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Texas Water Resources Institute
make every drop count

Economic and Conservation Evaluation of Capital Renovation Projects: Hidalgo County Irrigation District No. 1 (Edinburg) – North Branch / East Main – Final

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Authors' Note:

The original analysis reporting on the North Branch / East Main was contained in a two-component report (i.e., TR-205) which was published in November 2002 and subsequently reviewed by the Texas Water Development Board (TWDB) and the Bureau of Reclamation (BOR). Subsequent to the original report's release, the BOR established guidelines which disallowed water savings being claimed if an additional investment would be required to realize the water savings. In addition, Hidalgo County Irrigation District No. 1 (HCID #1) and their consulting engineer (i.e., Melden & Hunt, Inc.) improved estimates of other water-saving categories and operation and maintenance expenses. Also, the initial construction cost estimate used in this analysis includes cost items (approximately $100K) previously not included in the original analysis/report. This *Final* document incorporates the revised data, as well as minor edits to the text.

This and the aforementioned report (i.e., TR-205) were developed to assist HCID #1 in their submitting of project materials to the BOR, Border Environment Cooperation Commission, and North American Development Bank. Distribution of this report will initially be limited to HCID #1 and their consulting engineer, the BOR, and the TWDB. Only after the BOR has scored and finalized the next grouping of irrigation districts' proposed capital-rehabilitation projects will the final results for this HCID #1 project be made available to other stakeholders and the public. This is anticipated to occur sometime in late 2003 or early 2004.

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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 large water mains and canals, 1,700 miles of pipelines, and 700 miles of laterals that deliver water to agricultural fields and urban areas. Yet, many of these key components are more than 100 years old, outdated and in need of repair or replacement. Texas Agricultural Experiment Station and Texas Cooperative Extension economists and engineers are collaborating with Rio Grande Basin irrigation district managers, their consulting engineers, the 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

[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).

comparison of projects with different economic lives. As a result, RGIDECON© is capable of providing valuable information for prioritizing projects in the event of funding limitations. Results of the analyses can be compared with economic values of water to conduct cost-benefit analyses. Methodology is also included in the spreadsheet for appraising the economic costs 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:

- ***George Carpenter, Joe Barrera, Sonny Hinojosa, Wayne Halbert, 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;

- ***Larry Smith, Jim Holdar, 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, and James Allard.*** These individuals are with the U.S. Bureau of Reclamation in various management, engineering, and environmental roles. They have been instrumental in fostering a collaborative environment in which several agencies mutually fulfill their responsibilities and conduct related activities. They have taken the lead in bringing the Texas Water Development Board into planning and facilitating cooperation across State and Federal agencies;

- ***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: Hidalgo County Irrigation District No. 1 (Edinburg) – North Branch / East Main – Final

Abstract

Initial construction costs and net annual changes in operating and maintenance expenses are identified for a single-component capital renovation project proposed by Hidalgo County Irrigation District No. 1 to the Bureau of Reclamation and North American Development Bank. The proposed project involves installing 4.83 miles of multi-size pipeline to replace a segment of the North Branch / East Main canal. Both nominal and real estimates of water and energy savings and expected economic and financial costs of those savings are identified throughout the anticipated 48-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 **5,838 ac-ft of water** per year and **3,293,049,926 BTUs (965,138 kwh) of energy** per year. The calculated economic and financial cost of water savings is estimated to be **$15.58 per ac-ft**. The calculated economic and financial cost of energy savings is estimated at **$0.0000392 per BTU ($0.134 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 $30.68 per ac-ft of water savings. The initial construction cost per BTU (kwh) of energy savings measure is $0.0000544 per BTU ($0.186 per kwh). The ratio of initial construction costs per dollar of total annual economic savings is estimated to be -1.58.

Bureau of Reclamation's Endorsement of RGIDECON©

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

IN REPLY
REFER TO:
TX-Clark
PRJ-8.00

JUL 24 2002

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

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

Dear Dr. Lacewell:

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

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

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

Sincerely,

M L Martin

for Larry Walkoviak
Area Manager

A Century of Water for the West
1902-2002

Economic and Conservation Evaluation of Capital Renovation Projects: Hidalgo County Irrigation District No. 1 (Edinburg) – North Branch / East Main – Final

Executive Summary

Introduction

Recognizing the seriousness of the water crisis in South Texas, the U.S. Congress enacted Public Law (PL) 106-576, entitled "The Lower Rio Grande Valley Water Conservation and Improvement Act of 2000 (Act)." Therein, Congress authorized investigation into four water conservation projects for irrigation districts relying on the Rio Grande for their municipal, industrial, and agricultural irrigation supply of water. Subsequent legislation 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. Hidalgo County Irrigation District No. 1's 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 Hidalgo County Irrigation District No. 1 has submitted its two BOR projects to BECC/NADB and has received preliminary notification of a $2,887,500 grant from NADB, pending final certification of its project proposals. Thus, the analysis reported herein supports the Hidalgo County Irrigation District No. 1's BOR and BECC/NADB project proposal for the North Branch / East Main.

Similar to their efforts on the legislation-authorized projects, Texas Agricultural Experiment Station (TAES) and Texas Cooperative Extension (TCE) economists and engineers are collaborating with Rio Grande Basin irrigation district managers, their consulting engineers, the BECC, and 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©

[1] This report contains economic and financial analysis results for a capital rehabilitation project proposed by the Hidalgo County Irrigation District No. 1. Readers interested in the methodological background and/or prior reports are directed to pp. 28-29 which identify related publications.

satisfies the legislation-authorized projects and that the BOR will use the results for economic and energy evaluation. Subsequently, the BECC has also acknowledged these analyses are adequate and acceptable for the Districts' Stage 1 and 2 submissions.

This report provides documentation of the economic and conservation analysis conducted for the Hidalgo County Irrigation District No. 1's project proposal toward its certification with BECC, as well as its proposal to the BOR. 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 approximately 20,000 acres of agricultural cropland and diverts up to 10,409 acre feet (ac-ft) for residential and commercial water users in the city of Edinburg and those areas serviced by the North Alamo Water Supply and Sharyland Water Supply Corporations. Additionally, the District provides up to 42,253 ac-ft to Santa Cruz Irrigation District No. 15. Recent agricultural water use during fiscal years 1998 - 2001 for the District has ranged from 53,792 to 67,661 ac-ft, with the four-year average at 61,804 ac-ft. Municipal and industry (M&I) water use has ranged from 8,741 to 10,466 ac-ft, with the four-year average at 9,515 ac-ft.

Proposed Project Components

The capital improvement project proposed by the District to BECC, NADB, and BOR consists of one component. Specifically, it includes:

- installing 25,500 feet of multi-size (60", 54", and 48") RG/RC[3] pipeline to replace a segment of concrete-lined canal (of the "North Branch / East Main") – this will reduce seepage and evaporation losses, reduce percolation losses by increasing head pressure at diversion points, and reduce relift pumping requirements.

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

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

3 Rubber-gasket, reinforced-concrete pipeline is abbreviated RG/RC.

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.[4]

Anticipated Water and Energy Savings

Annual water and energy savings are calculated for each component separately and also as a combined total across all components, if applicable. Water savings are comprised of and associated with (a) reductions in Rio Grande diversions, (b) increased head at farm diversion points, (c) reduced seepage losses in canals, and (d) better management of water flow. Energy savings can result from reduced diversions, reduced relift pumping, and/or efficiency improvements with new pumps and motors, and are comprised of (a) the amount of energy used for pumping and (b) the cost (value) of such energy.[5]

Cost of Water and Energy Savings

The estimated cost per ac-ft of water saved and the estimated cost of energy saved resulting from a component's purchase, installation, and implementation is analyzed to gauge 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 comprising the Hidalgo County Irrigation District No. 1's BOR and NADB project. With only one component

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

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

comprising this project, aggregation of component results are 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: North Branch / East Main [Multi-Size Pipe]

Component #1 of the District's proposed BOR and NADB project consists of installing 25,500 feet of 60", 54", and 48" rubber-gasket, reinforced concrete pipeline to replace segments of concrete-lined canal. The installation period is projected to take two years with an ensuing expected useful life of 48 years. No losses of operations or otherwise adverse impacts are anticipated during the installation period since this will occur in the off-season.

Initial and O&M Costs

Estimated initial capital investment costs total $3,847,125 ($796,581 per mile). Annual increases in O&M expenditures of $6,964 ($1,442 per mile of canal converted to pipeline) are expected. Additionally, reductions in annual O&M expenditures of $75,070 ($15,544 per mile) are anticipated for discontinued maintenance. Therefore, a net decrease in annual O&M costs of $68,107 ($14,102 per mile) (basis 2003) is expected.[6]

Anticipated Capital Recovery

The conversion of open, concrete-lined canal into pipeline provides the potential for the recovery of some land for alternative uses. It is anticipated that in association with this component, 34.09 acres of land will be marketable through ensuing years at a real 2003 value of $511,364. These "capital recovery" dollars are considered a reduction in the real costs of this component.

Anticipated Water and Energy Savings

Both *off-* and *on-farm* water savings are predicted to be forthcoming from the 25,500 feet of multi-size (60", 54", 48") pipeline with the nominal total being 307,200 ac-ft over the 48-year productive life of this component and the real 2003 total being 125,415 ac-ft. Annual *off-farm* water savings estimates are based on reduced seepage and evaporation of 6,034.00 ac-ft (6,021.98 ac-ft of seepage + 12.02 ac-ft of evaporation) after the multi-size pipeline has been installed. Annual *on-farm* water savings of 366.0 ac-ft are predicted to be forthcoming from reduced percolation losses which are based on a 1-foot increase in head pressure affecting 3,330 acres. Associated energy savings estimates are 173,280,053,335 BTU (50,785,479 kwh) in nominal terms over the 48-year productive life and 70,741,906,465 BTU (20,733,267 kwh) in real 2003 terms. Energy savings are based on reduced diversions at the Rio Grande and reduced use of a relift pump within the water-delivery system.

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6 Note the 'pipeline - leak repair' expense is not included in determining O&M costs in the first year as the contractor's warranty is expected to cover any extraordinary repair-type expense (Smith).

Cost of Water and Energy Savings

The economic and financial cost of water savings forthcoming from the multi-size pipeline (60", 54", and 48") component is estimated to be $15.58 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 $90,981 (in 2003 terms) by the annuity equivalent of the total net water savings of 5,838 ac-ft (in 2003 terms). The economic and financial cost of energy savings are estimated at $0.0000392 per BTU ($0.134 per kwh). This value is obtained by dividing the annuity equivalent of the total net cost stream for energy savings from all sources of $129,032 (in 2003 terms) by the annuity equivalent of the total net energy savings of 3,293,049,926 BTU (965,138 kwh) (in 2003 terms).

Summary

The following table summarizes key information regarding the single-component of Hidalgo County Irrigation District No. 1's project proposed to BOR and NADB, 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 Hidalgo County Irrigation District No. 1's North Branch / East Main Project Proposal to BOR and NADB, 2003.

