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September 2005

Texas Water Resources Institute
make every drop count

Economic and Conservation Evaluation of Capital Renovation Projects: United Irrigation District of Hidalgo County (United) – Rehabilitation of Main Canal, Laterals, and Diversion Pump Station – Preliminary

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Authors' Note:

This preliminary report was developed to assist the United Irrigation District (UID) of Hidalgo County in their submitting of project materials to the U.S. Bureau of Reclamation (USBR). Distribution of this report will initially be limited to the UID and their consulting engineer, the USBR, and the Texas Water Development Board (TWDB). After the USBR and TWDB have reviewed UIDs Project Plan and provided comments, a final economic analysis and report will be prepared incorporating those review comments affecting the economic analysis. Initially, distribution of the final report will be kept to the same limited group of stakeholders. Only after the USBR has scored and finalized the next grouping of irrigation districts' proposed capital-rehabilitation projects will the final results for UIDs project be made available to other stakeholders and the public. This is anticipated to occur sometime in late 2005.

This research was supported by the "Rio Grande Basin Initiative" which is administered by the Texas Water Resources Institute of the Texas A&M University System with funds provided by the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, under Agreement Numbers 2005-45049-03209 and 2005-34461-15661.

Preface [1]

Recognizing the seriousness of the water crisis in South Texas, the U.S. Congress enacted Public Law 106-576, entitled "The Lower Rio Grande Valley Water Resources Conservation and Improvement Act of 2000 (Act)." In that Act, the U.S. Congress authorized water conservation projects for irrigation districts relying on the Rio Grande for supply of agricultural irrigation, and municipal and industrial water. Several phases of project planning, evaluation, and financing are necessary, however, before these projects may be constructed. The U.S. Bureau of Reclamation (USBR) is the agency tasked with administering the Act and it has issued a set of guidelines for preparing and reviewing such proposed capital renovation projects.

Based on language in the Act, the "Guidelines for Preparing and Reviewing Proposals for Water Conservation and Improvement Projects Under Public Law 106-576 (Guidelines)" require three economic measures as part of the USBRs evaluation of proposed projects:

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

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

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

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

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

associated with energy savings. There are energy savings from pumping less water, in association with reducing leaks, and from improving the efficiency of pumping plants.

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

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

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

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

About the Authors

M. Edward Rister
Ronald D. Lacewell
Allen W. Sturdivant

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.; and **Sturdivant**, Extension Associate, Department of Agricultural Economics, Texas Cooperative Extension, Agricultural Research and Extension Center, Weslaco, TX.

Acknowledgments

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

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

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

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

- ***Ari Michelsen and Jose Amador, and Terry Lockamy.*** As Resident Director and former Resident Director, respectively, of the Agricultural Research and Extension Centers at El Paso and Weslaco, and as Regional Program Director for the South Region, all have been very supportive and helpful in many ways;

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

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

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

- ***Thomas Michalewicz, Larry Walkoviak, Mike Irlbeck, Debbie Blackburn, and James Allard.*** These individuals are with the USBR in various management, engineering, and environmental roles. They have been instrumental in fostering a collaborative environment between several agencies and have taken the lead in bringing the Texas

Water Development Board into planning and facilitating cooperation across State and Federal agencies;

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

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

- ***Allan Jones, B. L. Harris, Ellen Weichert, and Rosemary Payton.*** As Director, Associate Director, Business Administrator, and Senior Administrative Coordinator of the Texas Water Resources Institute, respectively, they provide leadership for the Rio Grande Basin Initiative funded through a grant from Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture;

- ***Megan Stubbs.*** As a former graduate student with the Bush School at Texas A&M University, Megan contributed useful insight and commentary while reviewing our work and also led the writing of other related reports on the evolution, development, and operations of Texas Lower Rio Grande Valley irrigation districts;

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

- ***John R. C. Robinson.*** As a former District Economist and as a former coauthor on related economic studies, John assisted much with introductions, ground-truthing, and editorial review of analysis reports. We wish him well with his new Extension Economist, Cotton Marketing and Risk Management responsibilities in the Department of Agricultural Economics at Texas A&M University; and

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

Thanks to everyone noted above. We as authors do, however, accept responsibility for any errors or omissions in this report and/or the economic spreadsheet model, RGIDECON©.

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Economic and Conservation Evaluation of Capital Renovation Projects: United Irrigation District of Hidalgo County (United) – Rehabilitation of Main Canal, Laterals, and Diversion Pump Station – Preliminary

Abstract

Initial construction costs and net annual changes in operating and maintenance expenses are identified for a three-component capital renovation project proposed by the United Irrigation District to the U.S. Bureau of Reclamation (USBR). The proposed project involves: installing 4.66 miles of pipeline in the Main Canal and Lateral 7N, installing 13.46 miles of pipeline in several laterals and sub-laterals, and rehabilitating the District's Rio Grande diversion pumping plant. Both nominal and real estimates of water and energy savings and expected economic and financial costs of those savings are identified throughout the anticipated useful lives for all three components. Sensitivity results for both the cost of saving water and the cost of saving energy are presented for several important parameters.

Annual water and energy savings forthcoming from the total project are estimated, using amortization procedures, to be **1,409 ac-ft of water** per year and **4,506,882,727 BTUs (1,320,892 kwh) of energy** per year. The calculated economic and financial cost of saving water is estimated to be **$325.20 per ac-ft**. The calculated economic and financial cost of saving energy is estimated at **$0.0001113 per BTU ($0.380 per kwh)**.

In addition, real (vs. nominal) values are estimated for the USBRs three principal evaluation measures specified in the U.S. Public Law 106-576. The aggregate initial construction cost per ac-ft of water savings measure is $354.30 per ac-ft of water savings. The aggregate initial construction cost per BTU (kwh) of energy savings measure is $0.0003376 per BTU ($1.152 per kwh). The aggregate ratio of initial construction costs per dollar of total annual economic savings is estimated to be -3.442.

U. S. Bureau of Reclamation's Endorsement of RGIDECON©

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

IN REPLY
REFER TO:

TX-Clark
PRJ-8.00

JUL 24 2002

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

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

Dear Dr. Lacewell:

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

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

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

Sincerely,

M L Martin

for Larry Walkoviak
Area Manager

A Century of Water for the West
1902-2002

Economic and Conservation Evaluation of Capital Renovation Projects: United Irrigation District of Hidalgo County (United) – Rehabilitation of Main Canal, Laterals, and Diversion Pump Station – Preliminary

Executive Summary

Introduction

Recognizing the seriousness of the water crisis in South Texas, the U.S. Congress enacted Public Law (PL) 106-576, entitled "The Lower Rio Grande Valley Water Conservation and Improvement Act of 2000 (Act)." Therein, Congress authorized investigation into four water conservation projects for irrigation districts relying on the Rio Grande for their municipal, industrial, and agricultural irrigation supply of water. Subsequent legislation (i.e., PL 107-351, or "Lower Rio Grande Valley Water Resources Conservation and Improvement Act of 2002") amended the previous Act by adding 15 conservation projects. The project proposed by United Irrigation District (UID) is included among the amended fifteen projects. *Authorization* of these projects does not guarantee federal funding (i.e., appropriations) as several phases of planning and evaluation are necessary before these projects may be approved for financing and construction.

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, and using RGIDECON© to develop supportive materials documenting the sustainability of the projects being proposed by Texas irrigation districts to the U.S. Bureau of Reclamation (USBR).[1] The USBR, in a letter dated July 24, 2002, stated that RGIDECON© satisfies requirements of the legislation-authorized projects and that the USBR will use the results for economic and energy evaluation.

