existence of "on-allocation" status for an ID does not alter this assumption.

7 Note that previous Rister et al. analyses for other Districts' projects assumed "repairs" were covered by the contractor's warranty for one or two years. Since the MCWCID #1 is installing the lining system itself with an in-kind contribution, all expenses, including any extraordinary repair-type expenses, are included in O&M expenses for each year (Purkeypile).

Anticipated Water and Energy Savings

Only *off-farm* water savings are predicted to be forthcoming from the Main Canal lining project component, with the nominal total being 414,673 ac-ft over the 49-year productive life of this component and the real 2003 total being 173,660 ac-ft. The annual *off-farm* water-savings estimate of 8,462.7 ac-ft per year are based on 8,400.0 ac-ft of seepage savings, and 62.7 ac-ft of annualized canal "blow-out" savings.[8] With no anticipated *on-farm* water savings, total savings equal the *off-farm* water savings estimate of 8,462.7 ac-ft per year, with associated energy savings estimates of 104,700,027,121 BTU (30,685,823 kwh) in nominal terms over the 49-year productive life and 43,847,187,938 BTU (12,850,876 kwh) in real 2003 terms.

The MCWCID #1's Rio Grande diversions are gravity flow in nature. As a result there are no energy savings forthcoming from reduced diversion pumping of the projected water savings. Rather, the energy "savings" identified for this project are associated with increased electricity production, provided for by increased water deliveries (stemming from the anticipated water savings) to the AEP Power Plant.[9] That is, after installation, the District anticipates all of the water savings to be delivered to generate additional hydro-electric energy by a second party, as opposed to being used for agriculture irrigation. An implicit assumption embedded in this assertion is that annual Rio Grande supplies/diversions will be at "normal" levels. That is, in the pecking order for receiving water, the hydro-electric plant is last. Thus, if the power plant is to receive more water in the future, then all others (i.e., municipalities and agriculture) must have received their required diversions.[10]

These energy savings (i.e., water savings allowing increased water deliveries and subsequently increased energy production) are markedly different than reduced energy use from decreased Rio Grande diversions and/or reduced relift pumping (as recognized in other studies; i.e., Rister et al. 2002b-c, 2003a-k).[11] Within this economic analysis, the increased future revenues from the increased energy production/savings are recognized and effectively act as a credit towards the initial construction of the lining project through the use of a present value calculation vs. inflation-adjusted nominal values. The value of these energy savings as described are estimated at $184,702 over the 49-year useful life of the lining system. Key factors to this

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8 Per District records, blow-out water losses in the Main Canal are estimated at 1,568 ac-ft per occurrence (Cooley), and happen about every 25 years. The apportioned annualized water savings from eliminating the instances of Main Canal blow-outs are thus 62.7 ac-ft (i.e., 1,568 ac-ft ÷ 25 years = 62.7 ac-ft per year).

9 Note the anticipated increased production of energy will be made by a second party (i.e., not the District), and will not require any additional capital investment. This assumption is similar to recognizing "on-farm" reduced percolation savings from increased head pressure which allows for quicker flood/furrow irrigation.

10 Note economic results comparing scenarios *with* and *without* energy savings are provided later in this report.

11 Recognition of this type of energy savings is similar to the water savings assumed in the analysis for the Cameron County Irrigation District No. 2's (CCID #2) proposed new pumping plant project in association with an enhanced ability to divert "no-charge" water (Rister et al. 2003a). That is, the District's revenues from water deliveries to the AEP Power Plant will increase due to the project, similar to the manner in which CCID #2's water supply improved from additional no-charge pumping with the pumping plant.

present value calculation include (a) the discount rate, (b) the expected life of the lining system, (c) the volume of estimated annual water savings, (d) the average of 74 kwh of energy produced per ac-ft of water delivered to the AEP Power Plant, and (e) the $0.018 per kwh contracted revenue rate.

Cost of Water and Energy Savings

The economic and financial cost of water savings forthcoming from lining the 3-mile segment of Main Canal is estimated to be **$33.37** 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 $269,797 (in 2003 terms) by the annuity equivalent of the total net water savings of 8,084 ac-ft (in 2003 terms). The economic and financial cost of energy savings are estimated at **$0.0001322** per BTU (**$0.451** per kwh). These values are obtained by dividing the annuity equivalent of the total net cost stream for energy savings from all sources of $269,797 (in 2003 terms) by the annuity equivalent of the total net energy savings of 2,041,095,338 BTU (598,211 kwh) (in 2003 terms).[12]

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 illustrates 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.

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12 The energy savings (i.e., increased energy production) assumed herein are different than previous studies. The effect of this assumption is considered marginal with regards to the cost of saving water, and can be seen by comparing RGIDECON© analyses *with* and *without* energy savings. "*With*" is the base analysis previously discussed and "*without*" is a sensitivity analysis in which the projected water savings are used by agriculture, resulting in no increased energy production and value thereof. Economic and financial costs associated with the *without energy savings* scenario are **$34.68** per ac-ft of water savings, and **$0.0000000** per BTU (**$0.000** per kwh) (2003 basis), with the zero energy-cost savings interpreted as "n/a" since there are no energy savings. These values compare to those reported in the Executive Summary and the main body of this report. A comparison of real (as opposed to nominal) key results *with* and *without* consideration for energy savings is provided in **Table 8** on page 47 of this report. The higher cost of the water-savings value of $34.68 seen here results from $11,272 (2003 dollars) in lost annual hydro-electric water-delivery revenues which would otherwise offset a portion of the initial construction costs. Recognizing the different source of energy savings presumed in this analysis, the authors subscribe to the notion that the supply of electricity is to be improved with the project. Remember, however, this view is heavily dependent upon the District's assertion that all water savings will be diverted to the AEP Power Plant (as opposed to being used by agriculture), and the related implicit assumption that annual Rio Grande supplies/diversions will be at "normal" levels.

Summary

The following table summarizes key information regarding the single-component of Maverick County Water Control and Improvement District No. 1's BOR and NADB project, with a more complete discussion provided in the text of the complete report.

Table ES1. Summary of Data and Economic and Conservation Analysis Results for Maverick County Water Control and Improvement District No. 1's BOR and NADB Project, 2003.

	Project Component Lining Main Canal
Initial Investment Cost ($)	$ 4,509,819
Expected Useful Life (years)	49
Net Changes in Annual O&M ($)	($ 23,211)
Annuity Equivalent of Net Cost Stream – Water Savings ($/yr)	$ 269,797
Annuity Equivalent of Water Savings (ac-ft)	8,084
Calculated Cost of Water Savings ($/ac-ft)	**$ 33.37**
Annuity Equivalent of Net Cost Stream – Energy Savings ($/yr)	$ 269,797
Annuity Equivalent of Energy Savings (BTU)	2,041,095,338
Annuity Equivalent of Energy Savings (kwh)	598,211
Calculated Cost of Energy Savings ($/BTU)	**$ 0.0001322**
Calculated Cost of Energy Savings ($/kwh)	**$ 0.451**

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 Bureau of Reclamation's (BORs) evaluation of the proposed projects. According to the BOR, 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 A into one set of uniform measures utilizes the present value methods followed in the calculation of the economic and financial results reported in the main body of the text, but does not include the development of annuity equivalent measures. These compromises in approaches are intended to maintain the spirit of the legislated criteria's intentions. Only real, present value measures are presented and discussed for the legislated criteria aggregate results, thereby designating all such values in terms of 2003 equivalents. **Differences in useful lives across project components are not fully represented, however, in these calculated BOR values.**

The initial construction costs per ac-ft of water savings measure is $25.97 per ac-ft of water savings which is lower than the comprehensive economic and financial value of **$33.37 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, and/or other proposed projects.

The initial construction cost per BTU (kwh) of energy savings measure is $0.0001029 per BTU ($0.351 per kwh). These cost estimates are lower than the **$0.0001322 per BTU ($0.451 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 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 -13.65, 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) $13.65 of initial construction costs are expended for each such dollar reduction in O&M expenditures, with the latter represented in total real 2003 dollars for the project's 50-year single-component planning period.

Economic and Conservation Evaluation of Capital Renovation Projects: Maverick County Water Control and Improvement District No. 1 (Eagle Pass) – Lining Main Canal – Preliminary

Introduction

Maverick County Water Control and Improvement District No. 1's proposed "Lining Main Canal" project is included among the fifteen irrigation-district projects authorized in the amending legislation entitled "Lower Rio Grande Valley Water Resources Conservation and Improvement Act of 2002 (Act)", or United States Public Law (PL) 107-351. This Act amended previous legislation which stated, "If the Secretary determines that ... meet[s] the review criteria and project requirements, as set forth in section 3 [of the Act], the Secretary may conduct or participate in funding engineering work, infrastructure construction, and improvements for the purpose of conserving and transporting raw water through that project" (United States Public Law 106-576). This report provides documentation of an economic and conservation analysis conducted for a single-component project proposed by the Maverick County Water Control and Improvement District No. 1 (MCWCID #1) to the Bureau of Reclamation (BOR) during the Fall of 2003.[1] Other project components are anticipated to be proposed to BECC/NADB by the District, but are not part of the BOR legislative-authorized projects and are not evaluated within this analysis report. That is, this analysis report supports the MCWCID #1's BOR project proposal and one component of its multi-component BECC/NADB project proposal.

Irrigation District Description[2]

Maverick County lies along the Rio Grande in South Texas and is included in the State's Region M Water Planning Group (**Exhibit 1**).[3] The Maverick County Water Control and Improvement District No. 1 office is located approximately 10 miles north of Eagle Pass, Texas (**Exhibits 2** and **3**). The District boundary covers approximately 80,000 acres of the western-most reaches of Maverick County (R. J. Brandes Company 2003a) (**Exhibit 4**). The postal address is Rt. 2, Box 4700, Eagle Pass, TX 78852, with the physical location being approximately 10 miles north of Eagle Pass, TX off of highway 277. Telephone contact information is 830/773-5129 and the fax number is 830/757-5607. Roy Cooley is the General Manager, with Dee Purkeypile of R. J. Brandes Company, Austin, TX, serving as the lead consulting engineer for this project.

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1 Readers interested in the methodological background and/or prior reports are directed to pp. 29-31 which identify related publications.

2 The general descriptive information presented was assimilated from several documents (listed in the References section) provided by Dee Purkeypile (lead consulting engineer) of R. J. Brandes Company.

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

The District services 849 water accounts, including 549 agricultural irrigation accounts (R. J. Brandes Company 2003b). The majority of agricultural acreage is serviced under "as-needed" individual water orders for pecan orchards, vegetable crops, and field crops utilizing flood- or furrow-irrigation techniques. A small amount of the District's agriculture acreage is irrigated by drip or micro-emitter systems (Cooley).

Irrigated Acreage and Major Crops

The District delivers water to approximately 38,500 acres of agricultural cropland within its district. Furrow- and flood-irrigation techniques account for approximately 99% of irrigation deliveries (Cooley). Special turnout connections are provided, at the customer's expense, as requested to district customers utilizing polypipe, gated pipe, etc. Flood irrigation is the norm for orchards and pastures. The typical crop mix across the District is noted in **Table 1**, which illustrates the relative importance (on an acreage basis) of field crops, vegetables, pecans, etc.

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 2,049.0 acre feet (ac-ft) of water rights for M&I diversions to Maverick County and the City of Eagle Pass (**Exhibit 5**), with additional deliveries to the towns of Quemado and El Indio. After fulfilling municipalities' requirements, the needs of agricultural irrigators are addressed, with requirements of the hydro-electric generation plant receiving the lowest priority (Cooley).