	Project Component
	N. Branch / E. Main (Multi-Size Pipeline)
Initial Investment Cost ($)	$ 3,847,125
Expected Useful Life (years)	48
Net Changes in Annual O&M ($)	($ 68,107)
Annuity Equivalent of Net Cost Stream – Water Savings ($/yr)	$ 90,981
Annuity Equivalent of Water Savings (ac-ft)	5,838
Calculated Cost of Water Savings ($/ac-ft)	**$ 15.58**
Annuity Equivalent of Net Cost Stream – Energy Savings ($/yr)	$ 129,032
Annuity Equivalent of Energy Savings (BTU)	3,293,049,926
Annuity Equivalent of Energy Savings (kwh)	965,138
Calculated Cost of Energy Savings ($/BTU)	**$ 0.0000392**
Calculated Cost of Energy Savings ($/kwh)	**$ 0.134**

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.

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 $30.68 per ac-ft of water savings which is higher than the comprehensive economic and financial value of **$15.58 per ac-ft** identified and discussed in the main body of the analysis report. The differences in these values are attributable to the incorporation of both initial capital costs and changes in operating expenses in the latter value, and its treatment of the differences in the useful lives of the respective component(s) of the proposed project.

The initial construction cost per BTU (kwh) of energy savings measure is $0.0000544 per BTU ($0.186 per kwh). These cost estimates are higher than the **$0.0000392 per BTU ($0.134 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 -1.58, 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) $1.58 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: Hidalgo County Irrigation District No. 1 (Edinburg) – North Branch / East Main – Final

Introduction

Hidalgo County Irrigation District No. 1's proposed North Branch / East Main 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 the single-component project comprising the Hidalgo County Irrigation District No. 1's proposed project to the Border Environment Cooperation Commission (BECC), the North American Development Bank (NADB), and the Bureau of Reclamation (BOR) during the Fall of 2003.[1]

Irrigation District Description[2]

Twenty-eight irrigation districts exist in the Texas Lower Rio Grande Valley (**Exhibit 1**).[3] The Hidalgo County Irrigation District No. 1 office is located in Edinburg, Texas (**Exhibits 2** and **3**). The District boundary covers 38,285 acres of Hidalgo County (**Exhibit 4**). Postal and street addresses are P.O. Box 870, 1904 N. Expressway 281, Edinburg, TX 78540. Telephone contact information is 956/383-3886 and the fax number is 956/383-5593. George Carpenter is the District Manager, with Larry Smith of Melden & Hunt, Inc., Edinburg, TX, serving as the consulting engineer for this project.

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1 Readers interested in the methodological background and/or prior reports are directed to pp. 28-29 which identify related publications.

2 The general descriptive information presented was assimilated from several sources, including documents provided by George Carpenter (the District manager), the IDEA website maintained by Guy Fipps and his staff in the Department of Biological and Agricultural Engineering at Texas A&M University, College Station, Texas, the Project Plan and Environmental Information Summary submissions (Melden & Hunt, Inc 2002a-b, 2003) to the Border Environment Cooperation Commission (BECC) and Bureau of Reclamation (BOR), the BECC's Project Strategic Plan for Hidalgo County Irrigation District No. 1, the Region M Rio Grande Regional Water Planning Group report, and Fipps' Technical Memorandum in the latter report (Fipps 2000).

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

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

Irrigated Acreage and Major Crops

The District delivers water to approximately 20,000 acres of agricultural cropland within its district. Furrow irrigation accounts for approximately 70-75% of irrigation deliveries. Special turnout connections are provided, as requested, to the small percentage of district customers utilizing polypipe, gated pipe, etc. Flood irrigation is the norm for orchards, sugarcane, and pastures. The typical crop mix across the District is noted in **Table 1**, which illustrates the relative importance (on an acreage basis) of vegetables, citrus, corn, sugarcane, etc. The crop mix distribution within a particular irrigation district may vary considerably depending on output prices and the relative available local water supplies. For example, in water-short years, sugarcane acreage, although a perennial crop, may “migrate” to districts and/or areas appearing to be water-rich, in a relative sense.

Municipalities Served

The District’s priority in diverting water is to first meet the demands of residential and commercial users[4] within the District. To facilitate delivery, the District holds 10,409 acre feet (ac-ft) of water rights for M&I diversions to the city of Edinburg, the North Alamo and Sharyland Water Supply Corporations, and an additional 42,253 ac-ft of water rights for Santa Cruz Irrigation District No. 15 (**Exhibit 5**). After fulfilling municipalities’ requirements, needs of agricultural irrigators are addressed.

It is important to note that each irrigation district is responsible, under normal “non-allocation status” situations, for maintaining a fully-charged delivery system, thereby providing “push water” to facilitate delivery of municipal water. When on an “allocation status” and when individual irrigation district water supplies (including account balances) are inadequate for charging an irrigation district’s delivery system to facilitate municipal water delivery, however, Rio Grande Valley-wide irrigation districts (i.e., as a collective group, drawing on all of their account balances) are responsible for providing the necessary water to facilitate delivery of municipal water in individual irrigation districts (Hill).

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

Historic Water Use

The most recent four years (i.e., 1998-2001) demonstrate a range of water use in the District (**Table 2**). Agricultural use has ranged from 53,792 to 67,661 ac-ft with an average of 61,804 ac-ft. M&I water use has ranged from 8,741 to 10,466 ac-ft with the average at 9,515 ac-ft. The average total water diverted within the District during this time period is 71,318 ac-ft with a range from 62,606 to 78,127 ac-ft. Although the District relies upon the Rio Grande for its water, the District's agricultural water diversions during recent years have not been significantly hampered by deficit allocations forthcoming from the Rio Grande. Thus, the four-year water use figures are appropriate for use in forecasting future diversions (Carpenter).[5]

Assessment of Technology and Efficiency Status

The District's pumping plant diverts water from the Rio Grande near the town of Penitas (**Exhibit 5**). From there, the water flows 14 miles until it reaches the cities of McAllen and Edinburg where the District boundary begins. The current pumping plant, which has an average lift at the Rio Grande of 33 feet (**Table 3**), was built in 1926 and has a typical operating capacity of 450 cfs and a maximum of 600 cfs. More than 92 miles of canal, 109 miles of pipeline, 12 relift pumping stations, and one 500 ac-ft storage reservoir comprise the District's delivery-system infrastructure.

The District has been aggressive in increasing the maximum amount of water deliverable to each turnout while also increasing its overall efficiency by reducing irrigation time requirements. The District has initiated a Geographic Information System (GIS) program for linking a mapping system to a database, indicating where water has been ordered, for what types of crops, the various systems necessary to deliver the water, etc. Volumetric pricing in water deliveries has become more acceptable, with approximately 40-50 percent of current agricultural water use volumetrically measured. Producers' use of water-conserving methods and equipment is encouraged (Carpenter).

Water Rights Ownership and Sales

The District holds Certificates of Adjudication No's. 0816-000, 0816-001, 0816-002, and 0816-003 (**Table 3**). 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

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5 The supply/demand balance within irrigation districts varies. In recent years, some districts have had appropriations matching their demands, while others have not. Having extreme unavailability of water supplied is an event realized with a previous irrigation-district analysis report (i.e., 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 - - report TR-241), 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).

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 transportation delivery loss charged by the District; that is, purchase or lease of one ac-ft of water from sources inside or outside the District will result in users receiving some amount less than one ac-ft at their diversion point.

Water charges assessed irrigators within the District consist of an annual flat-rate maintenance and operations fee assessment of $18.00 per irrigated acre (which is paid for by the landowner) (**Table 3**). An additional $9.00 per acre per irrigation is assessed (either to the landowner-operator, or tenant-producer), with such irrigations approximated at 0.61 ac-ft per acre. On an ac-ft basis, this equates to a variable charge of $14.75 per acre. Volumetrically-priced irrigation water is priced at $13.50 per ac-ft in the District (Carpenter) (**Table 3**).

In the event of water supplies exceeding District demands, current District policy is to sell annual water supplies, even on long-term agreement, rather than market a one-time sale of water rights (Carpenter). 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 replacing a segment of the North Branch / East Main with multi-size (i.e., 60", 54", and 48") pipeline. Though sometimes referred to as a component within this report, it is locally referred to as the "North Branch / East Main Project" (Carpenter) (**Table 4**).[6]

Component #1: North Branch / East Main [Multi-Size Pipeline]

The "North Branch / East Main" services approximately 3,330 acres within the District. Summary data for this component of the District's proposed project, are presented (in **Tables 4, 5, 6,** and **7**) with discussion of that data following.

<u>Description</u>

This project component consists of installing 25,500 feet (or 4.83 miles) of multi-size (i.e., 60", 54", and 48") rubber-gasket, reinforced concrete pipeline to replace a segment of the North Branch / East Main. The North Branch / East Main is a concrete-lined canal (east of Edinburg, TX) which has significant seepage problems. After the concrete pipeline is installed and has effectively replaced the segment of concrete-line canal, the old concrete lining will be removed. Replacing the concrete-lined canal is expected to (**Table 5**):

a) reduce seepage losses estimated at 6,021.98 ac-ft per year;
b) reduce evaporation losses estimated at 12.02 ac-ft per year;

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

c) reduce percolation losses estimated at 366.00 ac-ft per year (caused by increased head at farm diversion points, thereby facilitating faster field irrigation); and

d) reduce relift pumping requirements within the water-delivery system for an estimated 5,348.87 ac-ft of water per year, thereby reducing energy costs further.

Installation Period

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

Productive Period

A useful life of 48 years[7] for the multi-size pipeline is expected and assumed in the baseline analysis (**Table 6**). A shorter useful life is possible, but 48 years is considered reasonable and consistent with engineering expectations (Smith). Sensitivity analyses are utilized to examine the effects of this assumption. The first year of the productive period is assumed to occur during year 3 of the 50-year planning period.

Projected Costs

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

Initial. Based on discussions with 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., excavate, purchase, install) for the 25,500 feet of multi-size pipeline total $3,847,125 ($796,581 per mile) in 2003 nominal dollars (**Tables 6** and **7**) (Melden & Hunt, Inc. 2003). Sensitivity analyses on the total amount of all capital expenditures are utilized to examine the effects of this assumption. All expenditures are assumed to occur on day one of this project's inception, thereby avoiding the need to account for inflation in the cost estimate.

Recurring. Annual operating and maintenance (O&M) expenditures associated with the installed segments of multi-size pipeline are expected to be different than those presently

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

occurring for the concrete-lined canal. Annual O&M expenditures associated with the affected canal are anticipated to be $1,442 (basis 2003 dollars) per mile of pipeline, or a total of $6,964 (**Table 6**). In the first year after installation of the multi-size pipeline, the 'pipeline - leak repair' portion of O&M are assumed to be covered by the contractor's warranty (Smith).