This report documents the economic analysis conducted for the project proposed by the United Irrigation District (i.e., the District) to the USBR. 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]

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1 This report contains economic and financial analysis results for a capital rehabilitation project proposed by the United Irrigation District (a.k.a. United). Readers interested in the methodology and/or prior reports are directed to pp. 41-43 which identify related publications.

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

District Description

The District delivers water to more than 28,000 acres of agricultural cropland with its 71,582 ac-ft of irrigation water rights, with the actual water available varying from year to year. In addition, the District holds municipal/industrial water rights of 25,540 ac-ft per year. The District contracts for delivery of water to the City of McAllen (up to 11,250 ac-ft per year), the City of Mission (up to 7,720 ac-ft per year), and the Sharyland Water Supply Corporation (up to 7,256 ac-ft per year), with actual deliveries generally below the maximum quantity. The District does not deliver to a major industrial customer. The District is currently a supplemental supplier of raw water for its municipal customers.

Recent agricultural water use during fiscal years 1999-2003 for the District has ranged from 6,942 to 18,703 ac-ft, with the five-year average at 12,203 ac-ft. Municipal and industry (M&I) water use during 1999-2003 has been fairly consistent, ranging from 11,391 to 14,551 ac-ft, with the five-year average at 13,169 ac-ft. Although the District relies upon the Rio Grande for its water, the District's agricultural water diversions during recent years have not been significantly hampered by deficit allocations. Thus, the five-year water use figures are considered appropriate for use in forecasting future diversions.

Proposed Project Components

The capital improvement project proposed by the District to the USBR consists of three components:

- installing 4.66 miles of multi-size pipe (i.e., 60", 54", 48", 42", 36", 30", and 24") in the **Main Canal and Lateral 7N** – when both segments are installed, this will reduce seepage and evaporation in the water pathways by a total of 514 ac-ft per year – installation will be phased-in between calendar years 2005 and 2014;

- installing 13.46 miles of multi-size pipe (i.e., 30", 24", and 18") in numerous **Laterals and Sub-Laterals** in the upper portion of the District – when all segments are installed, this will reduce seepage and evaporation in the laterals by a total of 1,149 ac-ft per year – installation will be phased-in between calendar years 2005 and 2012; and

- **rehabilitating the diversion pumping plant** at the Rio Grande by replacing the gas engine with a 500 horsepower electric motor, complete with adjustable-speed drive and a soft start – this will not save water, but it is anticipated to significantly reduce energy consumption, operation and maintenance costs, and provide for increased operational assuredness well into the future.

Economic and Conservation Analysis Features of RGIDECON©

RGIDECON© is an Excel spreadsheet developed by TAES/TCE economists to investigate the economic and conservation merits of capital renovation projects proposed by Rio Grande Basin irrigation districts. RGIDECON© facilitates integration and analysis of information pertaining to proposed projects' costs, productive lives, water and energy savings, and resulting per unit costs of water and energy savings. RGIDECON© simplifies capital budgeting analyses of up to five individual components comprising a project; it reports on individual components, and the total aggregate over all components comprising the project.

Cost Considerations: Initial & Changes in O&M

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

Anticipated Water and Energy Savings

Annual water and energy savings are calculated for each component separately and also for a combined total across all components, if applicable. Water savings can originate from (a) increased head at farm diversion points, (b) reduced seepage and evaporation losses in canals, and/or (c) better management of water flow, and are considered to result in reduced Rio Grande diversions. 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 (i.e., value) of such energy.[4]

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.

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

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

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 three components comprising UIDs project, and then aggregated across all components. With regards to water and energy savings, areas or sources are first identified, with the subsequent discussion quantifying estimates for those sources.

Component #1: Main Canal and Lateral 7N

Component #1 of the District's proposed USBR project is referred to as "Main Canal and Lateral 7N" and consists of installing 4.66 miles of multi-size pipe (i.e., 60", 54", 48", 42", 36", 30", and 24") in segments of the Main Canal and Lateral 7N. This component is anticipated to be installed over the course of several years. Each of these two segments (i.e., Main Canal and Lateral 7N) comprising component #1 are part of the larger, long-term rehabilitation project proposed by the District. These two segments will be installed separately and phased-in between calendar years 2005 and 2014. The installation period is projected to be approximately one year for both segments, albeit at different time periods, with each segment's ensuing expected life to be 50 years. A loss of operations (or other adverse impact) is not anticipated during the installation period as much of the work will be done in the off season, and when water is needed, alternative supply routes will be used to maintain service to the impacted areas.

Initial and O&M Costs

Estimated initial capital investment costs total $4,660,420 ($1,000,611 per mile) in nominal dollars; which is equivalent to $3,686,029 ($791,405 per mile) in present-day values as some of the initial investment for the multi-segment project component is to be "spent" in 2006, with the remainder in 2013. That is, the higher total incorporates an engineer-determined 5% annual project cost inflation factor, basis CY 2005, while the lower total discounts the nominal total at an annual 6.125% rate.

Annual increases in O&M expenditures for the new pipeline of $8,853 are expected after both segments are installed/implemented. Simultaneously, reductions in annual O&M expenditures of $29,510 are anticipated from discontinued maintenance of the existing water pathways, after both segments are installed/implemented. Therefore, after both segments are installed/implemented, a net decrease in annual O&M costs of $20,657 is expected (i.e., $8,853 - $29,5104) (basis 2005 dollars).

Anticipated Water and Energy Savings

Only off-farm water savings are predicted to be forthcoming from component #1, with the nominal total being 25,700 ac-ft over the 50-year productive life of this component and the real 2005 total being 10,478 ac-ft. The annual *off-farm* water-savings estimate of 514.0 ac-ft per year (after both segments are installed/implemented) are based on seepage and evaporation savings. Since there are no annual *on-farm* water savings, the *off-farm* value represents total annual water savings, with associated energy savings estimates of 26,368,919,580 BTU (7,728,288 kwh) in nominal terms over the 50-year productive life and 10,751,030,345 BTU (3,150,947 kwh) in real 2005 terms. Energy savings are based on reduced diversions at the Rio Grande, and reduced relifting within the delivery system.

Cost of Water and Energy Savings

The economic and financial cost of water savings forthcoming from component #1 is estimated to be $391.71 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 $182,991 by the annuity equivalent of the total net water savings of 467 ac-ft (in 2005 terms). The economic and financial cost of energy savings are estimated at $0.0003926 per BTU ($1.340 per kwh). This value is obtained by dividing the annuity equivalent of the total net cost stream for energy savings from all sources of $188,193 by the annuity equivalent of the total net energy savings of 479,324,031 BTU (140,482 kwh) (in 2005 terms).

Component #2: Laterals and Sub-Laterals

Component #2 of the District's proposed USBR project is referred to as "Laterals and Sub-Laterals" and consists of installing 13.46 miles of multi-size pipe (i.e., 30", 24", and 18") in numerous Laterals and Sub-Laterals. The District's project is anticipated to be installed over the course of several years between 2005 and 2012. Each of the segments comprising component #2 are part of the larger, long-term rehabilitation project proposed by the District. The segments will be installed separately and phased-in between calendar years 2005 and 2012. The installation period is projected to range from approximately three months to one year for each segment, albeit at different time periods, with each segment's ensuing expected life to be 50 years. A loss of operations (or other adverse impact) is not anticipated during the installation period as much of the work will be done in the off season, and when water is needed, alternative supply routes will be used to maintain service to the impacted areas.

Initial and O&M Costs

Estimated initial capital investment costs total $9,503,093 ($705,765 per mile) in nominal dollars; which is equivalent to $7,349,634 ($545,834 per mile) in present-day values as some of the initial investment for the multi-segment project component is to be "spent" in most every year between CYs 2005 and 2012, with the remainder in 2013. That is, the higher total incorporates an engineer-determined 5% annual project cost inflation factor, basis CY 2005, while the lower total discounts the nominal total at an annual 6.125% rate.