Historic Water Use

A recent five-year period (i.e., 1994-1998) demonstrates a wide range of water use in the District (**Table 2**). Agricultural use has varied from 42,677 ac-ft to 105,893 ac-ft, with an average of 71,657 ac-ft.[5] Since the District's agricultural water diversions during recent years have been significantly hampered by deficit allocations, the cited five-year water use figures are not considered appropriate for use in forecasting future diversions (Cooley).[6] Since water

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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.

5 Information for municipal and industry (M&I) water use was not made available.

6 The supply/demand balances across Rio Grande Basin irrigation districts vary. 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), and Hidalgo County Irrigation District No. 2 (a.k.a. San Juan)) did not advise of incurring extreme water unavailability. In fact, one district recently made a significant one-time sale of water (external to the District).

savings are based on other criteria (i.e., not a % of diversions), future projected diversions have no impact on the expected water savings anticipated forthcoming from this project and are thus ignored in this analysis.

Assessment of Technology and Efficiency Status

The District diverts water from the Rio Grande at its headgates which are located approximately 18 miles northwest of Quemado, TX (**Exhibit 4**). The District does not operate a Rio Grande diversion-site pumping station or any relift pumps within the conveyance system as the District operates entirely by gravity flow (R. J. Brandes Company 2003b). Instead of a pumping station, a low-water dam located about one mile downstream of the headgates creates backwater which then flows through the Main Canal – at times, nearly all of the Rio Grande flow is diverted through the Main Canal (R. J. Brandes Company 2003c).

Once diverted from the Rio Grande, water is conveyed 32 miles through the Main Canal to a point where a portion is diverted to the intake for the AEP/Central Power and Light Hydro-electric Power Plant (AEP Power Plant hereafter). Approximately 95% of the District's Rio Grande diversions into the Main Canal are used to generate electricity and then returned to the river (R. J. Brandes Company 2003c). The volume of power plant diversions are affected by the amount of irrigation water required north and south of the power plant. North-of-power-plant irrigation requirements are diverted from the Main Canal, while southern requirements are diverted from the Canal Extension. The majority of the District's water-delivery infrastructure system consists of 90 miles of canals, 200 miles of laterals, 250 miles of sub-lateral canals and farm ditches, and 2 seldom-used reservoirs with a combined 260 ac-ft holding capacity (R. J. Brandes Company 2003a-b).

The District diverts the hydro-electric water with authority from the State of Texas with its *non-consumptive* certificate of adjudication providing diversion rights up to 1,085,966 ac-ft annually. Once diverted from the Rio Grande, all diversions are measured at a gaging station located 13 miles downstream from the headgates. Inherit in delivering water are conveyance losses. To minimize the effects of conveyance loss upon the hydro-electric diversions, the State of Texas provides credits to the District (as measured at 13 return-flow monitoring stations) for water returned to the Rio Grande (R. J. Brandes Company 2003c). Any remaining conveyance losses are left to be absorbed by agriculture irrigators. Various studies have estimated the overall system conveyance loss to be 2-5% of total diversions, but after the credits are received for non-consumptive uses (i.e., hydro-electric), the remaining conveyance losses are applied to agriculture diversions and constitute an estimated 33% delivery-loss factor towards agriculture water deliveries (Cooley). That is, the volume of hydro-electric deliveries benefit with no conveyance loss, while agriculture is forced to suffer all "non-credited" conveyance losses and subsequently receives less water than what it might otherwise receive.

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. Due to some unanticipated difficulties, the District has temporary placed on hold its use of a computerized Geographic Information System (GIS) program for linking a mapping system to a database, indicating where water has been ordered, for what types of crops, the various systems necessary to deliver the water, etc. Approximately 99% of agricultural water use is volumetrically measured using portable meters. Producers' use of water-conserving methods and equipment is encouraged by the District (Cooley).

Water Rights Ownership and Sales

The District holds two Certificates of Adjudication (i.e., No's. 2671 and 2688) (**Table 3**) which authorize the annual *consumptive* use of 135,895 ac-ft for irrigation, 2,049 ac-ft for municipal and domestic purposes, 100 ac-ft for mining, and the annual *non-consumptive* use of 1,085,966 ac-ft for generation of hydro-electric power (R. J. Brandes Company 2003c). The District does not divert/deliver, on an on-going basis, toward 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 allocations (and possibly the water rights). Such purchases and/or leases are subject to a $3.50 per ac-ft delivery fee and a 33% transportation delivery loss charged by the District (Cooley); that is, purchase 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.

Volumetrically-priced charges (i.e., 99% of the District's irrigation assessments) assessed irrigators within the District consist of an annual *flat-rate fee* of $7.00 per irrigable acre (paid by the landowner, whether the land is irrigated or not) (**Table 3**). Thereafter, an additional $7.00 per acre *water-assessment fee* may or may not be assessed (to the landowner-operator or tenant-producer) (**Table 3**). The water assessment fee is subject to waiver in water-short years, or if the land is not to be irrigated for that year – this fee has been suspended for the last three years. Finally, a *water-delivery fee* of $3.50 per ac-ft is charged on water delivered to the farm turnout. Thus, depending upon the water-assessment fee, the rates equate to an annual irrigation charge of $10.50 or $17.50 for the first ac-ft of water (Cooley); additional irrigation water use beyond one ac-ft is charged at $3.50 per ac-ft. Further, the District charges a delivery charge of $73.00 per ac-ft for Municipal water, $33.25 per ac-ft for Domestic water, $13.25 per ac-ft for Livestock water if the user has a current irrigation account, or $73.00 per ac-ft for Livestock water without a current account. Finally, a major portion of the District's revenue is received from a 1.8 cents per kilowatt-hour assessment to the AEP Power Plant. On average, each ac-ft of water delivered to the AEP Power Plant produces 74 kwh of energy (Cooley).

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

Project Data

As proposed by the District, the capital improvement for this project consists of lining a 3-mile segment of the Main Canal. Though often referred to as a component within this report, it is locally referred to as the "Main Canal Project" (Cooley) (**Table 4**).[7]

Component #1: Main Canal

The "Main Canal" is the initial delivery infrastructure water traverses after it is diverted (by gravity flow) from the Rio Grande. After traveling about 32 miles, the Main Canal splits into the Canal Extension and the intake structure to the AEP Power Plant. Thus, the Main Canal conveys virtually all water diverted into the District. Summary data for the District's single-component project are presented in **Tables 4, 5, 6,** and **7** with discussion of that data following.

Description

This project consists of lining a 3-mile (15,840-foot) section of the Main Canal with a urethane lining and concrete anchor and ballast system. The project section is currently earthen. Once installed and brought on-line, this project is expected to (**Table 5**):

a) reduce "off-farm" seepage losses estimated at 8,400.0 ac-ft per year; and
b) reduce annualized "off-farm" blow-out losses estimated at 62.7 ac-ft per year.

Installation Period

It is anticipated that it will take one year after purchase and project initiation for the lining to be installed and fully implemented (**Table 6**). During this time, it is anticipated the flow of water will be interrupted for 4 months, causing lessened water deliveries to the AEP Power Plant valued at $320,000 to the District (i.e., $80,000 per month). No other loss of operations or otherwise adverse impacts, such as to agriculture production, are anticipated during the installation period.

Productive Period

A useful life of 49 years[8] for the canal lining is expected and assumed in the baseline analysis (**Table 6**). A shorter useful life is possible, but 49 years is considered reasonable and consistent with engineering expectations (Purkeypile). Sensitivity analyses are utilized to

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

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

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 BOR 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.

Capital investment costs (i.e., purchase, mobilize) for the 3.0 miles of lining system total $4,509,819 ($1,503,273 per mile) in 2003 dollars (**Table 6**) (Purkeypile). Sensitivity analysis on the total amount of all capital expenditures is 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 lining system are expected to be slightly different than those presently occurring for the earthen Main Canal. Annual O&M expenditures associated with the affected segment of the canal delivery system (i.e., after installation of the lining) are anticipated to be $1,500, or $500 per mile (basis 2003 dollars) (**Table 6**). Since the MCWCID #1 is installing the lining system with an in-kind contribution, all expenses, including any extraordinary repair-type expense is included in O&M expenses for each year (Purkeypile).

Projected Savings

Water. Water savings resulting from this project component's installation and utilization will not equate to reductions in diversions from the Rio Grande, as the saved water will be delivered to generate additional electricity. Estimates of water savings are comprised, in this case, of only off-farm agricultural irrigation savings; i.e., no savings related to M&I water use are anticipated.[9]

Off-farm savings include those occurring in the District's canal delivery system as a result of reduced seepage after the Main Canal is replaced with the lining system. In determining the estimated water losses, the District refers to historical flow studies of the Main Canal which

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[9] A major assumption made by the authors and embedded in this and other economic and conservation analyses of irrigation districts' (IDs) proposed capital rehabilitation 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.

indicate losses range from 0.2% to 0.4% percent of flow per mile throughout the entire year. The District applies the average of 0.3% to the flow to arrive at an estimated seepage loss for the 3-mile project section at 8,400 ac-ft per year (R. J. Brandes Company 2003c) (**Table 5**). Flow studies have been utilized in lieu of ponding studies to maintain an uninterrupted flow in the Main Canal (Purkeypile). 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 losses 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 (Purkeypile), consistent with assumptions embedded in previous analyses (e.g., Rister et al. 2003a-k). Additional annualized *off-farm* water savings of 62.7 ac-ft per year (**Table 5**) are expected from reducing the incidence of Main Canal blow-outs which will be realized with lining the earthen Main Canal (R. J. Brandes Company 2003c). The combined annual *off-farm* water savings associated with lining the 3-mile Main Canal section are estimated at 8,462.7 ac-ft (**Table 5**) (i.e., 8,400.0 + 62.7).

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

As shown in **Table 5**, *on-farm* water savings from reduced percolation losses are <u>not</u> expected to be forthcoming from this component. Therefore, combining all *off-* and *on-farm* water savings (without any additional conveyance loss included) results in 8,462.7 ac-ft (**Table 5**) being analyzed in the base analysis. As with other estimated water savings, this value is held constant during each year of the new lining 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 not expected to result in reduced Rio Grande diversions as the water will be delivered to generate additional electricity.

<u>Energy</u>. In previous studies, energy savings for a given project have been assumed to occur as a result of less water being diverted at the Rio Grande diversion site and/or because of lower relift pumping requirements at one or more points throughout the water-delivery system. The MCWCID #1's Rio Grande diversions are gravity flow in nature. As a result there are no energy savings forthcoming from reduced diversion pumping of the projected water savings. Rather, the energy "savings" identified for this project are associated with increased electricity production, provided for by increased water deliveries (stemming from the anticipated water

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[10] The District's irrigation conveyance loss to farm turnouts is estimated to be 33% (Cooley). This incorporates the fact that losses associated with deliveries to the AEP Power Plant are credited back to the District, (thereby effecting a delivery efficiency of 100% on hydro-electric deliveries). Overall, the District's conveyance losses have been estimated at 2-5% (Cooley). For the single-component project, additional water savings beyond the project-area attributed to conveyance loss are not claimed based on the assumption the claimed water savings will occur throughout the year and on the margin will not affect the "fullness" of the remainder of the canal system. That is, with water being saved at the component/project site, the remainder of 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 (Purkeypile).

savings) to the AEP Power Plant. That is, after installation, the District anticipates all of the water savings to be delivered to generate additional hydro-electric energy by a second party, as opposed to being used for agriculture irrigation. An implicit assumption embedded in this assertion is that annual Rio Grande supplies/diversions will be at "normal" levels. That is, in the pecking order for receiving water, the hydro-electric plant is last. Thus, if the power plant is to receive more water in the future, then all others (i.e., municipalities and agriculture) must have received their required diversions. That is, this MCWCID #1 project will facilitate increased energy production.[11] The amount of increased energy generation (i.e., "savings") and the associated monetary "savings" are detailed below for the District's single-component project.