Projected Savings

Water. Water savings are reductions in diversions from the Rio Grande, i.e., how much less water will be used by the District as a result of this project component's installation and utilization? Estimates of such savings are comprised, in this case, of only off-farm and on-farm agricultural irrigation savings; i.e., no savings related to M&I water use are anticipated.[8]

Off-farm savings include those occurring in the District's canal system as a result of reduced seepage after the North Branch / East Main is replaced with multi-size pipeline. A previous ponding-test study in the District by Fipps and Leigh, in the East Main 23 Canal, documented an average seepage rate of 27.87 gal/ft^2/day. Using this and other data, engineering calculations indicate an estimated annual savings of 6,021.98 ac-ft from reduced seepage (Melden & Hunt, Inc. 2003) (**Table 5**). 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 (Smith), consistent with assumptions embedded in previous analyses (Rister et al. 2002b-c, 2003a-i). Additional *off-farm* water savings of 12.02 ac-ft per year (**Table 5**) are expected from reduced evaporation when the North Branch / East Main is converted to pipeline (Melden & Hunt, Inc. 2003). The combined annual *off-farm* water savings forthcoming from the piping of the North Branch / East Main are estimated at 6,034.00 ac-ft (**Table 5**) (i.e., 6,021.98 + 12.02).

On-farm water savings are estimated to be forthcoming from one source. Reduced percolation losses of 366.00 ac-ft per year are expected from increased head pressure at farm diversion points which will allow for faster irrigation of fields (Lewis and Milne) (**Table 5**). The lower percolation losses are based on the assertion that head pressure will increase by a minimum of 1-foot, which translates to an 18% savings of the irrigation water currently being applied to the project area (Melden & Hunt, Inc. 2003). Multiplying this factor by the historical farm-diversion-point delivery rate of 0.61 ac-ft per acre and by the affected project area of 3,330 acres results in an estimated 366.00 ac-ft of savings (i.e., 3,330 x 0.61 x .18 = 366) (Melden & Hunt, Inc. 2003).

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

Estimates of both the *off*- and *on-farm* water savings do not include any conveyance loss that could potentially be realized during delivery of the water from the Rio Grande to the various and numerous delivery points. Thus, all noted water savings are based on a delivered basis, which is the same as the diverted basis for this project analysis.[9]

Therefore, combining all *off*- and *on-farm* water savings (without any additional conveyance loss included) results in 6,400.00 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 North Branch / East Main pipeline'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*- and *on-farm* water savings for this project are expected to result in reduced Rio Grande diversions.

Energy. In general, energy savings for a given project may occur as a result of less water being pumped 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 amount of such energy savings and the associated monetary savings are detailed below for the District's single-component project. Energy savings associated with both reduced diversions and reduced relifting are expected with this project.

Factors constituting energy savings associated with lessened diversion and relift pumping are twofold: (a) less energy used for pumping and (b) the cost (or value) of such energy. Recent historic energy records for the District's fiscal years 2000 and 2001 are presented in **Table 8.** On average, 483,959 BTU were used to pump each ac-ft of water used. Combining this with the anticipated 6,034.0 ac-ft of annual *off-farm* water savings results in anticipated annual irrigation energy savings of 2,920,206,422 BTU (855,864 kwh) (**Table 5**). Assuming the historical average cost of $0.0216 per kwh (i.e., FY 2000-2001),[10] the estimated annual irrigation energy cost savings are $18,524 in 2003 dollars (**Table 5**).

District management estimates 15% of the total water diverted by the District is relifted in the "North Branch / East Main," and that most of this water will not be relifted once the multi-size pipeline has replaced the canal (Carpenter). Thus, additional *off-farm* energy savings will be realized as the relift pumps are bypassed. Using the District's four-year average (1998-2001) of total water pumped of 71,318 ac-ft and multiplying by 15% and an assumed 50% reduction in the

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9 The District's system-wide conveyance loss is estimated to be 20% (Fipps and Pope), as determined by total water diversions minus total water sales. 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 entire canal system. That is, with water being saved at a component/project site, the District's delivery-system infrastructure will remain fully charged as usual and will therefore not produce additional water savings beyond those realized at the component/project site (Smith).

10 This estimated value is calculated using District information provided by George Carpenter which incorporates electric and natural gas cost elements.

amount of water relifted results in an estimated 5,348.9 ac-ft of non-relifted water.[11] Using an energy price estimate of $1.95 per ac-ft (which is based upon the Penitas pumping plant energy costs and the cost relationship to the relift station) and dividing into the cost per BTU at the Penitas pumping for 2001 results in an estimated 95,846 BTU per ac-ft relifted. Thus, 5,348.9 ac-ft multiplied by 95,846 BTU results in an anticipated *off-farm* annual energy savings of 512,665,828 BTU (150,254 kwh). Using the calculated energy cost of $0.0694 per kwh[12] results in $10,432 (in 2003 terms) of additional annual *off-farm* energy cost savings (**Table 5**).

Savings anticipated for the *on-farm* reductions in water use are determined in similar fashion and also appear in **Table 5**. Using the 483,959 BTU per ac-ft at diversion and multiplying by the 366.0 ac-ft of annual *on-farm* water savings results in additional anticipated annual irrigation energy savings of 177,128,862 BTU (51,913 kwh). Assuming $0.0216 cost per kwh, the estimated annual irrigation *on-farm* energy cost savings are $1,124 in 2003 dollars.

Combining all sources of energy savings, anticipated to be forthcoming from both *off-* and *on-farm* water savings and reduced relifting, results in total anticipated irrigation energy cost savings of 3,610,001,111 BTU (1,058,031 kwh) or the equivalent of $30,080 in 2003 dollars (**Table 5**). Sensitivity analyses are performed to examine the effects of the assumptions for both the amount of energy used per ac-ft of water pumped (diverted and relifted) and the cost per unit of energy.

Operating and Maintenance. Annual O&M expenses for the existing concrete-lined North Branch / East Main are estimated to be $15,544 per mile (Carpenter). Thus, across the total 4.83 miles (25,500 feet) of canal proposed for replacing with multi-size pipe, a reduction of $75,070 in O&M expense is anticipated (**Table 6**).

Reclaimed Property. District management anticipates 34.09 acres of real property worth $511,364 (in 2003 dollars) will be reclaimed in association with this project (**Table 6**).[13] This is based on an assumed 75% marketability of affected land at $15,000 per acre (Carpenter). Funds received for the reclaimed property (i.e., sold) are assumed received by the District in a lump-sum value at the project's inception, therefore bypassing the need to estimate property appreciation rates, which would be considered revenue forecasting and external to this 'cost' analysis report. Thus, realizable cash income is claimed as a credit against the costs of this project component in the amount of $511,364.

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11 Eliminating the need to relift water saves energy, but not water; i.e., the same amount of water is still diverted and delivered to users within the District – it is just not relifted. Therefore, energy is saved by not operating the relift pumps. In this instance, the District asserts 80%+ of the water in the project area (post project installation) will not require relifting. For a conservative measure, however, the District suggests a 50% reduction be used in this analysis (Smith, Carpenter).

12 The $0.0694 per kwh energy cost estimate for within-delivery system relift pumping is higher than the $0.0216 per kwh for diversion pumping at the Rio Grande because the former relies solely on electric power while the latter depends mostly on natural gas power.

13 The 34.09 acres is derived as: [(5 miles x 5,280 ft/mile x 75-ft average land-strip width) / 43,560 ft^2 per acre] x 75% marketability assumption.

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.

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.

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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."

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 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

[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).

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 and M&I along with the total use for each of the five most recent years (1998-2002). 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 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 in more detail earlier in this report, this District's agricultural irrigation use has averaged 61,804 ac-ft during the designated 4-year period. M&I use averages 9,515 ac-ft. The average total water use within the District (including conveyance loss) during 1998-2001 is 71,318 ac-ft. These values are perceived as appropriate for gauging future use during this project's planning period (Carpenter). Since water savings are based on other criteria (i.e., not a % of historical diversions), historical diversions have no impact on the expected water savings anticipated forthcoming from this project.

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.

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

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.

Energy Usage per Acre-Foot of Water

This analysis includes calculating the cost of energy savings and also crediting the value of such savings as a reduction in O&M expenditures when evaluating the cost of water savings associated with the project.[18] The historic average *diversion-energy* usage level of 483,959 BTU per ac-ft of water diverted by the District for calendar years 2000-2001 is used to estimate energy savings resulting when less water is diverted from the Rio Grande due to implementation of the proposed project (**Table 8**). In similar fashion, an estimated average *relift-energy* usage level of 95,846 BTU per ac-ft of water relifted is used to estimate energy savings when less water is relifted within the Districts' water-delivery system.[19] Thus, it is anticipated 483,959 BTU will be saved when Rio Grande diversions are reduced by one ac-ft, and for each ac-ft not relifted within the District, an additional 95,846 BTU will be saved. Another important assumption is there are 3,412 BTU per kwh (Infoplease.com). This equivalency factor allows for converting the energy savings information into an alternative form for readers of this report.

Value of Energy Savings per BTU/kwh

Correspondingly, historic average costs of diversion and relift energy are used to transform the expected energy savings into economic dollar values. Records for calendar years 1998-2002 indicate *diversion-energy* costs for the District have ranged from \$2.63 to \$3.54 per ac-ft diverted, with the average of \$3.08 per ac-ft used in this analysis report (**Table 8**). Since separate records for relift energy were not available, the average electric energy cost for diversions of \$1.95 per ac-ft was used (as described in footnote 19) as an estimate for *relift-energy* costs in this analysis. Sensitivity analyses are utilized to examine the implications of these estimates.

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

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18 "There are interests in identifying mutually-exclusive estimates of the costs per unit of (a) water saved and (b) energy saved for the respective projects and their component(s). 'Mutually-exclusive' refers to each respective estimate being calculated independent of the other. The measures are not intended to be additive ... – they are single measures, representing different perspectives of the proposed projects and their component(s)." (Rister et al. 2002a)

19 Separate energy records for the electric relift pump were not available. As an estimate, electric energy used at the diversion site were used to estimate electric energy at the affected relift station. That is, the average electric energy cost of \$1.95 per ac-ft diverted (at Penitas) is divided by the District's two-year average (i.e., 2000-2001) cost per electric BTU (at Penitas) results in an estimated 95,846 BTU per ac-ft relifted.

project, discussion of aggregated results are not provided, as was the case with previous irrigation districts' economic analyses reports.[20]

Component #1: North Branch / East Main [Multi-Size Pipeline]

The only component evaluated in this analysis is the replacing of 25,500 feet (4.83 miles) of the North Branch / East Main (which is currently concrete-lined) with multi-size (i.e, 60", 54", and 48") rubber-gasket, reinforced concrete pipeline. Results of the analysis for this single component project follow (**Table 9**).

Quantities of Water and Energy Savings

Critical values in the analyses are the amount of water and energy savings during the 48-year productive life of the pipeline.[21] On a nominal (i.e., non-discounted) basis, 307,200 ac-ft of irrigation water are projected to be saved; no M&I water savings are expected as a result of this project component.[22] Thus, the total nominal water savings anticipated are 307,200 ac-ft over the 48-year productive life of this component (**Table 9**). Using the 4% discount rate previously discussed, those nominal savings translate into 125,415 ac-ft of real irrigation savings and 0.0 ac-ft of real M&I water savings, representing a total real water savings of 125,415 ac-ft (**Table 9**).