Annual increases in O&M expenditures for the new pipeline of $25,593 are expected after all segments are installed/implemented. Simultaneously, reductions in annual O&M expenditures of $85,312 are anticipated from discontinued maintenance of the existing water pathways, after all segments are installed/implemented. Therefore, after all segments are installed/implemented, a net decrease in annual O&M costs of $59,718 is expected (i.e., $25,593 - $85,312) (basis 2005 dollars).

Anticipated Water and Energy Savings

Only off-farm water savings are predicted to be forthcoming from component #2, with the nominal total being 55,750 ac-ft over the 50-year productive life of this component and the real 2005 total being 21,029 ac-ft. The annual *off-farm* water-savings estimates begin with 89.0 ac-ft per year (for the first segment), and increase annually until 2012 where an anticipated 1,149 ac-ft per year is estimated to be saved after all segments are installed/implemented. That is, as more segments are completed, the water saved increases. All water savings are based on seepage and evaporation savings. Since there are no annual *on-farm* water savings, the *off-farm* value represents total annual water savings, with associated energy savings estimates of 58,996,609,955 BTU (17,290,917 kwh) in nominal terms over the 50-year productive life and 21,576,648,467 (6,323,754 kwh) in real 2005 terms. Energy savings are based on reduced diversions at the Rio Grande, and reduced relifting within the delivery system.

Cost of Water and Energy Savings

The economic and financial cost of water savings forthcoming from component #2 is estimated to be $323.58 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 $304,779 by the annuity equivalent of the total net water savings of 942 ac-ft (in 2005 terms). The economic and financial cost of energy savings are estimated at $0.0003262 per BTU ($1.113 per kwh). This value is obtained by dividing the annuity equivalent of the total net cost stream for energy savings from all sources of $315,241 by the annuity equivalent of the total net energy savings of 966,403,486 BTU (283,237 kwh) (in 2005 terms).

Component #3: Rehabilitate Diversion Pumping Plant

Component #3 of the District's proposed USBR project is termed "Rehabilitate Diversion Pumping Plant" and consists of rehabilitating the diversion pumping plant at the Rio Grande by replacing the gas engine with a 500 horsepower electric motor, complete with adjustable-speed drive and a soft start. The installation period is projected to take less than one month with an ensuing expected useful life of 25 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 $123,542, which provide for a 500 horsepower electric motor, complete with adjustable-speed drive and a soft start. Annual increases in O&M expenditures for the new motor of $4,902 are expected. Additionally, reductions in annual O&M expenditures of $14,406 are anticipated from discontinued maintenance associated with the existing gas engine. Therefore, a net decrease in annual O&M costs of $9,504 is expected (basis 2005 dollars).

Anticipated Water and Energy Savings

No water savings are predicted to be forthcoming from component #3. Expected associated energy savings, however, are estimated at 78,295,811,640 (22,947,190 kwh) in nominal terms over the 25-year productive life and 48,925,737,148 (14,339,313 kwh) in real 2005 terms. Energy savings are based only on efficiency improvements in diversion-pumping operations at the Rio Grande (i.e., no reduced pumping from forthcoming water savings).

Cost of Water and Energy Savings

Since there are no expected water savings from this component, the economic and financial cost of saving water is non-applicable. The economic and financial cost of energy savings are estimated at negative $0.0000006 per BTU (negative $0.002 per kwh). This value is obtained by dividing the annuity equivalent of the total net cost stream for energy savings from all sources of -$1,940 by the annuity equivalent of the total net energy savings of 14,339,313 BTU (897,173 kwh) (in 2005 terms).

Total Across All Components

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

Initial and O&M Costs

The total capital investment cost required for all components amounts to $14,287,055 in nominal dollars; which is equivalent to $11,159,204 in present-day values (i.e., a discounting adjustment for inflation and time at an annual rate of 6.125%) as the initial investment for the multi-component project will be "spent" over time, during the years 2005 to 2012. That is, the higher total incorporates an engineer-determined 5% annual project cost inflation factor, basis CY 2005, while the lower total discounts the nominal total at an annual 6.125% rate. Combining these costs with the projected changes in annual O&M expenditures, and the useful lives of the respective project components results in an annuity equivalent of $458,224 cost per year for water savings associated with the total project. The similar annuity equivalent measure for costs of energy savings is $501,494 per year.

Anticipated Water and Energy Savings

Only *off-farm* water savings are expected from the three components with the nominal total being 83,450 ac-ft over their expected productive lives and the real 2005 total being 31,508 ac-ft. On an average annual basis (or annuity equivalent), this amounts to 1,409 ac-ft across the three project components, representing **4.4%** of the current average water diversion by the District. Estimates of annual water savings are based on the net reduction in seepage and evaporation in canals and laterals. Associated energy savings estimates are 163,661,341,175 BTU (47,966,395 kwh) in nominal terms over their lives and 81,253,415,960 BTU (**23,814,014** kwh) in real 2005 terms. On an average annual basis (or annuity equivalent), this amounts to 4,506,882,727 BTU (1,320,892 kwh) across the three project components. Combined energy savings are based on reduced diversions at the Rio Grande (resulting in improved water supplies), and operational-efficiency improvements provided by a new diversion-pump motor.

Cost of Water and Energy Savings

The aggregation of the economic and financial costs of water and energy savings for the individual project components result in aggregate cost estimates of **$325.20 per ac-ft** cost of water savings and **$0.0001113 per BTU ($0.380 per kwh)** cost of energy savings.

Summary

The table at the top of the next page summarizes key information regarding each of the components of United Irrigation District's USBR project, with a more complete discussion provided in the main report.

Sensitivity Analyses

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

Table ES1. Summary of Key Data and Composite Value Analysis Results for Main Canal, Laterals, and Diversion Pumping Plant, UID, 2005.

	Project Component			
Item	Main Canal and Lateral 7N	Laterals and Sub-Laterals	Rehabilitate Diversion Pumping Plant	Aggregate
Input Data				
Initial Investment Cost ($) - effective nominal [a]	$4,660,420	$9,503,093	$123,542	$14,287,055
Initial Investment Cost ($) - discounted [b]	$3,686,029	$7,349,634	$123,542	$11,159,204
Expected Useful Life (years) [c]	50	50	25	n/a
Net Changes in Annual O&M ($)	($ 20,657)	($ 59,718)	($ 9,504)	$ (89,878)
Economic Results - Composite Values				
Annuity Equivalent of Net Cost Stream – Water Savings ($/yr)	$ 182,991	$ 304,779	($29,546)	$ 458,224
Annuity Equivalent of Water Savings (ac-ft)	467	942	n/a	1,409
Calculated Cost of Water Savings ($/ac-ft)	**$ 391.71**	**$ 323.58**	n/a	**$ 325.20**
Annuity Equivalent of Net Cost Stream – Energy Savings ($/yr)	$ 188,193	$ 315,241	$ (1,940)	$ 501,494
Annuity Equivalent of Energy Savings (BTUs)	479,324,031	966,403,486	3,061,155,211	4,506,882,727
Annuity Equivalent of Energy Savings (kwhs)	140,482	283,237	897,173	1,320,892
Calculated Cost of Energy Savings ($/BTU)	**$ 0.0003926**	**$ 0.0003262**	**$ (0.0000006)**	**$ 0.0001113**
Calculated Cost of Energy Savings ($/kwh)	**$ 1.340**	**$ 1.113**	**$ (0.002)**	**$ 0.380**

[a] As each component has multiple segments to be constructed, over a period of several years (2005 to 2013), these effective nominal values are summed across the years in which costs are expected to be incurred. That is, project costs are expected to rise in future years and thus incorporate a 5% annual project-material cost inflation factor, basis CY 2005 (Gonzalez).