These energy savings (i.e., increased energy production) are different than reduced energy use from decreased Rio Grande diversions and/or reduced relift pumping (as recognized in other studies; e.g., Rister et al. 2003a-k).[12] Within this economic analysis, the increased future revenues from the increased energy production (associated with increased water deliveries to the power plant) are recognized and effectively act as a credit towards the initial construction of the lining project. That is, in the first year after installation (i.e., year 2 of the 50-year planning horizon), the additional revenue from increased water deliveries to the AEP Power Plant for the next 49 years is recognized in a single present value calculation.

Different than in previous economic studies, the monetary value of energy savings is recognized using the present value calculation and not with inflation-adjusted nominal values. Furthermore, the "handling" of these increased revenues (i.e., energy savings) within RGIDECON© is such that future O&M expenses are not reduced with the "$'s of energy savings" – for to do so for this project would improperly affect the BOR legislative-mandated evaluation criteria values. Note the comprehensive economic and financial value calculated with RGIDECON© (identified and discussed in the following section and extensively in the main body of this analysis report) is not affected by this approach.[13]

The energy savings as described above are estimated at $184,702 (2003 dollars) over the 49-year useful life of the project. Key factors constituting "energy savings" with increased deliveries as calculated in the present value calculation include:

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11 Note the anticipated increased production of energy will be made by a second party outside the District, but will not require any additional capital expenditure. This assumption is similar to recognizing "on-farm" percolation water savings (brought about by increased head pressure).

12 Recognition of this type of energy savings is similar to the water savings recognized with the analysis for the Cameron County Irrigation District No. 2's (CCID #2) proposed new pumping plant project's ability to divert additional "no-charge" water (Rister et al. 2003a). That is, the District's revenues from water deliveries to the AEP Power Plant will increase due to the project, similar to the manner in which CCID #2's water supply improved with additional no-charge pumping.

13 That is, use of the present value calculation (which does not affect O&M) or the inflation-adjusted nominal values (which does affect O&M) results in the same economic and financial cost of saving water of $33.37 per ac-ft.

» 6.125% discount rate (common to all RGIDECON© analyses);
» 49 years of future water-delivery revenues (i.e., useful life of the lining system);
» 8,462.7 ac-ft of annual estimated water savings (delivered to AEP Power Plant);
» average of 74 kwh of energy produced per ac-ft of water delivered; and
» $0.018 per kwh contract revenue to the District.

Operating and Maintenance. Annual O&M expenses for the existing earthen Main Canal are estimated to be $8,237 per mile (Cooley). Thus, across the total 3 miles of the Main Canal proposed for replacing with the lining system, a net reduction of $23,211 (or $7,737 per mile) in O&M expense is anticipated (**Table 6**).

Reclaimed Property. No real property will be reclaimed in association with this project (**Table 6**). During the installation phase of this project, however, it is estimated delivery of water to the AEP Power Plant will be interrupted for 4 months. With an average $80,000 per month in lost revenues, the estimated *economic cost* against the project's initial construction is $320,000 (i.e, 4 x $80,000) (**Table 6**). Also, after project installation, the District anticipates all of the water savings will be delivered to generate additional hydro-electric energy by a second party, as opposed to being used for agriculture irrigation. The future increased hydro-electric water deliveries, over the next 49 years, are estimated at $184,702 (2003 dollars) though a present value calculation; thereby effecting an *economic benefit* (i.e., credit) towards the initial construction of the project.

Abbreviated Discussion of Methodology[14]

Texas Agricultural Experiment Station and Texas Cooperative Extension economists have developed an economic spreadsheet model, RGIDECON© (or, 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 embody economic and financial principles consistent with capital budgeting procedures for evaluating projects of different economic lives, thereby "leveling the playing field" and allowing "apples to apples" comparisons across projects. As a result, RGIDECON© also is capable of providing valuable information for implementing a method of prioritization of projects in the event of funding limitations.

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

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

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 activities (i.e., components). Lastly, the RGIDECON© model has been designed to accommodate "what if" analyses for Districts interested in evaluating additional, non-Act authorized capital improvement investments in their water delivery infrastructure.

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

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

Assumed Values for Critical Parameters

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

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. (2002a).

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.

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

As presented in Rister et al. (2002a), use of an overall discount rate of 6.125% in conjunction with a 4% social time value and the assumption of a 0% risk premium infers a 2.043269% annual inflation rate. Such an inferred rate is consistent with recent and expected rates of nominal price increases for irrigation construction, O&M, and energy costs (Rister et al. 2002a). Thus, a 2.043269% rate is used to compound 2003 nominal dollar cost estimates forward for years in the planning period beyond 2003. The rationale for assuming this rate is based both on the mathematical relationship presented above and analyses of several pertinent price index series and discussions with selected professionals.[16]

Pre-Project Annual Water Use by the District

Water availability and use in the District has varied some in recent years. **Table 2** contains the District's historic water use for agricultural irrigation for each of the years 1994-1998). Rather than isolate one particular year as the baseline on which to base estimates of future water savings, Bureau of Reclamation, Texas Water Development Board, Texas Agricultural Experiment Station, and Texas Cooperative Service 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), and its estimated water savings from its project are

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. (2002a), assuming the noted values for risk and time value.

based on historical diversions (i.e., a percentage of the total or agricultural irrigation diversions), a more-lengthy time series of water use is to be used to quantify representative water use and/or water savings.

As discussed, the District's agricultural irrigation use has averaged 71,657 ac-ft during the designated 5-year period. Since the District's agricultural water diversions during recent years have been significantly hampered by deficit allocations, the cited five-year water use figures are not considered appropriate in forecasting future diversions (Cooley). Since water savings are based on other criteria (i.e., not a % of diversions), future projected diversions have no impact on the expected water savings anticipated forthcoming from this project and are thus ignored in this analysis.

Value of Water Savings per Acre-Foot of Water

The analysis reported in this 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 Production per Acre-Foot of Water[18]

This analysis includes calculating the cost (i.e., value) of energy savings (i.e., increased energy production in the case of this analysis) and applying the value of such production as a credit to the project's construction cost when evaluating the cost of water savings associated with the project.[19] Juxtaposed to previous analysis reports by the authors (e.g., Rister et al. 2003a-k), the "energy savings" anticipated for this project are in fact an increase in energy production.

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

18 Note the heading "Energy *Production* per Acre-Foot of Water" is revised (from "Energy *Usage* per Acre-Foot of Water"; as used in previous economic studies by the authors) to reflect a major difference in how energy is affected by water savings. Thus, when comparing this with other reports, note a difference in certain topic headings, the presentation of data, and interpretation differences. For example, words such as "value", "produced", and "production" are substituted for the previously used words "costs", "saved", and "usage" in several places to denote the proper meaning/interpretation for this analysis.

19 "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. 2002a)

The average energy-production level of 252,488 BTU (74 kwh) per ac-ft of water delivered to the AEP Power Plant by the District is used to estimate energy "savings" resulting when more water is delivered to the AEP Power Plant due to implementation of the proposed project (**Table 8**). An important assumption is there are 3,412 BTU per kwh (Infoplease.com). This equivalency factor allows for converting the energy production information into an alternative form for readers of this report.

Value of Energy Produced per BTU/kwh

Corresponding to the amount of energy "produced", the current contract value of $0.018 per kwh ($0.0000053 per BTU) for energy production (associated with water deliveries to the AEP Power Plant) is used to transform the expected energy "savings" into an economic dollar value used in this analysis report (**Table 8**).[20] Sensitivity analyses are utilized to examine the implications of this value.

Economic and Financial Evaluation Results

The economic and financial analysis results forthcoming from an evaluation of the afore-mentioned data using RGIDECON© (Rister et al. 2002a) are presented in this section for this single-component project. Given there are not multiple components to the District's proposed project, discussion of aggregated results are not provided, as was the case with previous irrigation districts' economic analyses reports.[21]

Component #1: Main Canal

The only component evaluated in this analysis is the lining of a 3-mile long segment of the Main Canal with a urethane lining and concrete anchor and ballast system. Results of the analysis for this single-component project follow (**Table 9**).

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20 District management believes the $0.018 per kwh rate will remain effective for the foreseeable future. Also, since the authors' practice is to avoid revenue forecasting within cost analyses, it was agreed this nominal rate would be maintained into the future 49 years without compounding, with the realization that a increase may in fact occur at some future time. With these assumptions, a conservative estimate of the cost of saving water is made.

21 This report contains economic and financial analysis results for a single-component capital rehabilitation project proposed by the MCWCID #1. Prior reports containing multiple-component projects are identified on pp. 29-31 which identify related publications.

Quantities of Water Savings and Energy Production

Critical values in the analysis are the amount of water saved and energy produced during the 49-year productive life of the lining.[22] On a nominal (i.e., non-discounted) basis, 414,673 ac-ft of irrigation water are projected to be saved; no M&I or hydro-electric water savings are expected as a result of this project component.[23] Thus, the total nominal water savings anticipated are 414,673 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 173,660 ac-ft of real irrigation savings and 0.0 ac-ft of real M&I and hydro-electric water savings, representing a total real water savings of 173,660 ac-ft (**Table 9**).

On a nominal (i.e., non-discounted) basis, 104,700,027,121 BTU (30,685,823 kwh) of energy are projected to be produced in association with the forecast irrigation water savings (**Table 9**). Since there are no M&I or hydro-electric related energy savings, these values represent the total energy "savings" (i.e., production) for this project. Using the 4% discount rate previously discussed, those nominal savings translate into 43,847,187,938 BTU (12,850,876 kwh) of real irrigation-related energy savings over the 49-year productive life of this project (**Table 9**).

Cost of Water Saved

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

NPV of Net Cost Stream. Accounting for all capital purchase and installation construction costs, changes in O&M expenditures, and credits for energy savings, the nominal total cost of the 50-year planning period for the lining project is $2,691,221 (**Table 9**). This positive value infers a net economic cost (as opposed to a net economic savings), on a nominal basis. Using the previously-identified discount rate of 6.125%, these nominal cost dollars translate into present-day, real net costs of $4,179,406 (**Table 9**). This amount represents, across the total 50-year planning period, the total net costs, in 2003 dollars, of purchasing and installing

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

23 As noted previously, the District diverts water for M&I, agricultural, and hydro-electric purposes, and technically one could allocate a proportionate share of the forecasted water savings to M&I water use. In this instance, however, RGIDECON© results will not change and the authors have opted to simplify and allocate water savings only to agriculture uses. Further, since hydro-electric deliveries are credited with return flows to the Rio Grande and agriculture realizes all remaining conveyance losses, it is not appropriate to allocate any water savings to the hydro-electric aspect of the District.

the lining 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 positive nominal-value amount. This result occurs because in the nominal-value amount, the savings accruing from reduced O&M expenses and increased revenues from additional energy production in the lengthy planning period are sufficient to offset a large portion of the initial investment costs. In the case of the real-value amount, however, the savings occurring during the latter years of the planning period are discounted significantly and thus do not offset as much of the initial investment costs.

NPV of All Water Savings. As detailed above, the total nominal water savings anticipated are 414,673 ac-ft (**Table 9**). The corresponding total real water savings expressed in 2003 water quantities are 173,660 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 $4,179,406 correlates with the real water savings projection of 173,660 ac-ft; the respective annuity equivalents are $269,797 and 8,084 ac-ft (**Table 9**). The estimated cost of saving one ac-ft of water using the lining system comprising this project is **$33.37** (**Table 9**).[24] This value can be interpreted as the cost of leasing one ac-ft of water in year 2003. It is not the cost of purchasing the water right of one ac-ft. Following through with the economic and capital budgeting methodology presented in Rister et al. (2002a), this value represents the costs per year in present-day dollars of saving one ac-ft of water each year into perpetuity through a continual replacement series of the lining system with all of the attributes previously indicated.