On a nominal (i.e., non-discounted) basis, 173,280,053,335 BTU (50,785,479 kwh) of energy savings are projected to be saved in association with the forecast irrigation water savings and reduced relifting (**Table 9**). Since there are no M&I-related energy savings, these values represent the total energy savings for this project component. Using the 4% discount rate previously discussed, those nominal savings translate into 70,741,906,465 BTU (20,733,267 kwh) of real irrigation-related energy savings over the 48-year productive life of this component (**Table 9**).

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20 This report contains economic and financial analysis results for the single-component North Branch / East Main capital rehabilitation project proposed by the Hidalgo County Irrigation District No. 1. Prior reports containing multiple-component projects are identified on pp. 28-29 which identify related publications.

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

22 As noted previously, the District diverts water for both M&I and agricultural concerns, and technically one could allocate a proportionate share of the forecasted water savings to M&I water use. That is, in the last four years, M&I water use has averaged 13% of total District diversions (i.e., 9,515 ac-ft of 71,318 ac-ft) and one could allocate that proportion of the projected savings to M&I. In this instance, however, RGIDECON© results will not change and the authors have opted to simplify and not allocate water savings between M&I and agriculture uses. Under existing legislation and irrigation district operating procedures, municipal users are 'guaranteed' their water rights, leaving agriculture as the residual claimant on available water allocations to the District. Thus, any marginal, additional water supplies (e.g., water savings) are assumed to accrue to agriculture. In this case, it (agriculture) is credited with all of the water savings from this project component.

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 multi-size pipeline project is $(5,042,200) (**Table 9**). This negative value infers a net economic savings (as opposed to a net economic cost), on a nominal basis. Using the previously-identified discount rate of 6.125%, these nominal cost dollars translate into present-day, real costs of $1,409,379 (**Table 9**). This amount represents, across the total 50-year planning period, the total net costs, in 2003 dollars, of purchasing and installing the multi-size pipeline as well as payment of the net changes in O&M expenditures. Note that the positive real-value amount of costs is substantially greater than the negative nominal-value amount. This result occurs because in the nominal-value amount, the savings accruing from reduced O&M expenses and reduced energy use in the lengthy planning period are sufficient to more than offset the initial investment costs. In the case of the real-value amount, however, the savings occurring during the latter years of the planning period are discounted significantly and thus do not offset as much of the initial investment costs.

NPV of All Water Savings. As detailed above, the total nominal water savings anticipated are 307,200 ac-ft (**Table 9**). The corresponding total real water savings expressed in 2003 water quantities are 125,415 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 $1,409,379 correlates with the real water savings projection of 125,415 ac-ft; the respective annuity equivalents are $90,981 and 5,838 ac-ft (**Table 9**). The estimated cost of saving one ac-ft of water using the multi-size pipeline comprising this project is $15.58 (**Table 9**). This value can be interpreted as the cost of leasing one ac-ft of water in year 2003. It is not the cost of purchasing the water right of one ac-ft. Following through with the economic and capital budgeting methodology presented in Rister et al. (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 multi-size pipeline with all of the attributes previously indicated.

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

The most critical assumption made in the baseline analysis is considered to be that pertaining to the amount of reduction in Rio Grande diversions that will result from the purchase, installation, and implementation of the multi-size pipeline in the water-delivery system. Thus, the cost per ac-ft of water-saved sensitivity analyses consist of varying the off-farm water-savings dimension[23] of that factor across a range of 3,025 to 8,450 ac-ft (including the baseline 6,034 ac-ft) for the multi-size pipeline paired with variances in three other fundamental factors: (a) expected useful life of the investment; (b) initial capital investment costs; and (c) value of BTU savings (i.e., cost of energy). Results for these three sets of sensitivity analyses are presented in **Tables 10, 11,** and **12**, respectively.

Table 10 reveals a range of $9.91 to $75.02 cost per ac-ft of savings around the baseline estimate of $15.58. These calculated values were derived by varying the reduction in Rio Grande diversions arising from off-farm water savings from the multi-size pipeline from as low as 3,025 ac-ft up to 8,450 ac-ft about the expected 6,034 ac-ft and by investigating a range of useful lives of the multi-size pipeline down from the expected 48 years to as short as only 10 years. As should be expected, shorter-useful lives than the anticipated 48-year productive life resulted in higher cost estimates, lower off-farm (and the linked on-farm) water savings than the predicted 6,034 ac-ft per mile 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 $5.96 to $46.35 per ac-ft of savings around the baseline estimate of $15.58. These calculated values were derived by varying the reduction in Rio Grande diversions arising from off-farm water savings from the multi-size pipeline from as low as 3,025 ac-ft up to 8,450 ac-ft about the expected 6,034 ac-ft and by considering variations in the cost of the capital investment in the multi-size pipeline varying from $500,000 less than the expected $3,847,125 up to $500,000 more than the expected amount. As should be expected, both lower-than-the-anticipated $3,847,125 capital costs and/or higher-than-expected water savings contributed to lower cost estimates, while both higher investment costs and/or lower off-farm (and the linked on-farm) water savings than the predicted amounts increased the cost estimates.

The final set of sensitivity analyses conducted for the costs of water savings accounted for varying both the reduction in Rio Grande diversions arising from investment in multi-size pipeline and the cost of energy. **Table 12** is an illustration of the results of varying those parameters from as low as 3,025 ac-ft up to 8,450 ac-ft about the expected 6,034 ac-ft off-farm water savings and across a range of $0.0108 to $0.0325 per kwh energy costs about the expected $0.0216 per kwh level.[24] The resulting costs of water savings estimates ranged from a high of $39.70 per ac-ft down to a low of $6.98 per ac-ft. The lower cost results are associated with high water savings and high energy costs – the two factors combined contribute to substantial energy

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23 Other off-farm and on-farm water savings (e.g., reduced evaporation and percolation) are linked to off-farm 'seepage' water savings within RGIDECON©'s assessment of this project. Thus, as the off-farm 'seepage' water savings associated with the multi-size pipeline are varied in the sensitivity analyses, the other off-farm savings and on-farm savings also vary proportionately.

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

cost savings which substantially offset both the initial capital costs of the multi-size pipeline plus the anticipated changes in O&M expenses. The opposite effect is experienced with low energy usage per ac-ft of water savings and low water savings, i.e., higher costs estimates are calculated for these circumstances.

<u>Cost of Energy Saved</u>

Besides the estimated cost per ac-ft of water saved as a result of the multi-size pipeline's inception, purchase, installation, and implementation, another issue of interest is the cost of energy savings. Reduced water diversions from the Rio Grande will result as seepage, evaporation, and percolation losses are reduced. These reduced diversions associated with the proposed multi-size pipeline's capital renovation will result in less water being diverted, translating into energy savings. Additional energy savings are also projected for this project in association with reduced relift pumping. 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.

<u>NPV of Net Cost Stream</u>. Accounting for all capital purchase and installation construction costs, and changes in O&M expenditures, the nominal total cost of the 50-year planning period for the multi-size pipeline project is $(2,476,438) (**Table 9**). Using the previously-identified discount rate of 6.125%, these nominal cost dollars translate into a present-day, real cost of $1,998,821 (**Table 9**). This amount represents, across the total 50-year planning period, the total net costs, in 2003 dollars, of purchasing and installing the multi-size pipeline as well as payment of the net changes in O&M expenditures, ignoring the changes in energy costs and allowing no credits for the water savings.

<u>NPV of All Energy Savings</u>. As detailed above, the total nominal energy savings anticipated are 173,280,053,335 BTU (50,785,479 kwh) (**Table 9**). The corresponding total real energy savings expressed in 2003 energy quantities are 70,741,906,465 BTU (i.e., 20,733,267 kwh) over the 48-year productive life of this component, assuming the previously-identified discount rate of 4.00% (**Table 9**).

<u>Cost per BTU & kwh Saved</u>. The real net cost estimate of $1,998,821 correlates with the real energy savings projection of 70,741,906,465 BTU (20,733,267 kwh); the respective annuity equivalents are $129,032 and 3,293,049,926 BTU (965,138 kwh) (**Table 9**). The estimated cost of saving one BTU of energy using the multi-size pipeline comprising this project is $0.0000392 ($0.134 per kwh) (**Table 9**). An interpretation of this value is that it is the cost of saving one BTU (kwh) of energy in year 2003. Following through with the economic and capital budgeting methodology presented in Rister et al. (2002a), this value represents the <u>costs per year</u> in present-day dollars of <u>saving one BTU (kwh) of energy</u> into perpetuity through a continual replacement series of the multi-size pipeline with all of the attributes previously indicated.

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

The most critical assumption made in the baseline analysis in this respect is considered to be that pertaining to the amount of energy savings that will result from the purchase, installation, and implementation of the multi-size pipeline in the water-delivery infrastructure system. Thus, the cost per BTU (or kwh) of energy-saved sensitivity analyses consists of varying the amount of energy savings across a range of 80.0 percent up to 150.0 percent of the baseline 483,959 BTU (141.84 kwh) current average usage per ac-ft of water savings paired with variances in three other fundamental factors: (a) expected useful life of the investment; (b) initial capital investment costs; and (c) off-farm water savings of the new multi-size pipeline. 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 \$0.0000261 to \$0.0001040 cost per BTU (and \$0.089 to \$0.355 per kwh) of energy savings around the baseline estimate of \$0.0000392 per BTU (\$0.134 per kwh). These calculated values were derived by varying the amount of energy used per ac-ft of water savings across a range as low as 80.0% up to 150.0% of the expected 483,959 BTU (141.84 kwh) current average usage per ac-ft of water savings and by investigating a range of useful lives of the capital investment in the multi-size pipeline down from the expected 48 years to as short as only 10 years. As should be expected, shorter-useful lives than the anticipated 48-year productive life resulted in higher cost estimates, lower energy savings than the predicted 100% of current average usage also increased cost estimates, and higher-than-expected energy savings contributed to lower cost estimates.

Similarly, **Tables 15** and **16** are a presentation of a range of cost estimates varying from \$0.0000196 to \$0.0000612 per BTU (and \$0.067 to \$0.209 per kwh) of energy savings around the baseline estimate of \$0.0000392 per BTU (\$0.134 per kwh). These calculated values were derived by varying the amount of energy used per ac-ft of water savings across a range as low as 80.0% up to 150.0% of the expected 483,959 BTU (141.84 kwh) current average usage per ac-ft of water savings and by considering variations in the cost of the capital investment in the multi-size pipeline varying from \$500,000 less than the expected \$3,847,125 up to \$500,000 more than the expected amount. As should be expected, both lower-than-the-anticipated \$3,847,125 capital costs and/or higher-than-expected energy savings contributed to lower cost estimates while both higher investment costs and/or lower energy savings than the 483,959 BTU (141.84 kwh) increased the cost estimates.