[b] Effective Nominal totals discounted to present day values at a 6.125% annual rate, which is consistent with the methodology in other economic analyses (e.g., Rister et al. 2005).

[c] Although they both have 50-year expected useful lives, the actual expected discounting term for components #1 and #2 are 57 and 56 years, respectively. As the multiple segments comprising each component are scheduled to be installed in a staggered fashion, some segments will not begin their 50-year useful lives for several years. Thus, the expected terms (# years) for these two components are increased to allow for a 50-year useful life for each segment; which, for some segments does not begin for years.

Legislative Criteria

United States Public Law 106-576 (and the amending legislation U.S. Public Law 107-351) requires three economic measures be calculated and included as part of the information prepared for the USBRs (USBR 2001) evaluation of the proposed projects. According to the USBR, these measures are more often stated in their inverse mode:

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

The noted legislated criteria involve a series of calculations similar to, but different from, those used in developing the cost measures cited in the main body of the full analysis report. Principal differences consist of the legislated criteria not requiring aggregation of the initial capital investment costs with the annual changes in O&M expenditures, but rather entailing separate sets of calculations for each type of cost relative to the anticipated water and energy savings. The approach used in aggregating the legislated criteria into one set of uniform measures (presented in Appendix B) utilizes the present value methods used in calculating the economic and financial results reported in the main body of this report. It does not include, however, the development of annuity equivalent measures. These compromises in approaches are intended to maintain the spirit of the legislated criteria's intentions. Only real, present value measures are presented and discussed for the legislated criteria aggregate results, thereby designating all such values in terms of 2005 equivalents. **Differences in useful lives across project components are not fully represented, however, in these calculated values**.

The aggregate 'initial construction cost per ac-ft of water savings' measure is $354.30 per ac-ft of water savings which is slightly higher than the comprehensive economic and financial value of **$325.20 per ac-ft** identified and discussed in the main body of the analysis report. The differences in these values are attributable to the incorporation of both initial capital costs and changes in operating expenses in the latter value, and its treatment of the differences in the useful lives of the respective component(s) of the proposed project.

The aggregate 'initial construction cost per BTU (kwh) of energy savings' measure is $0.0003376 per BTU ($1.152 per kwh). These cost estimates are higher than the **$0.0001113 per BTU ($0.380 per kwh)** comprehensive economic and financial cost estimates identified for reasons similar to those noted above (i.e, with respect to costs per ac-ft of water savings).

The aggregate 'initial construction costs per dollar of annual economic savings' measure reduces to a ratio of -3.44, indicating that (a) the net change in annual O&M expenditures is negative, i.e., a reduction in O&M expenditures is anticipated; and (b) $3.44 of initial construction costs are expended for each such dollar reduction in O&M expenditures, with the latter represented in total real 2005 dollars accrued across the three project components' respective planning periods.

Economic and Conservation Evaluation of Capital Renovation Projects: United Irrigation District of Hidalgo County (Mission) – Rehabilitation of Main Canal, Laterals, and Diversion Pump Station – Preliminary

Introduction

The project proposed by United Irrigation District (a.k.a. United) is included among the fifteen irrigation-district projects authorized for water conservation in the Lower Rio Grande Valley Water Resources Conservation and Improvement Act of 2002 (Act), or United States Public Law (PL) 107-351. As stated in the legislation, "If the Secretary determines that ... meet[s] the review criteria and project requirements, as set forth in section 3 [of the Act], the Secretary may conduct or participate in funding engineering work, infrastructure construction, and improvements for the purpose of conserving and transporting raw water through that project" (United States Public Law 106-576). This report provides documentation of an economic and conservation analysis conducted for three components (focused on canal, lateral, and diversion pump station rehabilitation) comprising United Irrigation District's proposed project to the U.S. Bureau of Reclamation (USBR) during the Summer of 2005.[1]

Irrigation District Description[2]

Twenty-eight irrigation districts exist in the Texas Lower Rio Grande Valley (**Exhibit 1**).[3] The United Irrigation District is located in Mission, Texas (**Exhibits 2** and **3**). The District boundary covers many acres of Hidalgo County (**Exhibit 4**). The postal address is P.O. Box 877, Mission, TX 78573. Telephone contact information is 956/585-4818 and the fax number is 956/585-9743. Tito Nieto is the General Manager, with Alfonso Gonzalez, P.E. of Sigler, Winston, Greenwood & Associates, Inc., Weslaco, Texas, serving as the lead consulting engineer for this project.

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

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1 Readers interested in the methodology and/or prior reports are directed to pages 41-43 which identify related publications.

2 The general descriptive information presented was assimilated from several sources, including documents provided by Tito Nieto (the District manager), the Region M Rio Grande Regional Water Planning Group Report, and Fipps' Technical Memorandum in the latter report (Fipps 2000).

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

Irrigated Acreage and Major Crops

The District delivers water to approximately 28,000 acres of agricultural cropland within its district. Furrow irrigation accounts for the majority of irrigation deliveries. Flood irrigation is the norm for orchards, sugarcane, and pastures. The typical crop mix in the District is noted in **Table 1**, which illustrates the relative importance (on an acreage basis) of grain sorghum, cotton, sugarcane, citrus, etc. The crop mix distribution within a particular irrigation district (ID) 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/areas appearing to be water-rich, in a relative sense.

Municipalities Served

The District's priority in diverting water is to first meet the demands of residential and commercial users[4] within the District. To facilitate delivery, the District contracts up to 26,225 acre feet (ac-ft) of municipal/industrial water diversions to the cities of Mission, McAllen, and the Sharyland Water Supply Corporation (**Exhibit 5**). The District either owns or holds 25,540 ac-ft of municipal water rights. After fulfilling municipalities' requirements, needs of agricultural irrigators are addressed.

It is important to note that each ID 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 ID 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 IDs (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 IDs (Hill).

Historic Water Use

A recent five-year period (i.e., 1999-2003) demonstrates a range of water use in the District (**Table 2**). Agricultural use has ranged from 6,942 to 18,703 ac-ft, with an average of 12,203 ac-ft. M&I water use has ranged from 11,391 to 14,551 ac-ft, with the average at 13,169 ac-ft. The average total water diverted within the District during this time period is 32,111 ac-ft, with a range from 23,573 to 39,694 ac-ft.[5] Although the District relies upon the Rio Grande for its water, the District's agricultural water diversions during recent years have not been

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

5 On average, summing Agricultural and M&I water deliveries, and dividing by the total volume diverted results in an 80% delivery efficiency (i.e., $(12{,}203 + 13{,}169) \div 32{,}111 \approx .80$).

significantly hampered by deficit allocations forthcoming from the Rio Grande. Thus, the five-year water use figures are appropriate for use in forecasting future diversions (Nieto).[6]

Assessment of Technology and Efficiency Status

The District's pumping plant diverts water from the Rio Grande southwest of Mission, TX. near the community of Palmhurst (**Exhibit 5**). From there, the water flows into the Main Canal which delivers to the entire District. The current pumping plant was completed about 1960 and has a typical operating capacity of 90-100 cubic feet per second (cfs) and a maximum of 378 cfs. More than 160 miles of canals, laterals, and pipelines, along with the Rio Grande diversion pump station and two main relift pumping stations, comprise the majority of the District's delivery-system infrastructure.

The District has been aggressive in increasing the maximum amount of water deliverable to each turnout while also increasing its overall efficiency by reducing irrigation time requirements. The District has incorporated a Geographic Information System (GIS) program for linking a mapping system to a data base, indicating: where water has been ordered; for what types of crops; and various systems necessary to deliver the water. All of the agricultural water in the District is delivered on a temporal-pricing (i.e., time) basis. That is, turnout delivery volume rates are known and the District assesses deliveries on a $/hour basis.[7] Producers' use of water-conserving methods and equipment is encouraged (Nieto).