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24 The energy savings (i.e., increased energy production) assumed herein are different than previous studies. The effect of this assumption is considered marginal with regards to the cost of saving water, and can be seen by comparing RGIDECON© analyses *with* and *without* energy savings. "*With*" is the base analysis previously discussed and "*without*" is a sensitivity analysis in which the projected water savings are used by agriculture, resulting in no increased energy production and value thereof. Economic and financial costs associated with the *without energy savings* scenario are **$34.68** per ac-ft of water savings, and **$0.0000000** per BTU (**$0.000** per kwh) (2003 basis), with the zero energy-cost savings interpreted as "n/a" since there are no energy savings. These values compare to those reported in the Executive Summary and the main body of this report. A comparison of real (as opposed to nominal) key results *with* and *without* consideration for energy savings is provided in **Table 8** on page 47 of this report. The higher cost of the water-savings value of $34.68 seen here results from $11,272 (2003 dollars) in lost annual hydro-electric water-delivery revenues which would otherwise offset a portion of the initial construction costs.

Recognizing the different source of energy savings presumed in this analysis, the authors subscribe to the notion that the supply of electricity is to be improved with the project. Remember, however, this view is heavily dependent upon the District's assertion that all water savings will be diverted to the AEP Power Plant (as opposed to being used by agriculture), and the related implicit assumption that annual Rio Grande supplies/diversions will be at "normal" levels, allowing agriculture to utilize all of the irrigation water considered necessary for "normal" operations. That is, should there be any water shortages in the future such that any portion of the postulated water savings associated with this proposed project would be utilized by agriculture rather than diverted to the AEP Power Plant for electricity production, the costs of water savings would move away from the $33.37 per ac-ft estimate toward $34.68 per ac-ft. The narrow difference between these two values suggests the assumption in the base analysis provided in this report (that energy savings should be included) has a minimal impact on the comprehensive economic and financial cost of water savings; i.e., the $1.31 difference is considered to be a negligible difference by the authors.

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

The most critical assumption made in the baseline analysis is considered to be that pertaining to the amount of water savings that will result from the purchase, installation, and implementation of the canal lining in the water-delivery system. Thus, the cost per ac-ft of water-saved sensitivity analysis consists of varying the off-farm water-savings dimension[25] of that factor across a range of 4,200 to 11,750 ac-ft (including the baseline 8,400 ac-ft) for the new lining 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 paired sensitivity analyses are presented in **Tables 10, 11,** and **12**, respectively.

Table 10 reveals a range of $23.49 to $145.82 cost per ac-ft of savings around the baseline estimate of $33.37. These calculated values were derived by varying the off-farm water savings from the canal lining system from as low as 4,200 ac-ft up to 11,750 ac-ft about the expected 8,400 ac-ft and by investigating a range of useful lives of the new lining 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, while lower off-farm water savings than the predicted 8,400 ac-ft also increased cost estimates, and higher-than-expected water savings contributed to lower cost estimates.

Similarly, **Table 11** is a presentation of a range of cost estimates varying from $20.63 to $76.04 per ac-ft of savings around the baseline estimate of $33.37. These calculated values were derived by varying the off-farm water savings from the canal lining system from as low as 4,200 ac-ft up to 11,750 ac-ft about the expected 8,400 ac-ft and by considering variations in the cost of the capital investment in the new lining varying from $500,000 less than the expected $4,509,819 up to $500,000 more than the expected amount. As should be expected, both lower-than-the-anticipated $4,509,819 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 water savings arising from investment in the canal lining system and the "value" of energy. **Table 12** is an illustration of the results of varying those parameters from as

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[25] Other off-farm water savings (i.e., annualized canal blow-out savings) are linked to off-farm (i.e., seepage) water savings within RGIDECON©'s assessment of this proposed project. Thus, as the off-farm (seepage) water savings associated with lining the earthen Main Canal are varied in the sensitivity analyses, the other off-farm savings (i.e., annualized canal blow-out savings) also vary proportionately.

low as 4,200 ac-ft up to 11,750 ac-ft about the expected 8,400 ac-ft of off-farm water savings and across a range of $0.0090 to $0.0275 per kwh energy costs about the expected $0.180 per kwh level. The resulting cost of water savings estimates ranged from a high of $68.71 per ac-ft down to a low of $22.79 per ac-ft. The lower cost results are associated with high water savings and high energy values – 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 value of energy and low water savings, i.e., higher costs estimates are calculated for these circumstances.

Value of Energy Produced

Besides the estimated cost per ac-ft of water saved as a result of the canal lining system's inception, purchase, installation, and implementation, another issue of interest is the value of energy production. As seepage and annualized blow-out losses are reduced, the water savings associated with the proposed Main Canal's capital renovation will result in increased energy production. 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 the data parameters are presented below for the proposed project.

NPV of Net Cost Stream. Accounting for all capital purchase and installation construction costs, and changes in O&M expenditures, the nominal total cost of the 50-year planning period for the canal lining project is $2,691,221 (**Table 9**). Using the previously-identified discount rate of 6.125%, these nominal cost dollars translate into a present-day, real cost of $4,179,406 (**Table 9**). This amount represents, across the total 50-year planning period, the total net costs, in 2003 dollars, of purchasing and installing the new lining as well as payment of the net changes in O&M expenditures, ignoring the changes in energy values and allowing no credits for the water savings.

NPV of All Energy Produced. As detailed above, the total nominal energy production anticipated are 104,700,027,121 BTU (30,685,823 kwh) (**Table 9**). The corresponding total real energy production expressed in 2003 energy quantities are 43,847,187,938 BTU (12,850,876 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 Produced. The real net cost estimate of $4,179,406 correlates with the real energy production projection of 43,847,187,938 BTU (12,850,876 kwh); the respective annuity equivalents are $269,797 and 2,041,095,338 BTU (598,211 kwh) (**Table 9**). The estimated cost of producing one BTU of energy using the increased water deliveries as provided by the new lining system comprising this project is $0.0001322 ($0.451 per kwh) (**Table 9**).[26] An interpretation of this value is that it is the cost of producing one BTU (kwh) of

[26] The energy savings (i.e., increased energy production) assumed herein is different than those identified in previous studies. The effect of this assumption is considered marginal with regards to the cost of saving water, but are noteworthy with regard to the cost of saving energy. A comparison of real (as opposed to nominal) key results *with* and *without* the previously identified energy savings is provided in **Table 8** on p. 47 of this report. Economic and financial costs calculated for a *without energy savings* scenario are

energy in year 2003. Following through with the economic and capital budgeting methodology presented in Rister et al. (2002a), this value represents the costs per year in present-day dollars of producing one BTU (kwh) of energy into perpetuity through a continual replacement series of the canal 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 value measure (i.e., $ value per BTU (or kwh) produced) in response to changes in certain key parameters. The two-way Data Table feature of Excel (Walkenbach) again is utilized to accomplish these sensitivity analyses whereby two parameters are varied and all others remain constant at the levels assumed for the baseline analysis.

The most critical assumption made in the baseline analysis in this respect is considered to be that pertaining to the amount of energy production that will result from the purchase, installation, and implementation of the canal lining system in the water-delivery infrastructure system. Thus, the cost per BTU (or kwh) of energy-produced sensitivity analyses consists of varying the amount of energy production across a range of 80.0 percent up to 150.0 percent of the baseline 252,488 BTU (74 kwh) current average production 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 new lining. 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 $0.0000864 to $0.0003590 cost per BTU (and $0.295 to $1.225 per kwh) of energy production around the baseline estimate of $0.0001322 per BTU ($0.451 per kwh). These calculated values were derived by varying the amount of energy produced per ac-ft of water savings across a range as low as 80.0% up to 150.0% of the expected 252,488 BTU (74 kwh) current average production 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

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$0.0000000 per BTU (**$0.000** per kwh) (2003 basis). The zero cost of energy-savings values result when the assumption that water savings will result in increased annual hydro-electric water-delivery revenues is rejected; i.e., all of the water savings are consumed by agriculture, no energy is saved, and therefore energy savings can not have an associated cost. As previously mentioned, recognizing the different source of energy savings identified in this report and the underlying base analysis, the authors subscribe, however, to the notion that the supply of electricity is to be improved with the project.

Remember, however, this view is heavily dependent upon the District's assertion that all water savings will be diverted to the AEP Power Plant, and the subsequent implicit assumption that annual Rio Grande supplies/diversions will be at "normal" levels, allowing agriculture to utilize all of the irrigation water considered necessary for "normal" operations. That is, should there be any water shortages in the future such that any portion of the postulated water savings associated with this proposed project would be utilized by agriculture rather than diverted to the AEP Power Plant for electricity production, the costs of energy savings would be increased from the baseline estimate of $0.0001322 per BTU ($0.451 per kwh) since less energy would be produced, but the project costs would remain the same.

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 costs of producing additional energy, while lower energy production than the predicted 100% of current average of 252,488 BTU/ac-ft also increased costs, and higher-than-expected energy production contributed to lower costs of producing additional energy.

Similarly, **Tables 15** and **16** are a presentation of a range of cost estimates varying from $0.0000759 to $0.0001863 per BTU (and $0.259 to $0.636 per kwh) of energy production around the baseline estimate of $0.0001322 per BTU ($0.451 per kwh). These calculated values were derived by varying the amount of energy produced per ac-ft of water savings across a range as low as 80.0% up to 150.0% of the expected 252,488 BTU (74 kwh) current average production per ac-ft of water savings and by considering variations in the cost of the capital investment in the lining system varying from $500,000 less than the expected $4,509,819 up to $500,000 more than the expected amount. As should be expected, both lower-than-the-anticipated $4,509,819 capital costs and/or higher-than-expected energy production contributed to lower cost estimates, while both higher investment costs and/or lower energy production than the expected 252,488 BTU (74 kwh) increased the cost estimates.

The final set of sensitivity analysis conducted for the costs of energy produced accounted for varying both the amount of energy produced per ac-ft of water savings and the amount of water savings from the lining system. **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 252,488 BTU (74 kwh) current average production per ac-ft of water savings and from as low as 4,200 ac-ft up to 11,750 ac-ft about the expected 8,400 ac-ft off-farm water savings for the new 3-mile section of Main Canal. The resulting costs of energy production estimates ranged from a high of $0.0003382 per BTU ($1.154 per kwh) down to a low of $0.0000603 per BTU ($0.206 per kwh). The lower cost estimates are associated with high energy production per ac-ft of water savings and high off-farm water savings – the two factors combined contribute to substantial lower costs of producting energy. The opposite effect is experienced with low energy production per ac-ft of water savings and low off-farm water savings, i.e., higher costs estimates are calculated for these circumstances.

Limitations

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

- The 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 into the future several years. Obviously, there is imperfect information about such conditions, contributing to a degree of uncertainty as to the appropriate exact input values. Necessarily, such uncertainty contributes to some ambiguity surrounding the final result measures.

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

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

- Beyond the sensitivity analyses mentioned above, there is no 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 to be forthcoming from the proposed project, i.e., a complete cost-benefit procedure is not applied. Consequently, the comprehensive 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. (2002a).

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

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

While such caveats indicate real limitations, they should not be interpreted as negating of the results contained in this report. These results are bonafide and conducive for use in the appraisal of the proposed projects affiliated with Public Law 106-576 and Public Law 107-351 legislation as well as those projects being proposed to the BECC and NADB. The above issues are worthy of consideration for future research and programs of work, but should not be misinterpreted and/or misapplied to the extent of halting efforts underway at this time.