The final set of sensitivity analyses conducted for the costs of energy savings accounted for varying both the amount of energy used per ac-ft of water savings and the reduction in Rio Grande diversions arising from water savings from the multi-size pipeline. **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 483,959 BTU (141.84 kwh) current average usage per ac-ft of water savings and from as low as 3,025 ac-ft up to 8,450 ac-ft about the expected 6,034 ac-ft off-farm water savings for the new pipeline. The resulting costs of energy savings estimates ranged from a high of \$0.0000856 per BTU (\$0.292 per kwh) down to a low of \$0.0000194 per BTU (\$0.066 per kwh). The lower cost estimates are associated with high energy usage per ac-ft of water savings and high off-farm (and the linked on-farm) water savings – the two factors combined contribute to substantial energy cost savings. The opposite effect is experienced with low energy usage per ac-ft of water savings and low off-farm water savings, i.e., higher costs estimates are calculated for these circumstances.

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 cast aside.

- 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 issue of the net value of the proposed project is not addressed in this report.

- An individual project proposed by a District is evaluated in the positive, objective form noted earlier independent of other District's proposals. Should there be cause for comparison of potential performance across two or more proposed projects, such appraisals need to be conducted exogenous to this report. The results presented in the main body of this report could be useful for such prioritization processes, however, as discussed in Rister et al. (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 would provide an overall impact of the proposed renovations, thereby enhancing the economic strength of the analyses. Necessarily, it is suggested such an effort encompass a full cost-benefit assessment and potential alterations in cropping patterns, impacts of projected urban growth, distribution of water use across the Basin, etc. It is relevant to note that evaluation of Federal projects often employ a national perspective and consider such local impacts negligible. A more-localized perspective in the level of analyses results in greater benefits being estimated along with increased attention to the identity of 'winners' and 'losers' in the resulting adjustments that are anticipated. For example, while on a national perspective the issue of the 1.7 million ac-ft of water now owed to the U.S. may not be a high-priority issue, it certainly is viewed as a critical issue within the immediate Rio Grande Valley area.

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

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

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

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

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

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

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

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

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

Summary and Conclusions

The District's project proposal consists of a single component: installing 25,500 feet of multi-size (60", 54", and 48") RG/RC[25] pipeline to replace a segment of concrete-lined canal (of the "North Branch / East Main"), which has significant seepage problems. The required capital investment cost is $3,847,125.[26] This initial investment cost is significantly offset by the anticipated sale of reclaimed property amounting to $511,364 (**Table 6**). A two-year installation period with an ensuing 48-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- and *on-farm* water savings are predicted to be forthcoming from the single-component project. Expected water savings over the 48-year useful life are 307,200 nominal ac-ft, which translate into a 2003 basis of 125,415 real ac-ft (**Table 9**). Energy savings estimates

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25 Rubber-gasket, reinforced-concrete pipeline is abbreviated RG/RC.

26 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.

associated with the North Branch / East Main pipeline are 173,280,053,335 BTU (50,785,479 kwh) in nominal terms and 70,741,906,465 BTU (20,733,267 kwh) in real 2003 terms (**Table 9**).

Economic and financial costs of *water* savings forthcoming from the North Branch / East Main pipeline are estimated at $15.58 per ac-ft (**Table 9**). Sensitivity analyses indicate this estimate can be affected by variances in (a) the amount of reduction in Rio Grande diversions resulting from the purchase, installation, and implementation of the pipeline; (b) the expected useful life of the pipeline; (c) the initial capital investment costs of the pipeline; and (d) the value of BTU savings (i.e., cost of energy).

Economic and financial costs of *energy* savings forthcoming from the pipeline are estimated at $0.0000392 per BTU ($0.134 per kwh) (**Table 9**). Sensitivity analyses indicate factors of importance are (a) the amount of energy savings resulting from the purchase, installation, and implementation; (b) the expected useful life of the investment; (c) the initial capital investment costs; and (d) the amount of *off- 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

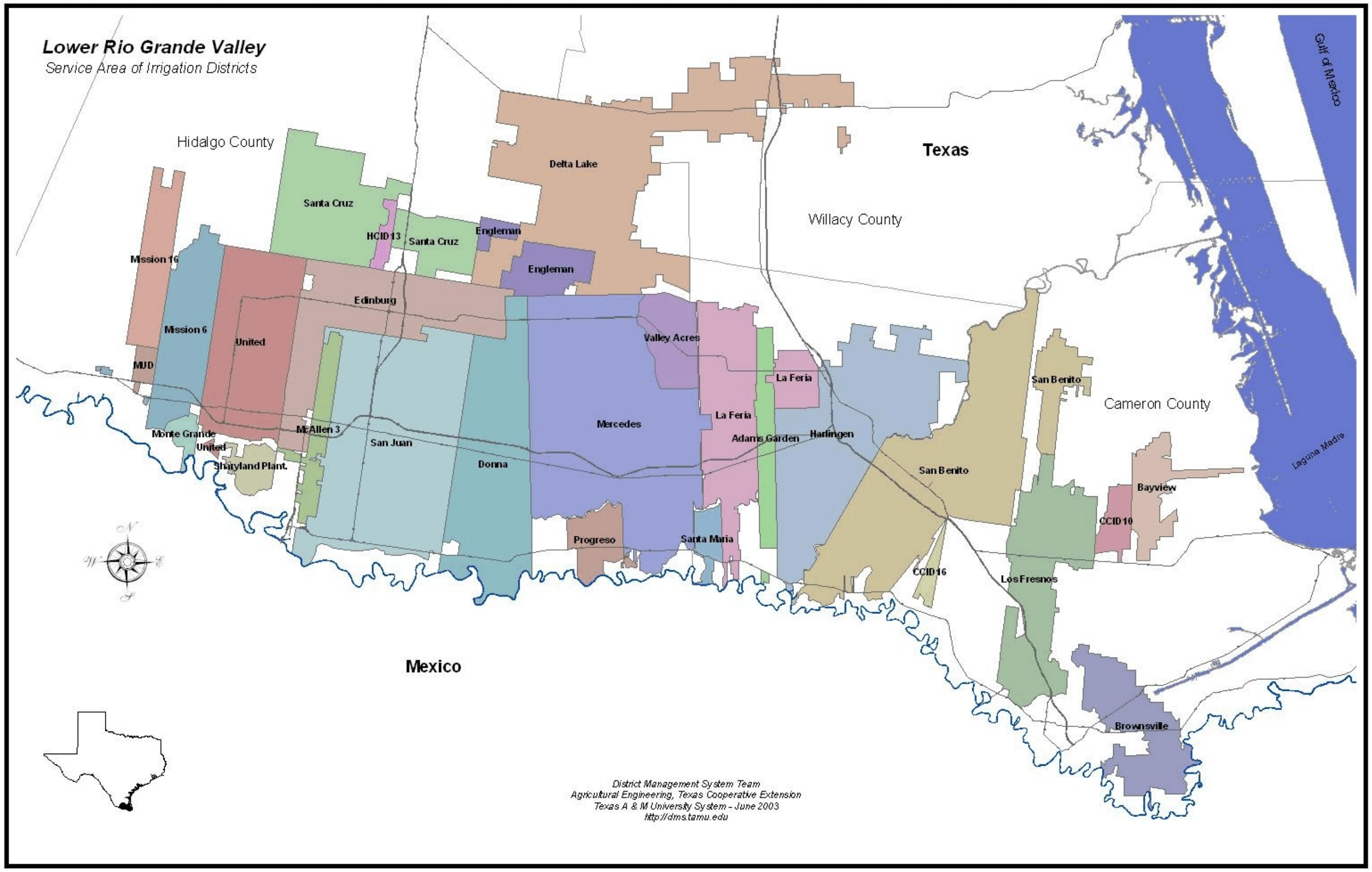

Exhibit 1. Illustration of Twenty-Eight Irrigation Districts in the Texas Lower Rio Grande Valley (Fipps et al.).

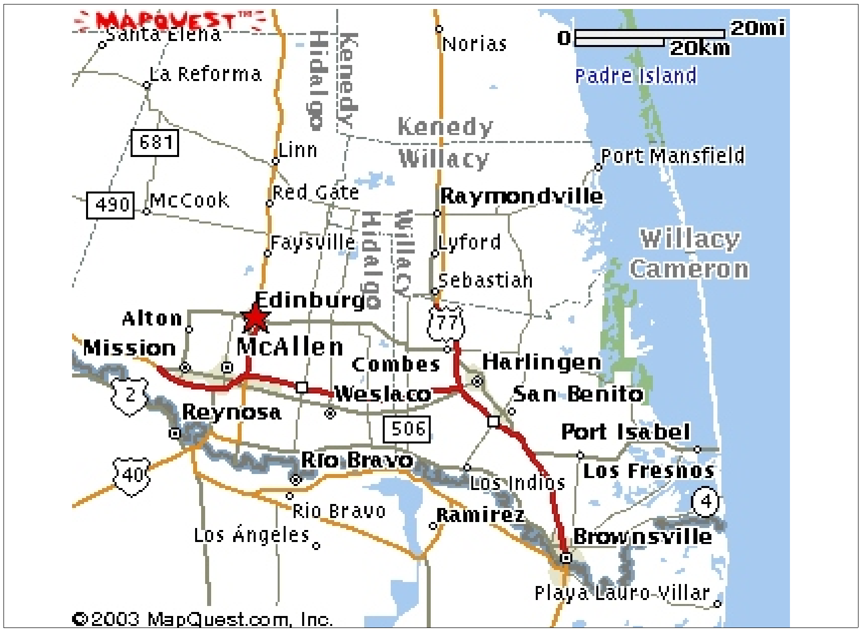

Exhibit 2. Edinburg, TX – Location of Hidalgo County Irrigation District No. 1 Office (MapQuest).

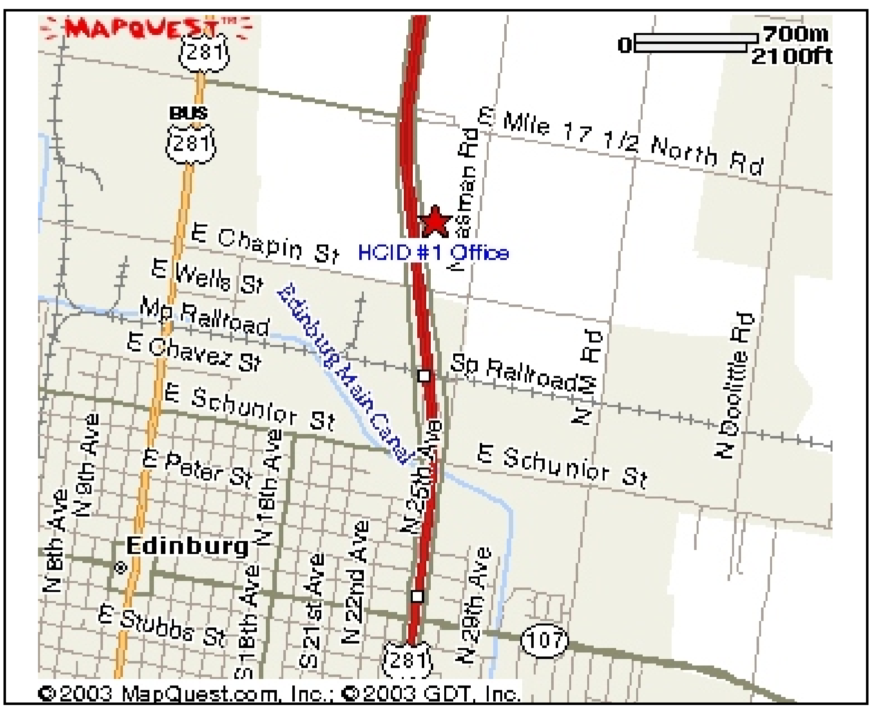

Exhibit 3. Detailed Location of Hidalgo County Irrigation District No. 1 Office in Edinburg, TX (MapQuest).