Water Rights Ownership and Sales

The District owns three Certificates of Adjudication (i.e., #'s 0846-000, A847-001, and B847-001) and holds/manages eleven other certificates whereby it provides diversion and delivery of raw water for municipal customers (**Table 3**). Further, users interested in acquiring additional water beyond their available allocations may acquire such water from parties interested in selling or leasing rights. Such external-to-the-District purchases and/or leases are subject to a transportation delivery loss charged by the District; that is, purchase or lease of one ac-ft from sources outside the District will result in users receiving some amount less than one ac-ft at their diversion point.

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

7 This temporal approach to pricing is completely unique among local irrigation districts. Further, the temporal aspect does lend itself to indirectly determining volumetric prices as water-delivery time can be multiplied by known volumetric flows (i.e., rate) to arrive at total volume.

Water charges assessed irrigators within the District include an annual flat-rate maintenance and operations fee of $16.50 per acre (which is typically paid for by the landowner) (**Table 3**). Volume at individual farm turnouts are such that each acre foot requires four hours of delivery time. Thus, an additional $5.00 per hour (equivalent to $^{1}/_{4}$ ac-ft) is assessed for water delivery (either to the landowner-operator, or tenant-producer), making delivery rates equate to $20 per ac-ft (i.e., $5/hr x 4 hours/ft = $20/ac-ft) of water. Water delivered to drip-meter irrigators is priced at $11.25 per hour, which, again with the standard assumed four hours of delivery time per ac-ft, translates into an equivalent variable assessment of $45.00 per ac-ft (Dunn) (**Table 3**).

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

Project Data

As proposed by the District, the rehabilitation of numerous canals, laterals, sub-laterals, and the diversion pumping plant is analyzed via three components as defined/described below.[8]

Component #1: Main Canal and Lateral 7N

The Main Canal and Lateral 7N extend the length of the District and collectively service a 3,650 acre area. Summary data for this component are presented in **Tables 4** and **5**, and discussed below. This project consists of installing 4.66 miles of multi-size pipe (i.e., 60", 54", 48", 42", 36", 30", and 24") in the Main Canal and Lateral 7N. Once installed, this component is expected to reduce seepage and evaporation by an estimated 514 ac-ft per year (**Table 4**). It is anticipated that it will take about one year after purchase and project initiation for each segment of this component to be installed and fully implemented (**Table 4**). A loss of operations (or other adverse impact) is not anticipated during installation as much of the work will be done in the off season, and when water is needed, alternative supply routes will be used to maintain service to the impacted areas.

[8] 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.

Productive Period

An effective useful life of 50 years[9] for the new pipeline is expected in the baseline analysis (**Table 5**). A shorter/longer useful life is possible, but 50 years is considered reasonable and consistent with engineering expectations (Gonzalez). Sensitivity analyses are utilized to examine the effects of this assumption. For both component segments, the productive period is assumed to begin the year immediately following the completion of construction (**Table 4**).

Projected Costs

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

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

Capital investment costs (i.e., excavate, purchase, install) for the 4.66 miles of pipeline total $4,660,420 ($1,000,611 per mile) nominal dollars (**Tables 4** and **5**) (Gonzalez). Sensitivity analyses on the total amount of capital expenditures are utilized to examine the effects of this assumption. All expenditures are assumed to occur according to the schedule provided in **Table 4**. Further, the construction costs provided (**Table 4**) are in nominal terms for the year in which construction spending occurs. That is, project costs (significantly impacted by the price of reinforced concrete pipe) are expected to rise in future years and thus incorporate a 5% annual project-material cost inflation factor, basis CY 2005 (Gonzalez).

Recurring. Annual operating and maintenance (O&M) costs for the new pipeline are expected to be different from those presently occurring for the earthen Main Canal and Lateral 7N. Annual O&M expenditures associated with the affected water pathways after installation of the pipeline are anticipated to be $8,853 ($1,901 per mile) (basis 2005 dollars) (**Table 5**).

Projected Savings

Water. Water savings are reductions in diversions from the Rio Grande, i.e., how much less water will be used by the District as a result of this component's installation and utilization?

9 Since the multiple segments comprising this component are scheduled to be installed in a staggered fashion over a period of years into the future, the expected terms (i.e., # of years) are increased to allow for an effective 50-year useful life for each segment. That is, to calculate net benefits for a segment having a 50-year useful life, which will not begin to produce benefits for another 7 years, necessarily required a modification to RGIDECON©. This change to allow a useful life greater than the original maximum 50-year planning horizon does impact the estimated discounted values. The result is, however, a more accurate representation of the component's true estimated net economic and financial costs. Further, the comparability of this project's results to prior analyses (e.g., Rister et al. 2005) is not materially affected as relevant future values are largely discounted in years which are 50-plus years into the future.

Estimates of such savings are comprised, in this case, of only off-farm savings with regards to agricultural (i.e., irrigation) water use only; i.e., no savings related to M&I water use are anticipated.[10]

Off-farm savings are those occurring in the District's canal delivery system as a result of reduced seepage and evaporation after the project segments of the Main Canal and Lateral 7N are piped. Ponding tests in segments of the Main Canal by Leigh and Fipps documented an annual average water seepage loss rate of 3.32 gal/ft^2/day (Sigler, Winston, Greenwood, & Associates, Inc.). Consulting engineers incorporated this and other information on project-area soil types, regional average annual rainfall, evaporation, and exfiltration to estimate 514 ac-ft per year of water savings from reduced seepage, exfiltration, and evaporation with the new pipeline (**Table 4**). Existing estimates of these water losses via seepage are applicable to canals/laterals in their present state. It is highly likely that additional deterioration and increased water loss and associated O&M expenses should be expected as canals/laterals age (Carpenter; Halbert). While estimates of ever-increasing seepage losses over time could be developed, the analysis conservatively maintains a constant water savings (Gonzalez), consistent with assumptions embedded in previous analyses (e.g., Rister et al. 2005).

Estimates of *off-farm* water savings do not include any conveyance losses that could potentially be realized during delivery of the water from the Rio Grande to the farm turnout gates. Thus, all noted water savings are based on a "delivered" basis, which is the same as the "diverted" basis for this project analysis.[11]

As shown in **Table 5**, *on-farm* water savings are <u>not</u> expected to be forthcoming from this component. Therefore, combining all water savings (without any additional conveyance loss included) results in 514.0 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 pipelines' productive lives to provide for a conservative analysis. Sensitivity analyses are performed on all water savings to examine the implications of this estimate. Annual *off-farm* water savings for this project are expected to result in reduced Rio Grande diversions.

<u>Energy</u>. In a general sense, energy savings for a given project <u>may</u> 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 component #1 of the

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

[11] The District's system-wide conveyance loss is estimated to be 80%, as determined by total water diversions minus total water sales. For this analysis, 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 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(s) (Gonzalez).

District's three-component project. Energy savings associated with reduced diversion and relift pumping are expected with this component. That is, water delivered with the Main Canal and Lateral 7N is diverted from the Rio Grande and is also relifted within the water-delivery system.

Energy savings associated with lessened diversion/relift pumping are comprised of: (a) reduced energy and (b) the cost (or value) of such energy. Recent historic records for calendar years 1999-2003 are presented in **Table 6** (diversion energy) and **Tables 7** and **8** (relift energy) with electricity representing 50% of the District's total diversion-energy and relift-energy expense. The District's average lift at the Rio Grande diversion site ranges from **16-20** feet (**Table 3**). On average, 390,121 BTU were used to pump each ac-ft of water diverted (**Table 6**). Multiplying this value by the anticipated 514.0 ac-ft of annual *off-farm* water savings results in anticipated annual irrigation energy savings of 200,522,168 BTU (58,770 kwh) (**Table 5**) from reduced diversions. Assuming the historical average cost of $0.025 per kwh (i.e., 1999-2003),[12] the estimated annual *off-farm* irrigation energy cost savings (diversion) are $1,453 in 2005 dollars (**Table 5**).