Recommended Future Research

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

- A comprehensive economic impact study of the proposed renovations would enhance the economic strength of the analyses. Necessarily, it is suggested such an effort encompass a full cost-benefit assessment and potential alterations in cropping patterns, impacts of projected urban growth, distribution of water use across the Basin, etc. It is relevant to note that evaluation of Federal projects often employ a national perspective and consider such local impacts negligible. A more-localized perspective in the level of analyses results in greater benefits being estimated along with increased attention to the identity of 'winners' and 'losers' in the resulting adjustments that are anticipated. For example, while on a national perspective the issue of the 1.5 million ac-ft of water now owed to the U.S. may not be a high-priority issue, it certainly is viewed as a critical issue within the immediate Rio Grande Valley area.

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

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

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

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

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

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

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

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

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

Summary and Conclusions

The District's project proposal consists of a single component: lining a 3-mile section of the Main Canal. The required capital investment cost is $4,509,819. A one-year installation period with an ensuing 49-year useful life (total of 50-year planning period) for the project is expected. Net annual O&M expenditures are expected to decrease (**Table 6**).

Off-farm water savings are predicted to be forthcoming from the single-component project. Expected water savings over the 49-year useful life are 414,673 nominal ac-ft, which translate into a 2003 basis of 173,660 real ac-ft (**Table 9**). Energy production estimates associated with the Main Canal are 104,700,027,121 BTU (30,685,823 kwh) in nominal terms and 43,847,187,938 BTU (12,850,876 kwh) in real 2003 terms (**Table 9**).

Economic and financial costs of *water* savings forthcoming from the Main Canal are estimated at **$33.37** per ac-ft (**Table 9**). Sensitivity analyses indicate this estimate can be affected by variances in (a) the amount of water savings resulting from the purchase, installation, and implementation of the lining; (b) the expected useful life of the lining; (c) the initial capital investment costs of the lining; and (d) the value of BTU savings (i.e., price of energy).

Economic and financial costs of *energy* savings forthcoming from the lining are estimated at **$0.0001322** per BTU (**$0.451** per kwh) (**Table 9**). Sensitivity analyses indicate factors of importance are (a) the amount of energy production resulting from the purchase, installation, and implementation of the investment; (b) the expected useful life of the investment; (c) the initial capital investment costs; and (d) the amount of *off- farm* water savings.

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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 to prevent seepage, resulting in increase flow rates.

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

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

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

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

Diversion points: Point along a canal 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 dollar values.

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

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

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

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

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

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

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

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

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

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

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.

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

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

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

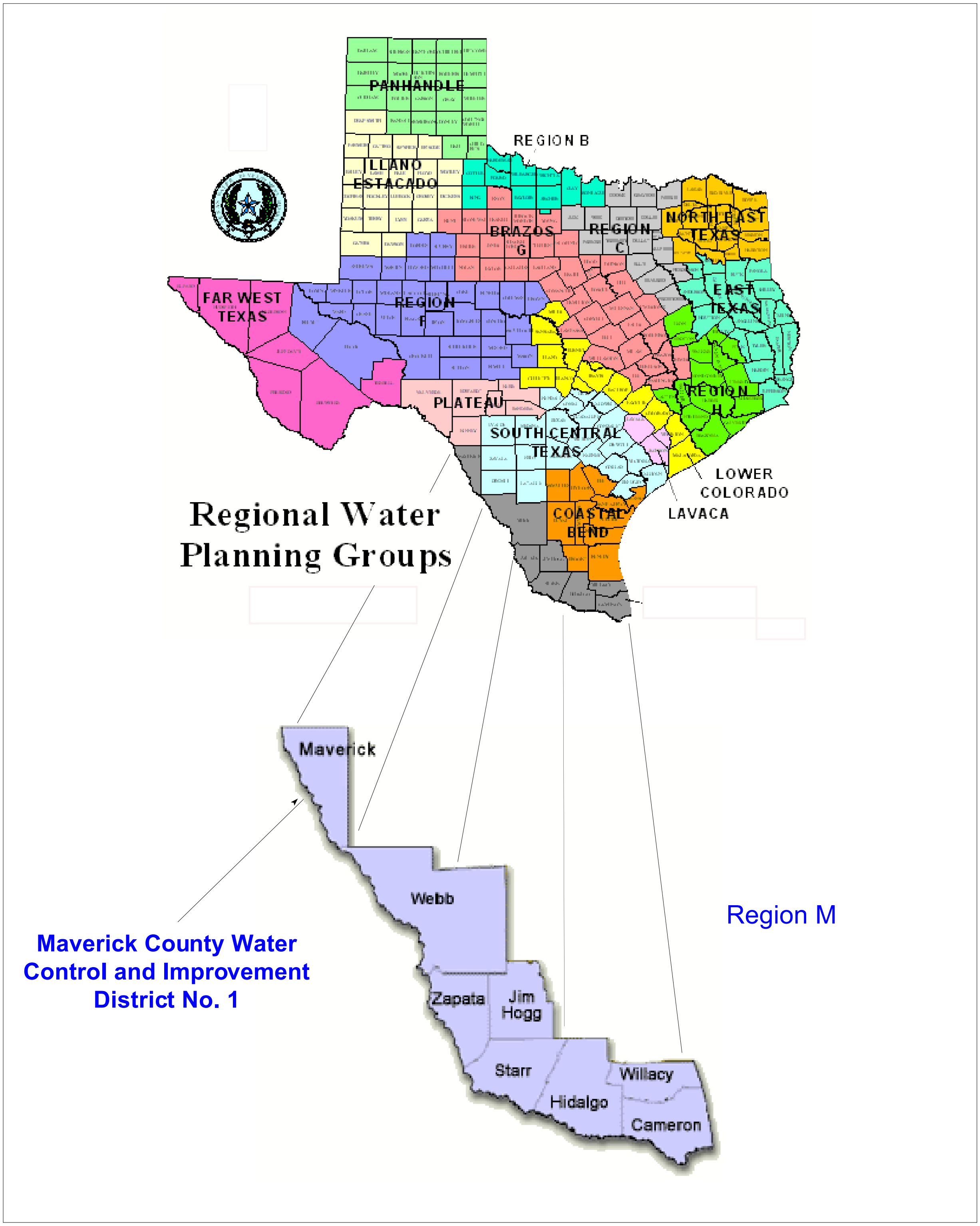

Exhibit 1. Illustration of Maverick County Water Control and Improvement District Within the Region M Water Planning Group of Texas (RGRWPG).

Exhibit 2. Eagle Pass, TX – Location of Maverick County Water Control and Improvement District No. 1 Office (MapQuest).

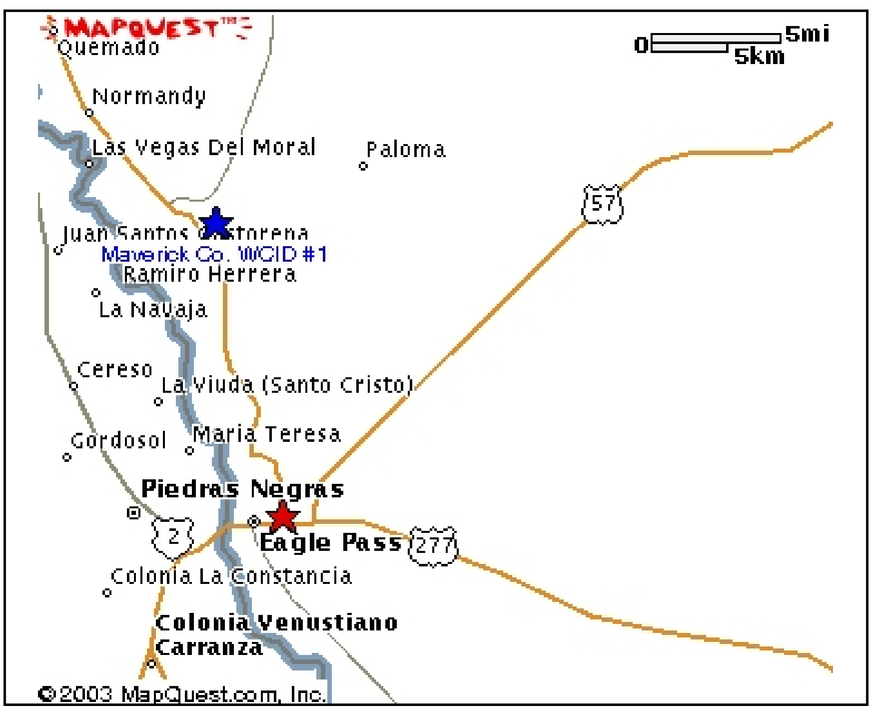

Exhibit 3. Detailed Location of Maverick County Water Control and Improvement District No. 1 Office in Eagle Pass, TX (MapQuest).

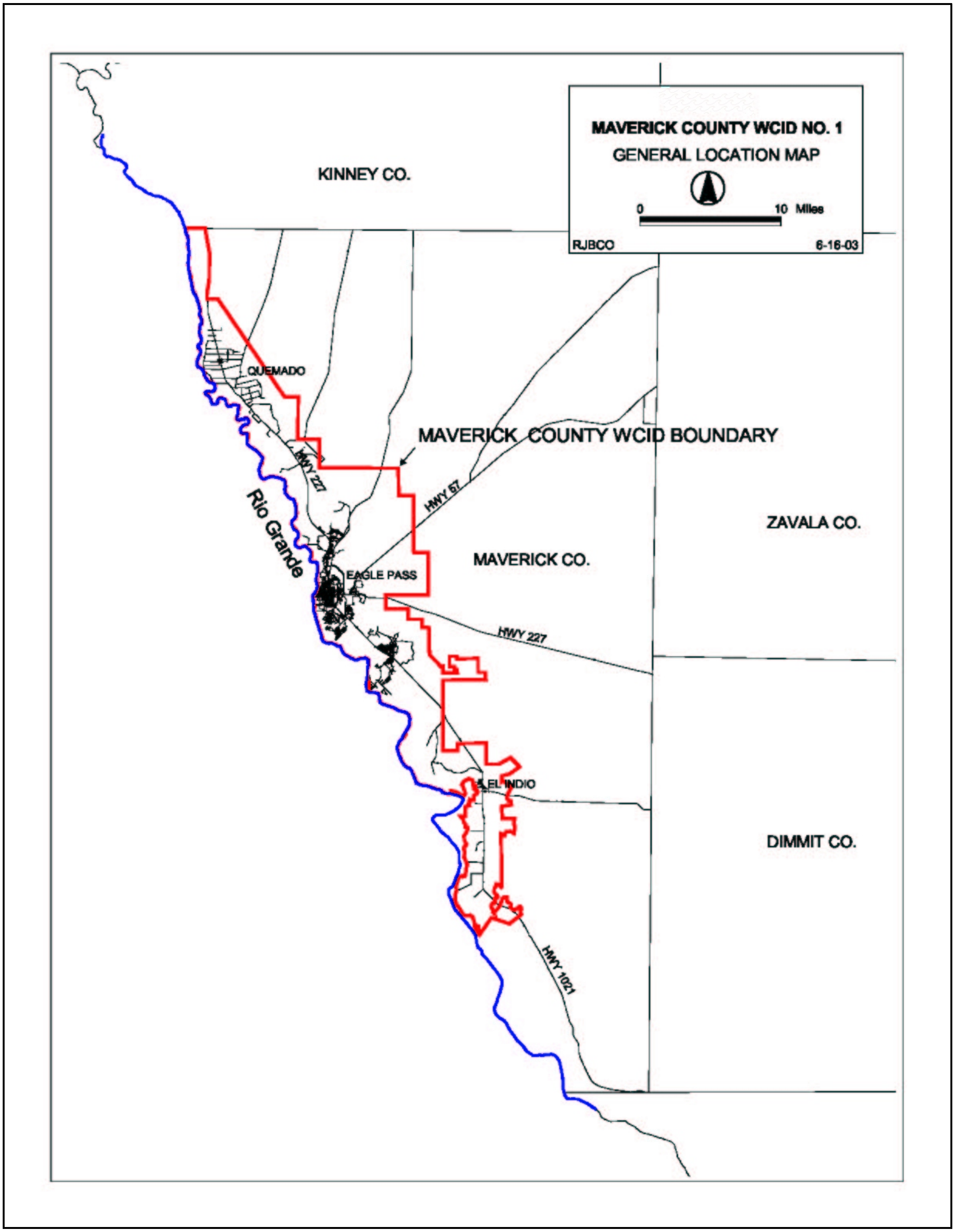

Exhibit 4. Illustrated Layout of Maverick County WCID No. 1 (Purkeypile).