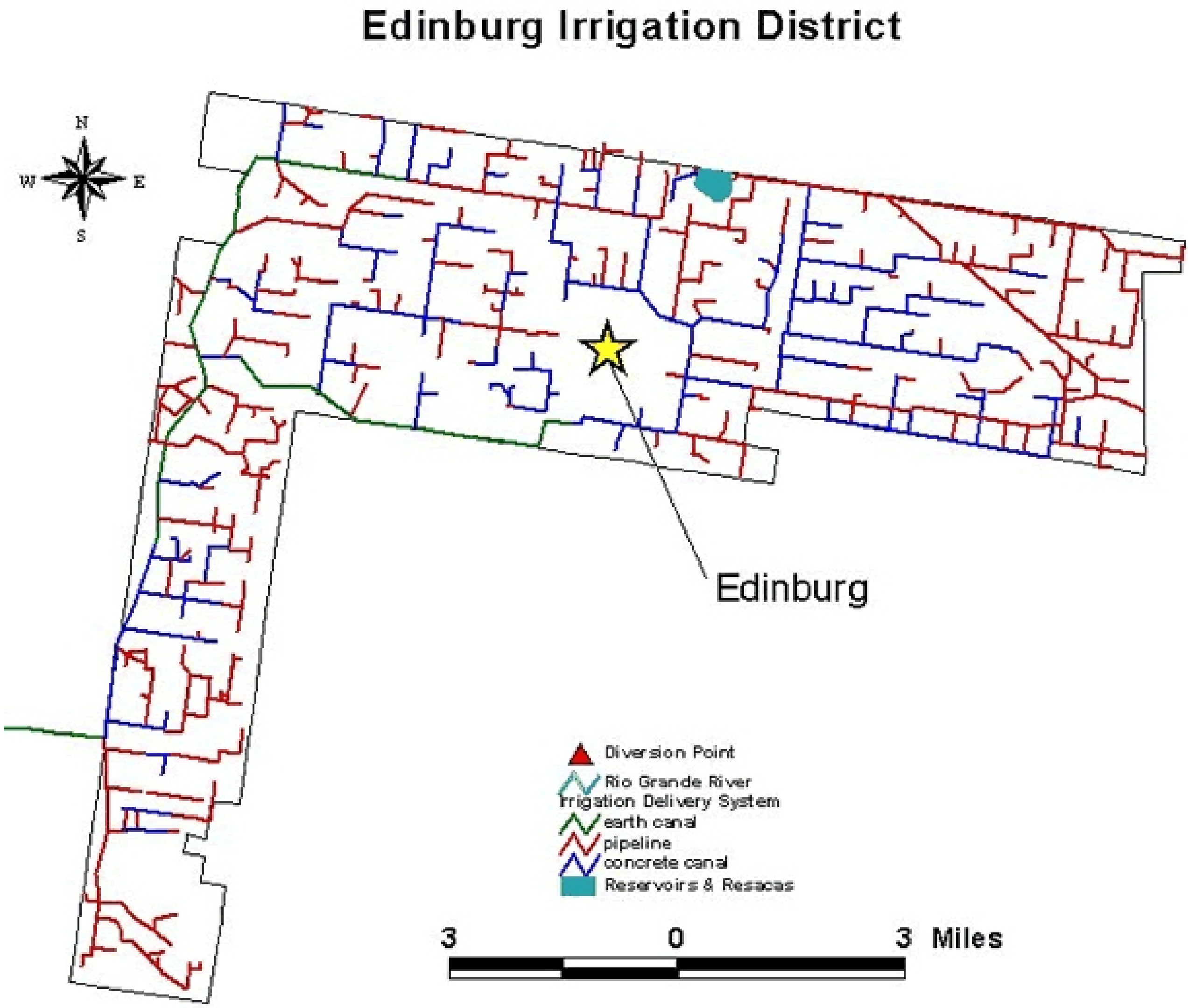

Exhibit 4. Illustrated Layout of Hidalgo County Irrigation District No. 1 (Fipps et al.).

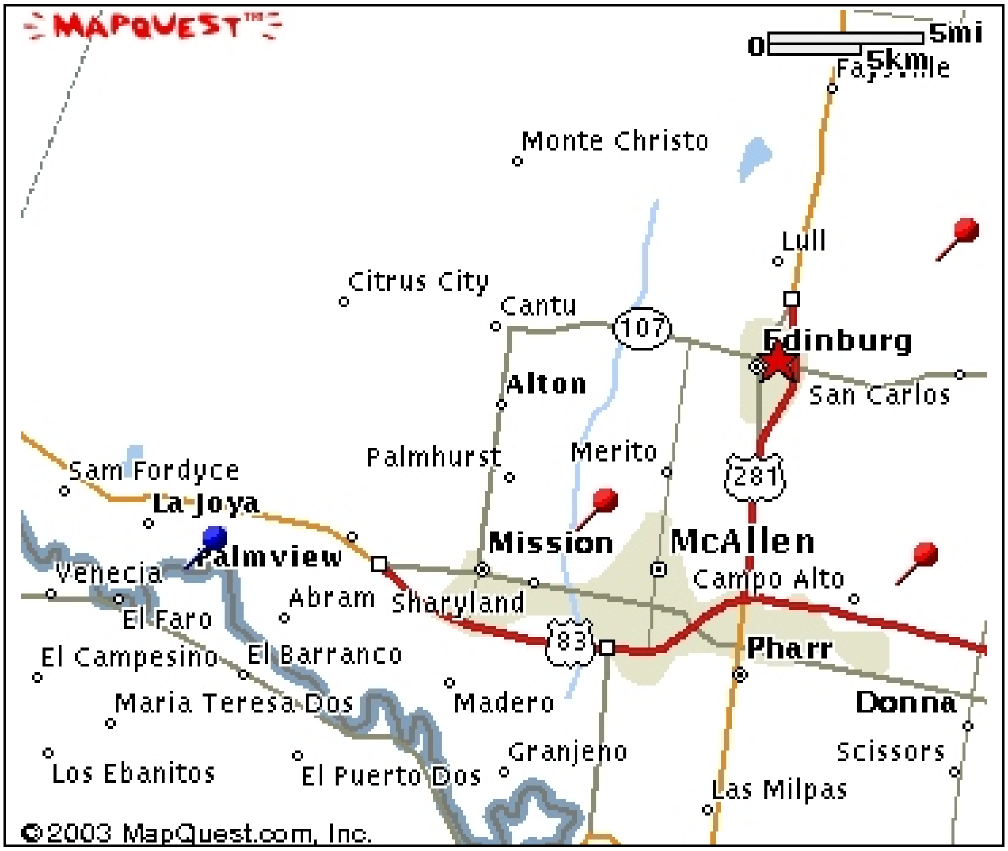

Exhibit 5. Location of Pumping Plant, and the Municipalities, Water Supply Corporations, and Irrigation Districts Served by Hidalgo County Irrigation District No. 1 (MapQuest).

Tables

Table 1. Average Acreage Irrigated by Hidalgo County Irrigation District No. 1 as per District Records for Calendar Years 1999-2001 (Carpenter).

Crop	Acres	%
Vegetables	10,260	35.5
Other[a]	7,359	25.5
Citrus	6,439	22.3
Corn	2,383	8.2
Sugarcane	893	3.1
Cotton	905	3.1
Grain sorghum	661	2.3
Total	28,899	100.0

[a] 'Other' includes golf courses, ponds, yards, etc.

Table 2. Historic Water Use (acre-feet), Hidalgo County Irrigation District No. 1, 1998-2001 (Carpenter).

	- - - - - - - - - - - - - - Calendar Year - - - - - - - - - - - - - - (values in annual ac-ft)				
Use	**1998**	**1999**	**2000**	**2001**	**4 year average**
M&I Use	10,038	8,814	8,741	10,466	9,515
Ag Irrigation Use	60,828	53,792	64,933	67,661	61,804
Total	70,866	62,606	73,674	78,127	71,318

Table 3. Selected Summary Information for Hidalgo County Irrigation District No. 1, 2003 (Carpenter).

Item	Description / Data
Certificates of Adjudication:	0816-000; 0816-001; 0816-002; and 0816-003.
Contracted Deliveries:	City of Edinburg; North Alamo Water Supply Corporation; Sharyland Water Supply Corporation; and Santa Cruz Irrigation District.
District Water Rates:	Volumetric-priced Irrigation: Flat Rate ($13.50 per ac-ft); Standard Irrigation: Flat Rate ($18.00 per acre); and Standard Irrigation: Irrigation Rate ($9.00 per irrigation).
Average Lift at Rio Grande:	33 feet.

Table 4. Selected Summary Characteristics of Proposed Multi-Size Pipeline Replacing North Branch / East Main Project Proposed to BOR and NADB, Hidalgo County Irrigation District No. 1, 2003 (Carpenter, Smith).

Characteristic Item	Description / Data
Project Name:	North Branch / East Main
Project Type:	Pipeline installation to replace concrete-lined canal.
Proposed Activity Description:	Replace 25,500 feet (4.83 miles) of the North Branch / East Main with multi-size rubber-gasket, reinforced-concrete pipeline.

Pipe Diameter / Length:

Diameter	Length (ft)	Length (miles)
60"	10,500	1.99
54"	5,250	0.99
48"	9,750	1.85
total	25,500	4.83

Table 5. Summary of Annual Water and Energy Savings Data (basis 2003) for 4.83 Miles of Multi-Size Pipeline Replacing North Branch / East Main Project Proposed to BOR and NADB, Hidalgo County Irrigation District No. 1, 2003 (Carpenter, Smith).