Additional *off-farm* energy savings due to reduced relift pumping are expected to be forthcoming from the pipeline project[13] as there will be a reduction in relift pumping due to water savings. The net amount of relift-energy reduction (from relift pumps #1 and #2) associated with this component is estimated to be 326,856,223 BTU (95,796 kwh), which, using the average historical (i.e., 1999-2003) relift-energy cost of $0.027/kwh equates to an annual relift-pumping energy savings of $2,580 (**Tables 5, 7** and **8**).

Since there are no *on-farm* water savings, the combined *off-farm* water savings results in total annual anticipated irrigation energy cost savings of 527,378,392 BTU (154,566 kwh) or the equivalent of $4,034 in 2005 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 diverted and relifted) and the cost per unit of energy.

Operating and Maintenance. Current annual O&M expenses for the existing earthen canal and lateral are estimated to be $29,510 (Nieto). Thus, across the total 4.66 miles of Main Canal and Lateral 7N proposed for piping, a reduction of $20,657 in O&M expense is anticipated (**Table 5**).

Reclaimed Property. District management anticipates 31.3 acres of real property worth $375,600 (in nominal 2005 dollars) will be reclaimed with this project (**Table 5**). This is based on a conservative assumed sales price of $12,000 per acre (basis 2005) (Nieto). As future years' land-sale values are expected to rise, a 4% property-appreciation factor is used to better estimate actual sales prices in future years (Nieto). The reclaimed property value effectively acts as a credit toward the project's initial construction costs.

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12 This estimated value is calculated using District information which incorporates data on electricity and natural gas energy sources for diversion pumping and their costs.

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

Component #2: Laterals and Sub-Laterals

Laterals and Sub-Laterals involved with this component are supplied by the Main Canal and are in the central and northern part of the District. Summary data for this component are presented in **Tables 4** and **5** with discussion of that data following. This project consists of installing 13.46 miles of multi-size pipe (i.e., 30", 24", and 18") in numerous laterals and sub-laterals in the upper portion of the District. Once installed and implemented, this component is expected to reduce seepage and evaporation estimated at 1,149 ac-ft per year (**Table 4**). It is anticipated that it will take from three months to one year after purchase and project initiation for each segment of this component to be installed and fully implemented (**Table 4**). A loss of operations (or other adverse impact) is not anticipated during installation as much of the work will be done in the off season, and when water is needed, alternative supply routes will be used to maintain service to the impacted areas.

Productive Period

An effective useful life of 50 years[14] for the new pipeline is expected in the baseline analysis (**Table 5**). A shorter/longer useful life is possible, but 50 years is considered reasonable and consistent with engineering expectations (Gonzalez). Sensitivity analyses are utilized to examine the effects of this assumption. For all component segments, the productive period is assumed to begin the year immediately following the completion of construction (**Table 4**).

Projected Costs

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

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

Capital investment costs (i.e., excavate, purchase, install) for the 13.46 miles of pipeline total $9,503,093 ($705,765 per mile) nominal dollars (**Tables 4** and **5**) (Gonzalez). Sensitivity analyses on the total amount of capital expenditures are utilized to examine the effects of this assumption. All expenditures are assumed to occur according to the schedule depicted in

14 Since the multiple segments comprising this component are scheduled to be installed in a staggered fashion over a period of years into the future, the expected terms (i.e., # of years) are increased to allow for an effective 50-year useful life for each segment. That is, to calculate net benefits for a segment having a 50-year useful life, which will not begin to produce benefits for another 6 years, necessarily required a modification to RGIDECON©. This change to allow a useful life greater than the original maximum 50-year planning horizon does impact the estimated discounted values. The result is, however, a more accurate representation of the component's true estimated net economic and financial costs. Further, the comparability of this project's results to prior analyses (e.g., Rister et al. 2005) is not materially affected as relevant future values are largely discounted in years which are 50-plus years into the future.

Table 4. Further, the construction costs provided (**Table 4**) are in nominal terms for the year in which construction spending occurs. That is, project costs (significantly impacted by the price of reinforced concrete pipe) are expected to rise in future years and thus incorporate a 5% annual project-material cost inflation factor, basis CY 2005 (Gonzalez).

Recurring. Annual operating and maintenance (O&M) costs associated with the new pipeline are expected to be different from those presently occurring for the earthen laterals and sub-laterals. Annual O&M expenditures associated with the affected laterals (after installation of the pipeline) are anticipated to be $25,593 ($1,901 per mile) (2005 dollars) (**Table 5**).

Projected Savings

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

Off-farm savings are those occurring in the District's canal delivery system as a result of reduced seepage and evaporation after the project segments of the Main Canal and Lateral 7N are piped. Ponding tests in segments of the Main Canal by Leigh and Fipps documented an annual average water seepage loss rate of 3.32 gal/ft2/day (Sigler, Winston, Greenwood, & Associates, Inc.). Consulting engineers incorporated this and other information on project-area soil types, regional average annual rainfall, evaporation, and exfiltration to estimate 1,149 ac-ft per year of water savings from reduced seepage, exfiltration, and evaporation with the new pipeline (**Table 4**). Existing estimates of these water losses via seepage are applicable to canals/laterals in their present state. It is highly likely that additional deterioration and increased water loss and associated O&M expenses should be expected as canals/laterals age (Carpenter; Halbert). While estimates of ever-increasing seepage losses over time could be developed, the analysis conservatively maintains a constant water savings (Gonzalez), consistent with assumptions embedded in previous analyses (e.g., Rister et al. 2005).

Estimates of *off-farm* water savings do not include any conveyance losses that could potentially be realized during delivery of the water from the Rio Grande to the farm turnout gates. Thus, all noted water savings are based on a "delivered" basis, which is the same as the "diverted" basis for this project analysis.[16]

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

16 The District's system-wide conveyance loss is estimated to be 80%, as determined by total diversions minus total sales (Nieto). For this analysis, additional savings, beyond the project-area attributed to conveyance loss are not claimed based on the assumption the claimed savings will occur throughout the year and on the margin will not affect the "fullness" of the canal system. That is, with water being saved at a project site, the District's delivery-system infrastructure will remain fully charged as usual and will not produce additional water savings beyond those realized at the component/project site(s) (Gonzalez).

As shown in **Table 5**, *on-farm* water savings are not expected to be forthcoming from this component. Therefore, combining all water savings (without any additional conveyance loss included) results in 1,149 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 pipelines' productive lives to provide for a conservative analysis. Sensitivity analyses are performed on all water savings to examine the implications of this estimate. Annual *off-farm* water savings for this project are expected to result in reduced Rio Grande diversions.

Energy. In a general sense, 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 component #2 of the District's three-component project. Energy savings associated with reduced diversion and relift pumping are expected with this component. That is, water delivered with the laterals and sub-laterals is diverted from the Rio Grande and is also relifted within the water-delivery system.

Energy savings associated with lessened diversion/relift pumping are comprised of: (a) reduced energy and (b) the cost (or value) of such energy. Recent historic energy records for calendar years 1999-2003 are presented in **Table 6** (diversion) and **Tables 7** and **8** (relift) with electricity representing 50% of the District's total diversion-energy and relift-energy expense. The District's average lift at the Rio Grande diversion site ranges from 16-20 feet (**Table 3**). On average, 390,121 BTU were used to pump each ac-ft of water diverted (**Table 6**). Multiplying this value by the anticipated 1,149.0 ac-ft of annual *off-farm* water savings results in anticipated annual irrigation energy savings of 448,639,092 BTU (131,489 kwh) (**Table 5**) from diversions. Assuming the historical average cost of $0.025 per kwh (i.e., 1999-2003),[17] the estimated annual *off-farm* irrigation energy cost savings (diversions) are $3,252 in 2005 dollars (**Table 5**).