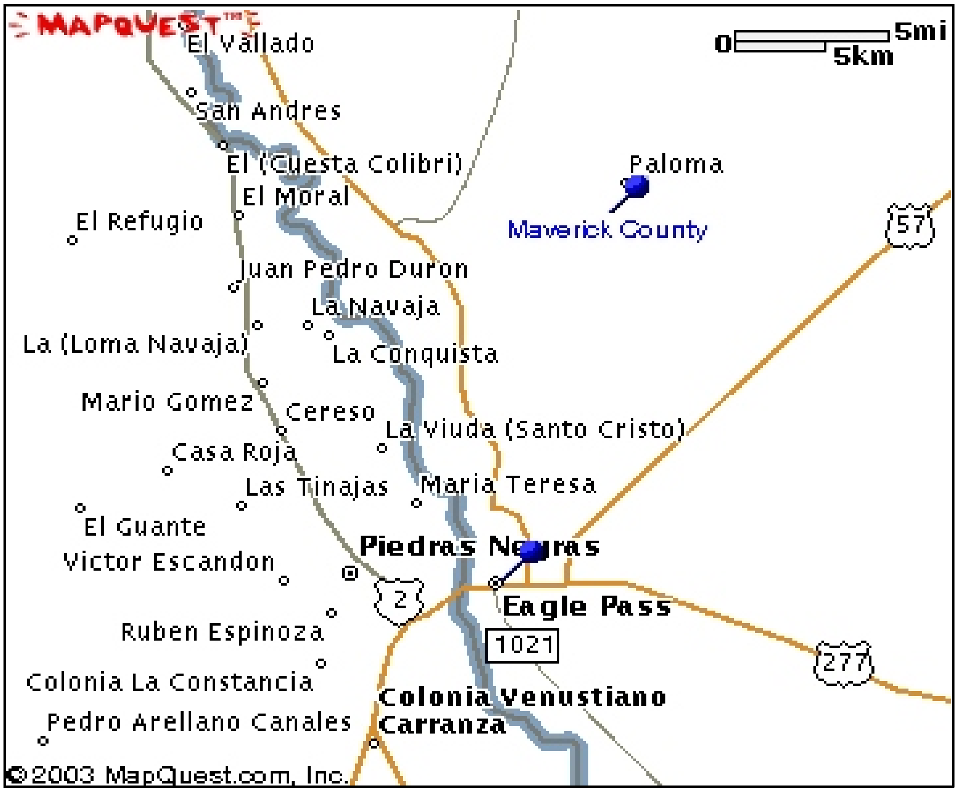

Exhibit 5. Location of Primary Municipalities and Water Supply Corporations Served by Maverick County Water Control and Improvement District No. 1 (MapQuest).

Tables

Table 1. Average Acreage Irrigated by Maverick County Water Control and Improvement District No. 1 for Calendar Year 2002 (R. J. Brandes Company 2003b).

	calendar year					5-year average	
Category / Enterprise	1998	1999	2000	2001	2002 [a]	acres	%
Field crops - annual							
SORGHUM	-	-	-	-	6,000	6,000	15.6 %
OATS	-	-	-	-	4,800	4,800	12.5 %
MISC. FIELD CROPS	-	-	-	-	3,100	3,100	8.1 %
CORN	-	-	-	-	2,000	2,000	5.2 %
SUNFLOWER	0	0	0	0	0	0	0.0 %
WHEAT	0	0	0	0	0	0	0.0 %
SOYBEAN	0	0	0	0	0	0	0.0 %
COTTON	0	0	0	0	0	0	0.0 %
						15,900	41.3 %
Citrus / Fruit							
CITRUS	0	0	0	0	0	0	0.0 %
OTHER FRUITS	0	0	0	0	0	0	0.0 %
						0	0.0 %
Pasture / Open							
PASTURE	-	-	-	-	11,800	11,800	30.6 %
OPEN LAND	0	0	0	0	0	0	0.0 %
						11,800	30.6 %
Other							
ALL OTHER	0	0	0	0	0	0	0.0 %
YARD-ACRES	0	0	0	0	0	0	0.0 %
YARD-LOTS	0	0	0	0	0	0	0.0 %
PALM-TREES	0	0	0	0	0	0	0.0 %
OTHER TREES	0	0	0	0	0	0	0.0 %
LAKE	0	0	0	0	0	0	0.0 %
GOLF COURSE	0	0	0	0	0	0	0.0 %
						0	0.0 %
Vegetables							
OTHER VEGETABLES	-	-	-	-	2,100	2,100	5.5 %
CABBAGE	-	-	-	-	800	800	2.1 %
ONIONS	-	-	-	-	700	700	1.8 %
PICKLES	0	0	0	0	0	0	0.0 %
GREENS	0	0	0	0	0	0	0.0 %
BEANS	0	0	0	0	0	0	0.0 %
BEETS	0	0	0	0	0	0	0.0 %
BROCCOLI	0	0	0	0	0	0	0.0 %
TOMATOES	0	0	0	0	0	0	0.0 %
PEPPERS	0	0	0	0	0	0	0.0 %
CARROTS	0	0	0	0	0	0	0.0 %
SQUASH	0	0	0	0	0	0	0.0 %
CUCUMBERS	0	0	0	0	0	0	0.0 %
LETTUCE	0	0	0	0	0	0	0.0 %
CILANTRO	0	0	0	0	0	0	0.0 %
CELERY	0	0	0	0	0	0	0.0 %
CAULIFLOWER	0	0	0	0	0	0	0.0 %
LEEKS	0	0	0	0	0	0	0.0 %
						3,600	9.4 %
Field Crops - perennial							
PECANS	-	-	-	-	5,500	5,500	14.3 %
SUGAR CANE	0	0	0	0	0	0	0.0 %
						5,500	14.3 %
Hay							
OTHER HAY	0	0	0	0	0	0	0.0 %
ALFALFA HAY	0	0	0	0	0	0	0.0 %
OTHER GRASSES	0	0	0	0	0	0	0.0 %
						0	0.0 %
Melons							
WATERMELONS	-	-	-	-	1,000	1,000	2.6 %
CANTALOUPES	-	-	-	-	700	700	1.8 %
HONEYDEW, ETC.	0	0	0	0	0	0	0.0 %
						1,700	4.4 %
Total					38,500	38,500	100.00%

[a] Acreage has been "steady" for the 1998-2002 period with 2002 data being representative of the 5-year average (Cooley).

Table 2. Historic Water Use (acre-feet), Maverick County Water Control and Improvement District No. 1, 1994-1998 (Cooley, Purkeypile).

	------------ Calendar Year ------------ (values in annual ac-ft)					
Use [a]	**1994**	**1995**	**1996**	**1997**	**1998**	**5-year average**
M&I Use	-	-	-	-	-	-
Ag Irrigation Use	105,893	68,231	73,253	68,231	42,677	71,657
Total	-	-	-	-	-	-

[a] Only Ag Irrigation Use values for 1994-1998 were provided by the District and consulting engineer, with diversions for years 1995 and 1997 appearing to be equal.

Table 3. Selected Summary Information for Maverick County Water Control and Improvement District No. 1, 2003 (Cooley).

Item	**Description / Data**
Certificates of Adjudication (Type Use \\ ac-ft):	**Class "A"** 2671 (Irrigation \\ 134,900.0 ac-ft); 2671 (Municipal/Domestic (El Indio Water Supply) \\ 2,049.0 ac-ft); 2671 (Hydro-electric (AEP Power Plant) \\ 1,085,966.0 ac-ft); 2671 (Recreation \\ 100.0 ac-ft); 2688 (Irrigation (Quemado Creek) \\ 725.0 ac-ft); and 2688 (Irrigation (Canon Grande Creek) \\ 270.0 ac-ft).
Municipalities Served	Maverick County; City of Eagle Pass; and City of Eagle Pass - formerly El Indio Water Supply.
District Water Rates:	**Volumetric-priced Irrigation:** Flat Rate Fee ($7.00 per acre, whether irrigated or not); plus Water Assessment Fee ($7.00 per acre irrigated, possibly waved); plus Water Delivery Fee ($3.50 per ac-ft delivered); **Domestic Delivery:** ($33.25 per ac-ft); **Municipal Delivery**: ($73.00 per ac-ft); **Livestock Delivery**: ($13.25 per ac-ft, $73.00 per ac-ft if no irr. account); and **AEP Power Plant Delivery**: ($0.018 per kwh, with avg 74 kwh/ac-ft delivered).
Avg. Lift at Rio Grande:	n/a; District operates entirely by gravity flow.

Table 4. Selected Summary Characteristics of Proposed Lining 3 Miles of Main Canal for BOR and NADB Project, Maverick County Water Control and Improvement District No. 1, 2003 (Cooley, Purkeypile).

Characteristic Item	Description / Data
Project Name:	Main Canal
Project Type:	Lining Installation
Proposed Activity Description:	Replace 3 miles of the Main Canal (i.e., earthen section) with a urethane lining and concrete anchor and ballast system.
Canal / Project Length:	
- feet	15,840
- miles	3.0

Table 5. Summary of Annual Water and Energy Savings Data (basis 2003) for Lining 3 Miles of the Main Canal for BOR and NADB Project, Maverick County Water Control and Improvement District No. 1, 2003 (Cooley, Purkeypile).

Item/Savings	Amount of Annual Water Savings by Type			Total Water Savings (ac-ft)	Associated Annual Energy Savings		
	Reduced Seepage (ac-ft)	Reduced Blow-outs (ac-ft)	Reduced Percolation (ac-ft)		BTU	kwh	$[a]
Annual Energy & Water Savings							
Agricultural Irrigation Use:							
Off-farm (reduced seepage)	8,400.0	0.0	0.0	8,400.0	2,120,899,200	621,600	$ 0
Off-farm (reduced blow-outs) - apportioned	0.0	62.7	0.0	62.7	15,836,047	4,641	0
Off-farm (reduced over deliveries)	0.0	0.0	0.0	0.0	0	0	0
Off-farm (reduced relifting)	0.0	0.0	0.0	0.0	0	0	0
On-farm (reduced percolation)	0.0	0.0	0.0	0.0	0	0	0
Sub-total	8,400.0	62.7	0.0	**8,462.7**	2,136,735,247	626,241	$ 0
Municipal and Industrial Use:							
Off-farm	0.0	0.0	0.0	0.0	0	0	0
On-farm	0.0	0.0	0.0	0.0	0	0	0
Sub-total	0.0	0.0	0.0	0.0	0	0	0
Total	8,400.0	62.7	0.0	**8,462.7**	2,136,735,247	626,241	$ 0

[a] The dollar value of energy savings is not displayed with the energy savings, as with previous reports (e.g., Rister et al. 2003a-k). In this analysis, the energy savings $'s are, in fact, increased revenues generated by increased water-delivery fees provided for by the project's forecasted water savings, and are accounted for in the analysis by a present value calculation vs. projecting and discounting the annual nominal amount displayed here. This approach prevents a distortion of BOR-legislated values.