Item/Savings	Amount of Annual Water Savings by Type: Reduced Seepage (ac-ft)	Reduced Evaporation (ac-ft)	Reduced Percolation (ac-ft)	Reduced Relift (ac-ft) [a]	Total Water Savings (ac-ft)	Associated Annual Energy Savings: BTU	kwh	$
Annual Energy & Water Savings								
Agricultural Irrigation Use:								
Off-farm (reduced seepage)	6,021.98	0.00	0.00	n/a	6,021.98	2,914,389,239	854,159	$18,487
Off-farm (reduced evaporation)	0.00	12.02	0.00	n/a	12.02	5,817,183	1,705	37
On-farm (reduced percolation)	0.00	0.00	366.00	n/a	366.00	177,128,862	51,913	1,124
Off-farm (reduced relift pumping) [a]	n/a	n/a	n/a	*5,348.87*	n/a	512,665,828	150,254	10,432
Sub-total	6,021.98	12.02	366.00	*5,348.87*	**6,400.00**	3,610,001,111	1,058,031	$ 30,080
Municipal and Industrial Use:								
Off-farm	0.00	0.00	0.00	n/a	0.00	0	0	0
On-farm	0.00	0.00	0.00	n/a	0.00	0	0	0
Sub-total	0.00	0.00	0.00	n/a	0.00	0	0	0
Total	6,021.98	12.02	366.00	*5,348.87*	**6,400.00**	3,610,001,111	1,058,031	$ 30,080

a The reduced volume of water to be relifted (caused by the project's implementation) is neither saved nor included in summing total water savings, but does contribute to reducing energy costs as relifting requirements within the District's water-delivery system is reduced.

Table 6. Summary of Project Cost and Expense Data (2003 dollars) for the North Branch / East Main Project Proposed to BOR and NADB, Hidalgo County Irrigation District No. 1 (Smith, Carpenter).

Item	Years	Component #1 - N. Branch / E. Main [a] Expenses / Revenues (total $'s)	($/mile)
Installation Period	2		
Productive Period	48		
Planning Period	50		
Initial Capital Investment Costs [b]		$ 3,847,125	$ 796,581
Annual Increases in O&M Expenses		$ 6,964	$ 1,442
Annual Decreases in O&M Expenses		$ 75,070	$ 15,544
Net Changes in Annual O&M Expenses		$ (68,107)	$ (14,102)
Value of Reclaimed Property (revenue) [c]		$ 511,364	

[a] Component #1- North Branch / East Main is 25,500 feet (4.83 miles) of multi-size pipeline (60", 54", and 48") replacing concrete-lined canal in a segment of the North Branch / East Main. This is the only project component; 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, into the materials associated with the final design phase of this project.

[c] Funds received for reclaimed property (i.e., sold) are assumed received by the District in a lump-sum value at the project's initiation. This is based on 75% marketability of affected land, resulting in 34.09 acres at $15,000 per acre (Carpenter). Although the actual sale of the estimated 34.09 acres may involve multiple sale events which are likely to occur over several future years, the value of savings used in the analyses are expressed in present value 2003 dollars.

Table 7. Details of Cost Estimate for Multi-Size Pipeline Replacing North Branch / East Main for Project Proposed to BOR and NADB (2003 dollars), Hidalgo County Irrigation District No. 1 (Melden & Hunt, Inc. 2003).

Item	($)'s
Purchase and Install Pipeline	$ 3,259,500
Legal Fees and O&M Manual Cost	20,200
Construction Management & Inspection Fees	78,500
Contingencies	488,925
In-Kind:	0
Total Project Costs [a]	$ 3,847,125

[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. Calculations Documenting Energy Use and Expenses for Hidalgo County Irrigation District No. 1, Per District Records (Carpenter).

	Fiscal Year		
Item	2000	2001	Average
Annual Cost - Electricity	$21,969	$97,894	
Annual Cost - Natural Gas	$171,389	$178,894	
Annual Cost - Total	$193,358	$276,788	$235,073
Water Diverted (ac-ft)	73,674	78,127	75,900
BTU used - Electricity	1,082,674,737	4,824,405,331	
BTU used - Natural Gas	33,098,880,404	34,548,256,370	
BTU used - Total	34,181,555,142	39,372,661,702	36,777,108,422
BTU/ac-ft water diverted	463,960	503,957	483,959
Energy Cost ($/BTU)	$0.0000057	$0.0000070	$0.0000063
Energy Cost ($/kwh)	$0.0193	$0.0240	$0.0216
Energy Cost ($/ac-ft)	$2.63	$3.54	$3.08

Table 9. Economic and Financial Evaluation Results Across the Project's Useful Life, Hidalgo County Irrigation District No. 1, Multi-Size Pipeline Replacing North Branch / East Main Project Proposed to BOR and NADB, 2003.

Results	Nominal	Real[a]
Water Savings (ac-ft)		
Agriculture Irrigation	307,200	125,415
M&I	0	0
Total ac-ft	307,200	125,415
annuity equivalent		5,838
Energy Savings (BTU)		
Agriculture Irrigation	173,280,053,335	70,741,906,465
M&I	0	0
Total BTU	173,280,053,335	70,741,906,465
annuity equivalent		3,293,049,926
Energy Savings (kwh)		
Agriculture Irrigation	50,785,479	20,733,267
M&I	0	0
Total kwh's	50,785,479	20,733,267
annuity equivalent		965,138
NPV of Initial Capital Investment Costs and Changes in O&M Expenditures, Including Energy Cost Savings	$ (5,042,200)	$ 1,409,379
annuity equivalent		$ 90,981
Cost of Water Savings ($/ac-ft)		$ 15.58
NPV of Initial Capital Investment Costs and Changes in O&M Expenditures, Ignoring Both Energy Cost Savings and Value of Water Savings	$ (2,476,438)	$ 1,998,821
annuity equivalent		$ 129,032
Cost of Energy Savings ($/BTU)		$ 0.0000392
Cost of Energy Savings ($/kwh)		$ 0.134

[a] Determined using a 4% discount factor.

Table 10. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings for 25,500 Feet (4.83 Miles) of North Branch / East Main and Expected Useful Life of the Capital Investment, Hidalgo County Irrigation District No. 1, Multi-Size Pipeline Replacing Concrete-Lined Canal Project Proposed to BOR and NADB, 2003.

		ac-ft of annual water loss (seepage & evaporation) for 25,500 feet of North Branch / East Main									
		3,025	3,625	4,225	4,825	5,425	**6,034**	6,625	7,250	7,850	8,450
Expected Useful life of Investment (years)	10	$75.02	$61.10	$51.14	$43.66	$37.83	$33.10	$29.34	$26.03	$23.35	$21.05
	20	$48.19	$39.25	$32.85	$28.05	$24.30	$21.26	$18.85	$16.72	$15.00	$13.52
	25	$43.25	$35.23	$29.49	$25.17	$21.81	$19.08	$16.92	$15.01	$13.46	$12.14
	30	$40.17	$32.72	$27.39	$23.38	$20.26	$17.72	$15.71	$13.94	$12.50	$11.27
	40	$36.75	$29.93	$25.05	$21.39	$18.53	$16.21	$14.37	$12.75	$11.44	$10.31
	48	$35.32	$28.77	$24.08	$20.56	$17.81	**$15.58**	$13.81	$12.26	$10.99	$9.91

Table 11. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings for 25,500 Feet (4.83 Miles) of North Branch / East Main and Initial Cost of the Capital Investment, Hidalgo County Irrigation District No. 1, Multi-Size Pipeline Replacing Concrete-Lined Canal Project Proposed to BOR and NADB, 2003.

		ac-ft of annual water loss (seepage & evaporation) for 25,500 feet of North Branch / East Main									
		3,025	3,625	4,225	4,825	5,425	**6,034**	6,625	7,250	7,850	8,450
Initial Capital Investment Cost ($)	$(500,000)	$24.29	$19.57	$16.18	$13.64	$11.66	$10.06	$8.78	$7.65	$6.74	$5.96
	$(250,000)	$29.81	$24.17	$20.13	$17.10	$14.74	$12.82	$11.30	$9.96	$8.87	$7.94
	$(100,000)	$33.11	$26.93	$22.50	$19.17	$16.58	$14.48	$12.81	$11.34	$10.14	$9.12
	$ -	$35.32	$28.77	$24.08	$20.56	$17.81	**$15.58**	$13.81	$12.26	$10.99	$9.91
	$100,000	$37.53	$30.61	$25.66	$21.94	$19.04	$16.69	$14.82	$13.18	$11.84	$10.70
	$250,000	$40.83	$33.37	$28.03	$24.01	$20.89	$18.35	$16.33	$14.56	$13.12	$11.89
	$500,000	$46.35	$37.97	$31.98	$27.47	$23.96	$21.11	$18.85	$16.86	$15.24	$13.86

Table 12. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings for 25,500 Feet (4.83 Miles) of North Branch / East Main and Value of Energy Savings, Hidalgo County Irrigation District No. 1, Multi-Size Pipeline Replacing Concrete-Lined Canal Project Proposed to BOR and NADB, 2003.

	ac-ft of annual water loss (seepage & evaporation) for 25,500 feet of North Branch / East Main										
		3,025	3,625	4,225	4,825	5,425	**6,034**	6,625	7,250	7,850	8,450
Value of Energy Savings ($/kwh)	$0.0108	$39.70	$32.78	$27.82	$24.10	$21.20	$18.84	$16.97	$15.33	$13.99	$12.85
	$0.0152	$37.95	$31.18	$26.33	$22.68	$19.84	$17.54	$15.71	$14.10	$12.79	$11.67
	$0.0195	$36.20	$29.57	$24.83	$21.26	$18.49	$16.24	$14.45	$12.87	$11.59	$10.50
	$0.0216	$35.32	$28.77	$24.08	$20.56	$17.81	**$15.58**	$13.81	$12.26	$10.99	$9.91
	$0.0238	$34.44	$27.97	$23.33	$19.85	$17.13	$14.93	$13.18	$11.64	$10.39	$9.32
	$0.0281	$32.69	$26.36	$21.83	$18.43	$15.78	$13.63	$11.92	$10.41	$9.20	$8.15
	$0.0325	$30.94	$24.76	$20.34	$17.01	$14.43	$12.33	$10.66	$9.19	$8.00	$6.98

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, Hidalgo County Irrigation District No. 1, Multi-Size Pipeline Replacing North Branch / East Main Project Proposed to BOR and NADB, 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									
		387,167	435,563	459,761	471,860	**483,959**	496,058	508,157	532,355	604,948	725,938
Expected Useful life of Investment (years)	10	$0.0001040	$0.0000925	$0.0000876	$0.0000854	$0.0000832	$0.0000812	$0.0000793	$0.0000757	$0.0000666	$0.0000555
	20	$0.0000668	$0.0000594	$0.0000563	$0.0000548	$0.0000535	$0.0000522	$0.0000509	$0.0000486	$0.0000428	$0.0000356
	25	$0.0000600	$0.0000533	$0.0000505	$0.0000492	$0.0000480	$0.0000468	$0.0000457	$0.0000436	$0.0000384	$0.0000320
	30	$0.0000557	$0.0000495	$0.0000469	$0.0000457	$0.0000446	$0.0000435	$0.0000424	$0.0000405	$0.0000357	$0.0000297
	40	$0.0000510	$0.0000453	$0.0000429	$0.0000418	$0.0000408	$0.0000398	$0.0000388	$0.0000371	$0.0000326	$0.0000272
	48	$0.0000490	$0.0000435	$0.0000412	$0.0000402	**$0.0000392**	$0.0000382	$0.0000373	$0.0000356	$0.0000313	$0.0000261