Additional *off-farm* energy savings due to reduced relift pumping are expected to be forthcoming from the pipeline project[18] as there will be a reduction in relift pumping due to water savings. The net amount of relift-energy reduction (from relift pumps #1 and #2) associated with this component is estimated to be 731,293,107 BTU (214,330 kwh), which, using the average historical (i.e., 1999-2003) relift-energy cost of $0.027/kwh equates to an annual relift-pumping energy savings of $5,773 (**Tables 5, 7** and **8**).

Since there are no *on-farm* water savings, the combined *off-farm* water savings results in total anticipated irrigation energy cost savings of 1,179,932,199 BTU (345,819 kwh) or the equivalent of $9,025 in 2005 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 diverted and relifted) and the cost per unit of energy.

17 This estimated value is calculated using District information which incorporates data on electricity and natural gas energy sources for diversion pumping and their costs.

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

Operating and Maintenance. Current annual O&M expenses for the existing earthen laterals and sub-laterals are estimated to be $85,312 (Nieto). Thus, across the total 13.46 miles of Laterals and Sub-Laterals proposed for piping, a reduction of $59,718 in O&M expense is anticipated (**Table 5**).

Reclaimed Property. District management anticipates 122.2 acres of real property worth $1,466,400 (in nominal 2005 dollars) will be reclaimed with this project (**Table 5**). This is based on a conservative assumed sales price of $12,000 per acre (basis 2005) (Nieto). As future years' land-sale values are expected to rise, a 4% property-appreciation factor is used to better estimate actual sales prices in future years (Nieto). The reclaimed property value effectively acts as a credit towards the project's initial construction costs.

Component #3: Rehabilitate Diversion Pumping Plant

The Rio Grande diversion pumping plant diverts all of the District's water. Summary data for this component are presented in **Tables 4** and **5** with discussion of that data following. This project primarily consists of replacing the gas engine with a 500 horsepower electric motor, complete with adjustable-speed drive and a soft start. Once installed and implemented, this component is not expected to save water, but it is anticipated to significantly reduce energy consumption, as well as provide for increased operational assuredness well into the future. It is anticipated that it will take less than one month after purchase and project initiation for the new electric motor to be installed and readied (**Table 4**). A loss of operations (or other adverse impact) is not anticipated as installation is scheduled to occur in the off-season.

Productive Period

A useful life of 25 years for the new diversion pump motor and soft-start is expected and assumed in the baseline analysis (**Table 5**). A shorter useful life is possible, but 25 years is considered reasonable and consistent with engineering expectations (Gonzalez). Sensitivity analyses are utilized to examine the effects of this assumption. The first year of the productive period is assumed to occur during year 1 of the 25-year planning period.

Projected Costs

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

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

Capital investment costs (i.e., purchase, install) for the diversion pump renovation total $123,542 in 2005 nominal dollars (**Tables 4** and **5**) (Gonzalez). Sensitivity analysis on the total amount of capital expenditures are utilized to examine the effects of this assumption. All expenditures are assumed to occur on day one of this project component's inception, thereby avoiding the need to account for inflation in the cost estimate.

Recurring. Annual operating and maintenance (O&M) costs associated with the new electric motor are expected to be different from those presently occurring for the gas motor. Annual O&M expenditures after installation of the new motor are anticipated to be $4,902 (basis 2005 dollars) (**Table 5**) (Gonzalez).

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 component's installation and utilization? Estimates of such savings are comprised, in this case, of zero savings.

Different from previously-analyzed projects (e.g., Rister et al. 2005), this project component is not anticipated to save water. Rather, the diversion-pump motor replacement is proposed as the District has concerns about operational reliability. And, since this pump motor diverts all of the water for the District, a proactive approach is deemed necessary (Nieto).

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. In this instance, the anticipated energy savings are based on efficiency improvements with installing a new pump motor at the Rio Grande diversion site. The amount of such energy savings and the associated monetary savings are detailed below for the District's proposed component #3.

Energy savings associated with lessened diversion/relift pumping are comprised of: (a) reduced energy and (b) the cost (or value) of such energy. Recent historic records for calendar years 1999-2003 are presented in **Table 6** (diversion energy) with electricity representing 31% of the District's total diversion-energy expense (and natural gas representing 69%). The average lift at the diversion site is approximately 16-20 feet (**Table 3**). On average, 114.34 kwh/ac-ft (390,121 BTU) were used to pump each ac-ft of water diverted (**Table 6**). The consulting engineer from Sigler, Winston, Greenwood, & Associates, Inc. anticipate an average energy total consumption rate of 75% of the original; thus, the new motor and soft-start are estimated to require 85.75 kwh/ac-ft (292,591 BTU/ac-ft) (Gonzalez). Multiplying the 28.58 kwh/ac-ft (97,530 BTU/ac-ft) reduction times the total annual average 32,111 ac-ft of water diverted at the Rio Grande (**Table 2**) results in a potential annual *off-farm* energy savings, due to improved operational efficiencies associated with installing a modern relift electric motor, of 3,131,832,466 BTU (917,888 kwh) (**Table 5**). Assuming the historical average cost of $0.025 per kwh (i.e., 1999-2003),[19] the estimated annual *off-farm* irrigation energy cost savings are $22,701 in 2005 dollars (**Table 5**). Sensitivity analyses are performed to examine the effects of

[19] This estimated value is calculated using District information which incorporates data on electricity and natural gas energy sources for diversion pumping and their costs.

the assumptions for both the amount of energy used (per ac-ft of water diverted) and the cost per unit of energy.

Operating and Maintenance. Annual O&M expenses for the existing diversion pump is estimated to be $14,406 (Nieto). Thus, after the new diversion pump is installed, a reduction of $9,504 in O&M expense is anticipated (**Table 5**).

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

Abbreviated Discussion of Methodology [20]

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

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

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

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

Public Law 106-576 legislation requires a variation of economic analyses in which the initial construction costs and annual economic savings are used independently in assessing the potential of capital renovations proposed by irrigation districts (USBR 2001). In addition, all calculations are performed on a nominal rather than real basis (Hamilton).

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

Unique to this analysis were adaptations to RGIDECON© to allow construction of individual components to be "phased-in" across a multi-year period (vs. the immediate time period; or alternatively, year *zero* in the planning horizon, as was typical in prior analyses) as provided for in the consulting engineer's project plan. As two components (in this project) have multiple segments to be constructed in a 'phased-in' fashion over the years 2005 to 2013, two modifications were incorporated and/or allowed:

1) Project costs as provided by the consulting engineer are expected to rise in future years and thus incorporate a 5% annual project-material cost inflation (Gonzalez). This annual project cost-increase factor is applied to only initial construction costs and differs from the 2.04% inflation (i.e., compound) factor utilized for all other costs and impacts (which are measured in dollars within RGIDECON©) in prior analyses. Other dollar-based costs/impacts in this analysis use the 2.04% compound factor. Further, consistent with all prior reports, the 6.125% discount rate is used herein to obtain current-year dollar values. Additional discussion on discount rates and compound factors is provided below.

2) An increase in the number of years for the "planning horizon" (i.e., total number of years in which water, energy, and cost savings occur) was required. That is, to allow a segment to have a 50-year useful life in which construction would not be initiated for several years, required an increased number of years in the planning horizon allowed in RGIDECON© . With this expansion in the planning horizon, components were allowed to have full and complete useful lives of 50 years, versus the "capped" 49-year useful life in prior analyses; i.e., previously, a 50-year maximum planning horizon in RGIDECON© necessitated a 49-year useful life when projects had an anticipated 1-year construction period.