Table 6. Summary of Project Cost and Expense Data for Lining 3 Miles of the Main Canal for BOR and NADB Project (2003 dollars), Maverick County Water Control and Improvement District No. 1 (Purkeypile, Cooley).

	Component #1 (Main Canal) [a]		
		Expenses / Revenues	
Item	**Years**	**(total $'s)**	**($/mile)**
Installation Period	1		
Productive Period	49		
Planning Period	50		
Initial Capital Investment Costs [b]		$ 4,509,819	$ 1,503,273
Annual Increases in O&M Expenses		$ 1,500	$ 500
Annual Decreases in O&M Expenses		$ 24,711	$ 8,237
Net Changes in Annual O&M Expenses		$ (23,211)	$ (7,737)
Value of Economic Benefit – Reclaimed Property (revenue)		$ 0	$ 0
Value of Economic Benefit – Increased water deliveries to AEP Power Plant [c]		$ 184,702	n/a
Value of Economic Cost – Interruption in water deliveries to AEP Power Plant [d]		$ 320,000	n/a

[a] Component #1- Main Canal is lining 15,840 feet (3.0 miles) of an earthen segment of the Main Canal. This is the only project component evaluated; thus, there are no aggregate values across multiple components to display and/or discuss.

[b] This value is the cost used in this economic and conservation analysis and report. Based on discussions with Bureau of Reclamation management (April 9, 2002; Austin, TX), 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, with the final design phase of this project.

[c] A present-value of the anticipated increased revenue from increased future water deliveries to the AEP Power Plant as enabled by the project's water savings. Serving as a credit towards the project's construction, an implicit assumption is that annual Rio Grande diversions will be at "normal" levels because the hydro-electric plant ranks last in priority, and therefore municipalities and agriculture must have received their desired diversions.

[d] The project's installation is expected to interrupt water deliveries (i.e., sales revenue) to the AEP Power Plant for 4 months, averaging $80,000/month.

Table 7. Details of Cost Estimate for Lining 3 Miles of the Main Canal for BOR and NADB Project (2003 dollars), Maverick County Water Control and Improvement District No. 1 (Purkeypile).

Item	**($)'s**
Purchase and Mobilize Materials	$ 3,417,846.40
Unlisted Items	0.00
Construction Management (Construction Phase Services)	205,070.78
Contingencies	341,784.64
In-Kind (District Installation Labor):	545,117.60
Total Project Costs [a]	$ 4,509,819.42

[a] This value is the cost used in this economic and conservation analysis and report. Based on discussions with Bureau of Reclamation management (April 9, 2002; Austin, TX), 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.

Table 8. Selected Energy Data and Key Results For Analyses With and Without Energy Savings, Maverick County Water Control and Improvement District No. 1, Lining 3 Miles of Main Canal for BOR and NADB Project, 2003.

Selected Energy Data		
	Without Energy Savings	**With Energy Savings** [a]
Average kwh generated per ac-ft of water at the AEP Power Plant	n/a	74
Average kwh generated per ac-ft of water at the AEP Power Plant	n/a	252,488
Revenue rate for hydro-electric water deliveries for each kwh generated	n/a	$0.018
Comparing Analyses for Scenarios *Without* and *With* Energy Savings - - Composite Economic and Finance Values (Real) [b] - -		
Water Savings (ac-ft)		
Power Plant Generation	173,660	173,660
annuity equivalent	8,084	8,084
Energy Savings (BTU)		
Power Plant Generation	0	43,847,187,938
annuity equivalent	0	2,041,095,338
Energy Savings (kwh)		
Power Plant Generation	0	12,850,876
annuity equivalent	0	598,211
Cost of Water Savings ($/ac-ft)	$ 34.68	$ 33.37
Cost of Energy Savings ($/BTU)	n/a	$ 0.0001322
Cost of Energy Savings ($/kwh)	n/a	$ 0.451
- - Bureau of Reclamation's Legislative Values (Real) [b] - -		
Dollar of Initial Construction Costs per Ac-Ft of Water Saved	$ 25.97	$ 25.97
Dollar of Initial Construction Costs per BTU of Energy Saved	n/a	$ 0.0001029
Dollar of Initial Construction Costs per kwh of Energy Saved	n/a	$ 0.351
Dollar of Initial Construction Costs per $ of Annual Economic Savings	-27.100	-13.649

[a] Provided by Cooley and Purkeypile.
[b] Determined using a 4% discount factor.

Table 9. Economic and Financial Evaluation Results Across the Project's Useful Life, Maverick County Water Control and Improvement District No. 1, Lining 3 Miles of the Main Canal for BOR and NADB Project, 2003.

Results	Nominal	Real[a]
Water Savings (ac-ft)		
Power Plant Generation	414,673	173,660
Agriculture Irrigation	0	0
M&I	0	0
Total ac-ft	414,673	173,660
annuity equivalent		8,084
Energy Savings (BTU)		
Power Plant Generation	104,700,027,121	43,847,187,938
Agriculture Irrigation	0	0
M&I	0	0
Total BTU	104,700,027,121	43,847,187,938
annuity equivalent		2,041,095,338
Energy Savings (kwh)		
Power Plant Generation	30,685,823	12,850,876
Agriculture Irrigation	0	0
M&I	0	0
Total kwh's	30,685,823	12,850,876
annuity equivalent		598,211
NPV of Initial Capital Investment Costs and Changes in O&M Expenditures, Including Energy Cost Savings	$ 2,691,221	$ 4,179,406
annuity equivalent		$ 269,797
Cost of Water Savings ($/ac-ft)		$ 33.37
NPV of Initial Capital Investment Costs and Changes in O&M Expenditures, Ignoring Both Energy Cost Savings and Value of Water Savings	$ 2,691,221	$ 4,179,406
annuity equivalent		$ 269,797
Cost of Energy Savings ($/BTU)		$ 0.0001322
Cost of Energy Savings ($/kwh)		$ 0.451

[a] Determined using a 4% discount factor.

Table 10. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings for 15,840 Feet (3.0 Miles) of Earthen Main Canal and Expected Useful Life of the Capital Investment, Maverick County Water Control and Improvement District No. 1, Lining Main Canal, for BOR and NADB Project, 2003.

	ac-ft of annual water loss (seepage) for 3 Miles of earthen Main Canal										
		4,200	5,050	5,900	6,725	7,550	**8,400**	9,250	10,075	10,925	11,750
Expected Useful life of Investment (years)	10	$145.82	$121.05	$103.42	$90.57	$80.53	$72.25	$65.49	$60.02	$55.25	$51.28
	20	$93.35	$77.42	$66.07	$57.81	$51.35	$46.02	$41.67	$38.15	$35.08	$32.52
	25	$83.71	$69.40	$59.21	$51.79	$45.98	$41.20	$37.29	$34.13	$31.37	$29.08
	30	$77.71	$64.41	$54.94	$48.04	$42.65	$38.20	$34.57	$31.63	$29.07	$26.93
	40	$71.06	$58.88	$50.21	$43.89	$38.95	$34.88	$31.55	$28.86	$26.51	$24.56
	49	$68.06	$56.38	$48.07	$42.01	$37.28	**$33.37**	$30.19	$27.61	$25.36	$23.49

Table 11. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings for 15,840 Feet (3.0 Miles) of Earthen Main Canal and Initial Cost of the Capital Investment, Maverick County Water Control and Improvement District No. 1, Lining Main Canal, for BOR and NADB Project, 2003.

	ac-ft of annual water loss (seepage) for 3 Miles of earthen Main Canal										
		4,200	5,050	5,900	6,725	7,550	**8,400**	9,250	10,075	10,925	11,750
Initial Capital Investment Cost ($)	$(500,000)	$60.07	$49.74	$42.39	$37.03	$32.84	$29.38	$26.56	$24.28	$22.29	$20.63
	$(250,000)	$64.07	$53.06	$45.23	$39.52	$35.06	$31.38	$28.37	$25.94	$23.82	$22.06
	$(100,000)	$66.46	$55.05	$46.93	$41.02	$36.39	$32.58	$29.46	$26.94	$24.74	$22.91
	$ -	$68.06	$56.38	$48.07	$42.01	$37.28	**$33.37**	$30.19	$27.61	$25.36	$23.49
	$100,000	$69.66	$57.71	$49.21	$43.01	$38.17	$34.17	$30.91	$28.27	$25.97	$24.06
	$250,000	$72.05	$59.70	$50.91	$44.51	$39.50	$35.37	$32.00	$29.27	$26.89	$24.91
	$500,000	$76.04	$63.02	$53.76	$47.00	$41.72	$37.37	$33.81	$30.94	$28.43	$26.34

Table 12. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings for 15,840 Feet (3.0 Miles) of Earthen Canal and Value of Energy Savings, Maverick County Water Control and Improvement District No. 1, Lining Main Canal, for BOR and NADB Project, 2003.

		ac-ft of annual water loss (seepage) for 3 Miles of earthen Main Canal									
		4,200	5,050	5,900	6,725	7,550	**8,400**	9,250	10,075	10,925	11,750
Value of Energy Savings ($/kwh)	$0.0090	$68.71	$57.04	$48.73	$42.67	$37.93	$34.03	$30.84	$28.26	$26.01	$24.14
	$0.0125	$68.46	$56.78	$48.47	$42.41	$37.68	$33.77	$30.59	$28.01	$25.76	$23.89
	$0.0160	$68.20	$56.53	$48.22	$42.16	$37.42	$33.52	$30.33	$27.75	$25.50	$23.63
	$0.0180	$68.06	$56.38	$48.07	$42.01	$37.28	**$33.37**	$30.19	$27.61	$25.36	$23.49
	$0.0200	$67.91	$56.24	$47.93	$41.87	$37.13	$33.23	$30.04	$27.46	$25.21	$23.34
	$0.0235	$67.66	$55.98	$47.67	$41.61	$36.88	$32.97	$29.79	$27.21	$24.96	$23.09
	$0.0275	$67.37	$55.69	$47.38	$41.32	$36.59	$32.68	$29.50	$26.92	$24.67	$22.79

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, Maverick County Water Control and Improvement District No. 1, Lining Main Canal, for BOR and NADB Project, 2003.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		201,990	227,239	239,864	246,176	**252,488**	258,800	265,112	277,737	315,610	378,732
Expected Useful life of Investment (years)	10	$0.0003590	$0.0003185	$0.0003015	$0.0002936	$0.0002862	$0.0002790	$0.0002723	$0.0002597	$0.0002279	$0.0001890
	20	$0.0002291	$0.0002031	$0.0001921	$0.0001871	$0.0001823	$0.0001777	$0.0001733	$0.0001652	$0.0001448	$0.0001198
	25	$0.0002053	$0.0001819	$0.0001720	$0.0001675	$0.0001632	$0.0001591	$0.0001551	$0.0001479	$0.0001295	$0.0001070
	30	$0.0001904	$0.0001687	$0.0001595	$0.0001553	$0.0001513	$0.0001475	$0.0001438	$0.0001371	$0.0001200	$0.0000991
	40	$0.0001740	$0.0001541	$0.0001457	$0.0001418	$0.0001381	$0.0001346	$0.0001313	$0.0001251	$0.0001095	$0.0000904
	49	$0.0001665	$0.0001474	$0.0001394	$0.0001357	**$0.0001322**	$0.0001288	$0.0001256	$0.0001197	$0.0001047	$0.0000864