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, Hidalgo County Irrigation District No. 1, Multi-Size Pipeline Replacing North Branch / East Main Project Proposed to BOR and NADB, 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									
		387,167	435,563	459,761	471,860	**483,959**	496,058	508,157	532,355	604,948	725,938
Expected Useful life of Investment (years)	10	$0.355	$0.315	$0.299	$0.291	$0.284	$0.277	$0.270	$0.258	$0.227	$0.189
	20	$0.228	$0.203	$0.192	$0.187	$0.182	$0.178	$0.174	$0.166	$0.146	$0.122
	25	$0.205	$0.182	$0.172	$0.168	$0.164	$0.160	$0.156	$0.149	$0.131	$0.109
	30	$0.190	$0.169	$0.160	$0.156	$0.152	$0.148	$0.145	$0.138	$0.122	$0.101
	40	$0.174	$0.155	$0.146	$0.143	$0.139	$0.136	$0.132	$0.126	$0.111	$0.093
	48	$0.167	$0.149	$0.141	$0.137	**$0.134**	$0.130	$0.127	$0.122	$0.107	$0.089

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, Hidalgo County Irrigation District No. 1, Multi-Size Pipeline Replacing North Branch / East Main Project Proposed to BOR and NADB, 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									
		387,167	435,563	459,761	471,860	**483,959**	496,058	508,157	532,355	604,948	725,938
Initial Capital Investment Cost ($)	$(500,000)	$0.0000367	$0.0000326	$0.0000309	$0.0000301	$0.0000294	$0.0000287	$0.0000280	$0.0000267	$0.0000235	$0.0000196
	$(250,000)	$0.0000429	$0.0000381	$0.0000361	$0.0000352	$0.0000343	$0.0000334	$0.0000326	$0.0000312	$0.0000274	$0.0000229
	$(100,000)	$0.0000465	$0.0000414	$0.0000392	$0.0000382	$0.0000372	$0.0000363	$0.0000355	$0.0000338	$0.0000298	$0.0000248
	$ -	$0.0000490	$0.0000435	$0.0000412	$0.0000402	**$0.0000392**	$0.0000382	$0.0000373	$0.0000356	$0.0000313	$0.0000261
	$100,000	$0.0000514	$0.0000457	$0.0000433	$0.0000422	$0.0000411	$0.0000401	$0.0000392	$0.0000374	$0.0000329	$0.0000274
	$250,000	$0.0000551	$0.0000490	$0.0000464	$0.0000452	$0.0000441	$0.0000430	$0.0000420	$0.0000401	$0.0000353	$0.0000294
	$500,000	$0.0000612	$0.0000544	$0.0000516	$0.0000502	$0.0000490	$0.0000478	$0.0000467	$0.0000445	$0.0000392	$0.0000327

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, Hidalgo County Irrigation District No. 1, Multi-Size Pipeline Replacing North Branch / East Main Project Proposed to BOR and NADB, 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									
		387,167	435,563	459,761	471,860	**483,959**	496,058	508,157	532,355	604,948	725,938
Initial Capital Investment Cost ($)	$(500,000)	$0.125	$0.111	$0.106	$0.103	$0.100	$0.098	$0.095	$0.091	$0.080	$0.067
	$(250,000)	$0.146	$0.130	$0.123	$0.120	$0.117	$0.114	$0.111	$0.106	$0.094	$0.078
	$(100,000)	$0.159	$0.141	$0.134	$0.130	$0.127	$0.124	$0.121	$0.115	$0.102	$0.085
	$ -	$0.167	$0.149	$0.141	$0.137	**$0.134**	$0.130	$0.127	$0.122	$0.107	$0.089
	$100,000	$0.175	$0.156	$0.148	$0.144	$0.140	$0.137	$0.134	$0.128	$0.112	$0.094
	$250,000	$0.188	$0.167	$0.158	$0.154	$0.150	$0.147	$0.143	$0.137	$0.120	$0.100
	$500,000	$0.209	$0.186	$0.176	$0.171	$0.167	$0.163	$0.159	$0.152	$0.134	$0.111

Table 17. Costs per BTU of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Reduced Water Losses, Hidalgo County Irrigation District No. 1, Multi-Size Pipeline Replacing North Branch / East Main Project Proposed to BOR and NADB, 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									
		387,167	435,563	459,761	471,860	**483,959**	496,058	508,157	532,355	604,948	725,938
ac-ft of annual water loss (seepage & evap.) for 25,500 feet of N. Branch / E. Main	3,025	$0.0000856	$0.0000761	$0.0000721	$0.0000702	$0.0000685	$0.0000668	$0.0000652	$0.0000623	$0.0000548	$0.0000457
	3,625	$0.0000745	$0.0000662	$0.0000627	$0.0000611	$0.0000596	$0.0000581	$0.0000568	$0.0000542	$0.0000477	$0.0000397
	4,225	$0.0000659	$0.0000586	$0.0000555	$0.0000541	$0.0000528	$0.0000515	$0.0000502	$0.0000480	$0.0000422	$0.0000352
	4,825	$0.0000591	$0.0000526	$0.0000498	$0.0000485	$0.0000473	$0.0000462	$0.0000451	$0.0000430	$0.0000379	$0.0000315
	5,425	$0.0000536	$0.0000477	$0.0000452	$0.0000440	$0.0000429	$0.0000419	$0.0000409	$0.0000390	$0.0000343	$0.0000286
	6,034	$0.0000490	$0.0000435	$0.0000412	$0.0000402	**$0.0000392**	$0.0000382	$0.0000373	$0.0000356	$0.0000313	$0.0000261
	6,625	$0.0000452	$0.0000402	$0.0000380	$0.0000371	$0.0000361	$0.0000353	$0.0000344	$0.0000329	$0.0000289	$0.0000241
	7,250	$0.0000418	$0.0000371	$0.0000352	$0.0000343	$0.0000334	$0.0000326	$0.0000318	$0.0000304	$0.0000267	$0.0000223
	7,850	$0.0000389	$0.0000346	$0.0000328	$0.0000319	$0.0000311	$0.0000304	$0.0000297	$0.0000283	$0.0000249	$0.0000208
	8,450	$0.0000365	$0.0000324	$0.0000307	$0.0000299	$0.0000292	$0.0000285	$0.0000278	$0.0000265	$0.0000233	$0.0000194

Table 18. Costs per kwh of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Reduced Water Losses, Hidalgo County Irrigation District No. 1, Multi-Size Pipeline Replacing North Branch / East Main Project Proposed to BOR and NADB, 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									
		387,167	435,563	459,761	471,860	**483,959**	496,058	508,157	532,355	604,948	725,938
ac-ft of annual water loss (seepage & evap.) for 25,500 feet of N. Branch / E. Main	3,025	$0.292	$0.260	$0.246	$0.240	$0.234	$0.228	$0.223	$0.212	$0.187	$0.156
	3,625	$0.254	$0.226	$0.214	$0.209	$0.203	$0.198	$0.194	$0.185	$0.163	$0.136
	4,225	$0.225	$0.200	$0.189	$0.185	$0.180	$0.176	$0.171	$0.164	$0.144	$0.120
	4,825	$0.202	$0.179	$0.170	$0.166	$0.161	$0.158	$0.154	$0.147	$0.129	$0.108
	5,425	$0.183	$0.163	$0.154	$0.150	$0.146	$0.143	$0.139	$0.133	$0.117	$0.098
	6,034	$0.167	$0.149	$0.141	$0.137	**$0.134**	$0.130	$0.127	$0.122	$0.107	$0.089
	6,625	$0.154	$0.137	$0.130	$0.126	$0.123	$0.120	$0.117	$0.112	$0.099	$0.082
	7,250	$0.142	$0.127	$0.120	$0.117	$0.114	$0.111	$0.109	$0.104	$0.091	$0.076
	7,850	$0.133	$0.118	$0.112	$0.109	$0.106	$0.104	$0.101	$0.097	$0.085	$0.071
	8,450	$0.124	$0.111	$0.105	$0.102	$0.100	$0.097	$0.095	$0.090	$0.080	$0.066

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: North Branch / East Main [Multi-Size Pipeline]

The District's BOR and NADB project consists of replacing 25,500 feet (4.83 miles) of the North Branch / East Main with multi-size (60", 54", 48") rubber-gasket, reinforced-concrete pipeline. 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

27 Unlike other districts' proposed projects with two or more components, the Hidalgo County Irrigation District No. 1's project consists of a single component. Thus, only one appendix (i.e., Appendix A) is provided as discussion of aggregate legislative criteria (in an Appendix B) is not required.

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

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

Summary Calculated Values

The initial construction costs associated with the purchase and installation of the multi-size pipeline amount to $3,847,125. 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 307,200 ac-ft of nominal *off*- and *on-farm* water savings are projected to occur during the productive life of the multi-size pipeline, with associated energy savings of 173,280,053,335 BTU (50,785,479 kwh). Using the 4% discount rate, the present or real value of such anticipated savings become 125,415 ac-ft and 70,741,906,465 BTU (20,733,267 kwh) (**Table A1**).

The accrued annual net changes in O&M expenditures over the multi-size pipeline's productive life are a total decrease of $8,889,325. Using the 2002 Federal discount rate of 6.125%,[28] this anticipated net decrease in expenditures represents a real cost reduction of $2,437,746 (**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 $12.52 in a nominal sense and $30.68 in real terms, while the initial construction costs per BTU (kwh) of energy saved are $0.0000222 ($0.076) in a nominal sense and $0.0000544 ($0.186) 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 pipeline 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 -0.43 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 multi-size pipeline. On a real basis, this ratio measure is -1.58

28 In order to maintain consistency across projects being analyzed by the authors in calendar years 2002 and 2003, the 2002 Federal discount rate of 6.125% is also applied to this and other reports analyzed in 2003.

(**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' project components) 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.

Appendix Tables

Table A1. Summary of Calculated Values for Multi-Size Pipeline Replacing North Branch / East Main, Hidalgo County Irrigation District No. 1's Proposed Project to BOR and NADB, 2003.

Item	Nominal PV	Real NPV
Dollars of Initial Construction Costs	$ 3,847,125	$ 3,847,125
Ac-Ft of Water Saved	307,200	125,415
BTU of Energy Saved	173,280,053,335	70,741,906,465
kwh of Energy Saved	50,785,479	20,733,267
$ of Annual Economic Savings (costs are + values and benefits [i.e., savings] are -)	$ (8,889,325)	$ (2,437,746)

Table A2. Legislated Evaluation Criteria for Multi-Size Pipeline Replacing North Branch / East Main, Hidalgo County Irrigation District No. 1's Proposed Project to BOR and NADB, 2003.

Criteria	Nominal PV	Real NPV
Dollar of Initial Construction Costs per Ac-Ft of Water Saved	$ 12.52	$ 30.68
Dollar of Initial Construction Costs per BTU of Energy Saved	$0.0000222	$0.0000544
Dollar of Initial Construction Costs per kwh of Energy Saved	$0.076	$0.186
$ of Initial Construction Costs per $ of Annual Economic Savings (costs are + values and benefits [i.e., savings] are -)	-0.433	-1.578

— Notes —