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, Maverick County Water Control and Improvement District No. 1, Lining Main Canal, for BOR and NADB Project, 2003.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		201,990	227,239	239,864	246,176	**252,488**	258,800	265,112	277,737	315,610	378,732
Expected Useful life of Investment (years)	10	$1.225	$1.087	$1.029	$1.002	$0.976	$0.952	$0.929	$0.886	$0.778	$0.645
	20	$0.782	$0.693	$0.656	$0.638	$0.622	$0.606	$0.591	$0.564	$0.494	$0.409
	25	$0.700	$0.621	$0.587	$0.571	$0.557	$0.543	$0.529	$0.504	$0.442	$0.365
	30	$0.650	$0.576	$0.544	$0.530	$0.516	$0.503	$0.491	$0.468	$0.409	$0.338
	40	$0.594	$0.526	$0.497	$0.484	$0.471	$0.459	$0.448	$0.427	$0.373	$0.308
	49	$0.568	$0.503	$0.476	$0.463	**$0.451**	$0.440	$0.429	$0.408	$0.357	$0.295

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, Maverick County Water Control and Improvement District No. 1, Lining Main Canal, for BOR and NADB Project, 2003.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		201,990	227,239	239,864	246,176	**252,488**	258,800	265,112	277,737	315,610	378,732
Initial Capital Investment Cost ($)	$(500,000)	$0.0001468	$0.0001299	$0.0001228	$0.0001195	$0.0001164	$0.0001134	$0.0001106	$0.0001053	$0.0000921	$0.0000759
	$(250,000)	$0.0001566	$0.0001387	$0.0001311	$0.0001276	$0.0001243	$0.0001211	$0.0001181	$0.0001125	$0.0000984	$0.0000811
	$(100,000)	$0.0001626	$0.0001439	$0.0001361	$0.0001325	$0.0001290	$0.0001257	$0.0001226	$0.0001168	$0.0001022	$0.0000843
	$ -	$0.0001665	$0.0001474	$0.0001394	$0.0001357	**$0.0001322**	$0.0001288	$0.0001256	$0.0001197	$0.0001047	$0.0000864
	$100,000	$0.0001705	$0.0001510	$0.0001427	$0.0001389	$0.0001353	$0.0001319	$0.0001287	$0.0001226	$0.0001072	$0.0000885
	$250,000	$0.0001764	$0.0001562	$0.0001477	$0.0001438	$0.0001401	$0.0001365	$0.0001332	$0.0001269	$0.0001110	$0.0000917
	$500,000	$0.0001863	$0.0001650	$0.0001561	$0.0001519	$0.0001480	$0.0001443	$0.0001407	$0.0001341	$0.0001174	$0.0000969

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, Maverick County Water Control and Improvement District No. 1, Lining Main Canal, for BOR and NADB Project, 2003.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		201,990	227,239	239,864	246,176	**252,488**	258,800	265,112	277,737	315,610	378,732
Initial Capital Investment Cost ($)	$(500,000)	$0.501	$0.443	$0.419	$0.408	$0.397	$0.387	$0.377	$0.359	$0.314	$0.259
	$(250,000)	$0.534	$0.473	$0.447	$0.435	$0.424	$0.413	$0.403	$0.384	$0.336	$0.277
	$(100,000)	$0.555	$0.491	$0.464	$0.452	$0.440	$0.429	$0.418	$0.399	$0.349	$0.288
	$ -	$0.568	$0.503	$0.476	$0.463	**$0.451**	$0.440	$0.429	$0.408	$0.357	$0.295
	$100,000	$0.582	$0.515	$0.487	$0.474	$0.462	$0.450	$0.439	$0.418	$0.366	$0.302
	$250,000	$0.602	$0.533	$0.504	$0.491	$0.478	$0.466	$0.454	$0.433	$0.379	$0.313
	$500,000	$0.636	$0.563	$0.532	$0.518	$0.505	$0.492	$0.480	$0.457	$0.400	$0.331

Table 17. Costs per BTU of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Reduced Water Losses in Earthen Main Canal, Maverick County Water Control and Improvement District No. 1, Lining Main Canal, for BOR and NADB Project, 2003.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		201,990	227,239	239,864	246,176	**252,488**	258,800	265,112	277,737	315,610	378,732
ac-ft of annual water loss (seepage) for 3 miles of earthen Main Canal	4,200	$0.0003382	$0.0003001	$0.0002840	$0.0002766	$0.0002696	$0.0002629	$0.0002565	$0.0002446	$0.0002146	$0.0001780
	5,050	$0.0002804	$0.0002487	$0.0002353	$0.0002292	$0.0002233	$0.0002177	$0.0002124	$0.0002025	$0.0001776	$0.0001471
	5,900	$0.0002393	$0.0002121	$0.0002007	$0.0001954	$0.0001904	$0.0001856	$0.0001811	$0.0001726	$0.0001513	$0.0001252
	6,725	$0.0002093	$0.0001855	$0.0001754	$0.0001708	$0.0001664	$0.0001622	$0.0001582	$0.0001508	$0.0001321	$0.0001092
	7,550	$0.0001859	$0.0001646	$0.0001557	$0.0001516	$0.0001476	$0.0001439	$0.0001404	$0.0001338	$0.0001171	$0.0000967
	8,400	$0.0001665	$0.0001474	$0.0001394	$0.0001357	**$0.0001322**	$0.0001288	$0.0001256	$0.0001197	$0.0001047	$0.0000864
	9,250	$0.0001507	$0.0001334	$0.0001261	$0.0001228	$0.0001196	$0.0001165	$0.0001136	$0.0001082	$0.0000946	$0.0000780
	10,075	$0.0001380	$0.0001221	$0.0001154	$0.0001123	$0.0001093	$0.0001066	$0.0001039	$0.0000989	$0.0000864	$0.0000712
	10,925	$0.0001268	$0.0001122	$0.0001060	$0.0001031	$0.0001004	$0.0000979	$0.0000954	$0.0000908	$0.0000793	$0.0000652
	11,750	$0.0001176	$0.0001039	$0.0000982	$0.0000955	$0.0000930	$0.0000906	$0.0000883	$0.0000841	$0.0000734	$0.0000603

Table 18. Costs per kwh of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Reduced Water Losses in Earthen Main Canal, Maverick County Water Control and Improvement District No. 1, Lining Main Canal, for BOR and NADB Project, 2003.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		201,990	227,239	239,864	246,176	**252,488**	258,800	265,112	277,737	315,610	378,732
ac-ft of annual water loss (seepage) for 3 miles of earthen Main Canal	4,200	$1.154	$1.024	$0.969	$0.944	$0.920	$0.897	$0.875	$0.834	$0.732	$0.607
	5,050	$0.957	$0.849	$0.803	$0.782	$0.762	$0.743	$0.725	$0.691	$0.606	$0.502
	5,900	$0.816	$0.724	$0.685	$0.667	$0.650	$0.633	$0.618	$0.589	$0.516	$0.427
	6,725	$0.714	$0.633	$0.599	$0.583	$0.568	$0.553	$0.540	$0.515	$0.451	$0.373
	7,550	$0.634	$0.562	$0.531	$0.517	$0.504	$0.491	$0.479	$0.456	$0.399	$0.330
	8,400	$0.568	$0.503	$0.476	$0.463	**$0.451**	$0.440	$0.429	$0.408	$0.357	$0.295
	9,250	$0.514	$0.455	$0.430	$0.419	$0.408	$0.398	$0.388	$0.369	$0.323	$0.266
	10,075	$0.471	$0.417	$0.394	$0.383	$0.373	$0.364	$0.354	$0.338	$0.295	$0.243
	10,925	$0.433	$0.383	$0.362	$0.352	$0.343	$0.334	$0.326	$0.310	$0.271	$0.223
	11,750	$0.401	$0.355	$0.335	$0.326	$0.317	$0.309	$0.301	$0.287	$0.250	$0.206

Appendix

Appendix A: Legislated Criteria Results[27]

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

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

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

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

Hamilton's suggested convention is adopted and used in the RGIDECON© model section reporting the Public Law 106-576 legislation's required measures. It is on that basis that the legislated criteria results are presented in Appendix A of this report.

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. Readers are directed to Rister et al. (2002a) for more information regarding the issues associated with comparing capital investments having differences in length of planning periods.

Component #1: Main Canal

The District's BOR and NADB project consists of lining 15,840 feet (3.0 miles) of the Main Canal a urethane lining and concrete anchor and ballast system. Details on the cost estimates and related projections of water and energy savings are presented in the main body of this report (**Tables 5, 6, 7,** and **9**). Below, a summary of the calculated values and results

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[27] Unlike other irrigation districts' proposed projects with two or more components, the MCWCID #1's project consists of a single component. Thus, only one appendix (i.e., Appendix A) is provided as presentation and discussion of aggregate legislative criteria (in an Appendix B) is not necessary.

corresponding to the legislated criteria are presented, with nominal and their discounted (i.e., real) transformations presented.

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

Summary Calculated Values

The initial construction costs associated with the purchase and installation of the urethane lining and concrete anchor and ballast system amount to $4,509,819. 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 414,673 ac-ft of nominal *off-farm* water savings are projected to occur during the productive life of the lining system, with associated energy savings of 104,700,027,121 BTU (30,685,823 kwh). Using the 4% discount rate, the present or real value of such anticipated savings become 173,660 ac-ft and 43,847,187,938 BTU (12,850,876 kwh) (**Table A1**).

The accrued annual net changes in O&M expenditures over the lining system's productive life are a total decrease of $1,788,654. Using the 2002 Federal discount rate of 6.125%, this anticipated net decrease in expenditures represents a real cost reduction of $319,734 (**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 $10.88 in a nominal sense and $25.97 in real terms, while the initial construction costs per BTU (kwh) of energy saved are $0.0000431 ($0.147) in a nominal sense and $0.0001029 ($0.351) 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 lining installation result in anticipated net decreases in annual costs (**Table A1**). Dividing the initial construction costs by the decreases in operating costs results in a ratio measure of -2.48 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 lining system. On a real basis, this ratio measure is -13.65 (**Table A2**), signifying construction costs are higher than the expected real values of economic savings in O&M during the planning period.

The proper interpretation of the ratio (i.e., initial construction cost divided by economic savings) can be somewhat difficult and involves recognition that the most desired value is negative and close to zero. 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 greater 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 less than negative one (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.

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.

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

Authors' Note

The energy savings associated with this project are somewhat analogous to the value of reclaimed land associated with the Hidalgo County Irrigation District No. 1 (a.k.a. Edinburg) project. That is, both of these items represent essentially a reduction in the net cost of the proposed projects. The economic methodology and calculated results defined by Rister et al. 2002a encompass these items. The legislative-mandated criteria being used by the Bureau of Reclamation (BOR) in scoring the various proposed rehabilitation projects does not provide for consideration of these type issues, however. That is to say, the value of the energy savings associated with the increased energy production at the AEP Power Plant is not included in the determination of the BOR's legislative criteria reported herein.

Appendix Tables

Table A1. Summary of Calculated Values for Lining Main Canal, Maverick County Water Control and Improvement District No. 1's BOR and NADB Project, 2003.

Item	Nominal PV	Real NPV
Dollars of Initial Construction Costs	$ 4,509,819	$ 4,509,819
Ac-Ft of Water Saved	414,673	173,660
BTU of Energy Saved	104,700,027,121	43,847,187,938
kwh of Energy Saved	30,685,823	12,850,876
$ of Annual Economic Savings (costs are + values and benefits [i.e., savings] are -)	$ (1,788,654)	$ (319,734)

Table A2. Legislated Evaluation Criteria for Lining Main Canal, Maverick County Water Control and Improvement District No. 1's BOR and NADB Project, 2003.

Criteria	Nominal PV	Real NPV
Dollar of Initial Construction Costs per Ac-Ft of Water Saved	$ 10.88	$ 25.97
Dollar of Initial Construction Costs per BTU of Energy Saved	$ 0.0000431	$ 0.0001029
Dollar of Initial Construction Costs per kwh of Energy Saved	$ 0.147	$ 0.351
$ of Initial Construction Costs per $ of Annual Economic Savings (costs are + values and benefits [i.e., savings] are -)	-2.480	-13.649

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