Assumed Values for Critical Parameters

This section presents the values assumed for several parameters which are considered critical in their effects upon the results. This discussion emphasizes the importance of these parameters and highlights the values used.[21]

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

Discount Rates and Compound Factors

The discount rate used for calculating net present values of the different cost streams represents a firm's required rate of return on capital (i.e., interest) or, as sometimes expressed, an opportunity cost on its capital. The discount rate is generally considered to contain three components: a risk-free component for time preference (i.e., social time value), a risk premium, and an inflation premium (Rister et al. 1999).

One estimate of such a discount rate from the District's perspectives would be the cost at which it can borrow money (Hamilton). Griffin notes, however, that because of the potential federal funding component of the project, it could be appropriate to ignore the risk component of the standard discount rate as that is the usual approach for federal projects. Hamilton notes that the Federal discount rate consists of two elements, time value of money and inflation, but that the rate is routinely used as a real rate, ignoring the inflationary component. After considering those views and interacting with Penson and Klinefelter, Texas A&M University agricultural economists specializing in finance, the 2002 Federal discount rate of 6.125% was adopted for use in discounting all financial streams for projects analyzed in 2002. In order to maintain consistency, this same rate is adopted for projects analyzed in 2003, 2004, and 2005.

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

As presented in Rister et al. 2002, use of an overall discount rate of 6.125% in conjunction with a 4% social time value and the assumption of a 0% risk premium infers a 2.043269% annual inflation rate. Such an inferred rate is consistent with recent and expected rates of nominal price increases for irrigation construction, O&M, and energy costs (Rister et al. 2002). Thus, a 2.043269% rate is used to compound 2005 nominal dollar cost estimates forward for years in the planning period beyond 2005. Rationale for assuming this rate is based both on the mathematical relationship presented above and analyses of several pertinent price index series and discussions with selected professionals.[22]

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

Pre-Project Annual Water Use by the District

Water availability and use in the District has varied in recent years. **Table 2** contains the District's historic water use among agricultural irrigation and M&I along with an indication of the total use for a recent five-year period (1999-2003). Rather than isolate one particular year as the baseline on which to base estimates of future water savings, USBR, Texas Water Development Board, Texas Agricultural Experiment Station, and Texas Cooperative Extension representatives agreed during the summer of 2002 to use the average levels of use during a five-year period as a proxy for the baseline (Clark et al. 2002a). At a subsequent meeting (Clark et al. 2002b), consideration was directed to recognizing, when appropriate, how allocation restrictions in recent years may have adversely affected the five-year average to the extent the values do not adequately represent potential irrigated acreage in future years during the project's planning period. Where an irrigation district has been impacted by allocation restriction(s), a more-lengthy time series of water use is to be used to quantify representative water use/savings.

As discussed in more detail earlier in this report, this District's agricultural irrigation use has averaged 12,203 ac-ft during the designated 5-year period. M&I use averages 13,169 ac-ft, with the total water use within the District (including conveyance losses of 6,740 ac-ft) during 1999-2003 being 32,111 ac-ft (**Table 2**). These values are perceived as appropriate for gauging future use during this project's planning period (Nieto).

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.[23] The results of this analysis can be used, however, in comparisons to exogenously-specified economic values of water to easily provide for implications of a cost-benefit analysis.

Energy Usage per Acre-Foot of Water

This analysis includes calculating the cost of energy savings and applying the value of such savings as a credit to the project's construction cost when evaluating the cost of water savings associated with the project.[24] The historic average *diversion-energy* usage level of 390,121 BTU per ac-ft of water diverted by the District for calendar years 1999-2003 is used to estimate energy savings resulting when less water is diverted from the Rio Grande due to

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

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

implementation of the proposed project (**Table 6**). In similar fashion, the historic average (1999-2003) *relift-energy* usage levels of 385,288 BTU per ac-ft and 250,619 BTU per ac-ft of water relifted at relift stations #1 and #2, respectively, are used to estimate energy savings when less water is relifted within the Districts' water-delivery infrastructure system (**Tables 7** and **8**). Thus, it is anticipated that 390,121 BTU will be saved when diversions from the Rio Grande are lessened by one ac-ft, and for each ac-ft of water not relifted within the District, an additional 635,907 BTU (i.e., 385,288 + 250,619 BTU) will be saved. Another important assumption is there are 3,412 BTU per kwh (Infoplease.com). This equivalency factor allows for converting the energy savings information into an alternative form for readers of this report.

Value of Energy Savings per BTU/kwh

Corresponding to the amount of energy saved, historic average pumping costs (diversion and relift) are used to determine dollar value of expected energy savings. Records for calendar years 1999-2003 indicate *diversion-energy* costs have ranged from $0.0000056 per BTU ($0.019 per kwh) to $0.0000090 per BTU ($0.031 per kwh). Multiplying the average of all 5 years' values by the average amount of energy used to divert an ac-ft of water for those years, and the average cost to divert an ac-ft has ranged from $2.19 to $3.53 per ac-ft, with the average of $2.83 per ac-ft used in this analysis (**Table 6**). Similarly, district records indicate *relift #1-energy* costs have ranged from $0.0000056 per BTU ($0.019 per kwh) to $0.0000112 per BTU ($0.038 per kwh), with *relift #2-energy* costs ranging from $0.0000062 per BTU ($0.021 per kwh) to $0.0000064 per BTU ($0.022 per kwh). Multiplying the average of all 5 years' values by the average amount of energy used to relift an ac-ft of water for those years, and the average cost to relift an ac-ft (i.e., total for relift #1 and relift #2) has ranged from $4.11 to $5.78 per ac-ft, with the average of $5.02 per ac-ft used in this analysis (**Tables 7** and **8**). Sensitivity analyses are utilized to examine the implications of these estimates.

Results – by Component

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

Component #1: Main Canal and Lateral 7N

The first component evaluated in this analysis is installing multi-size pipe (i.e., 60", 54", 48", 42", 30", 36", and 24") in 4.66 miles of the Main Canal and Lateral 7N. Results of the analysis for this component follow (**Table 9**).

Quantities of Water and Energy Savings

Critical values in the analysis are the quantities of water and energy anticipated being saved during the 50-year productive life of the pipeline.[25] On a nominal (i.e., non-discounted) basis, 25,700 ac-ft of irrigation water are projected to be saved; no M&I water savings are expected as a result of this project component.[26] Thus, the total nominal water savings anticipated are 25,700 ac-ft over the 50-year productive life of this component (**Table 9**). Using the 4% discount rate previously discussed, those nominal savings translate into 10,478 ac-ft of real irrigation savings and 0.0 ac-ft of real M&I water savings, representing a total real water savings of 10,478 ac-ft (**Table 9**).

On a nominal (i.e., non-discounted) basis, 26,368,919,580 BTU (7,728,288 kwh) of energy savings are projected to be saved in association with the forecast irrigation water savings (**Table 9**). Since there are no M&I-related energy savings, these values represent the total energy savings for this project. Using the 4% discount rate previously discussed, those nominal savings translate into 10,751,030,345 BTU (3,150,947 kwh) of real irrigation-related energy savings over the 50-year productive life of this project (**Table 9**).

Cost of Water Saved

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

NPV of Net Cost Stream. Accounting for all capital purchase and construction costs, changes in O&M expenditures, and credits for energy savings, the nominal total cost of the 57-year planning period for the new pipeline is $1,842,751 (**Table 9**). Using the previously-identified discount rate of 6.125%, these nominal cost dollars translate into present-day, real costs of $2,892,572 (**Table 9**). This amount represents, across the total 57-year planning period, the total net costs, in 2005 dollars, of purchasing and installing the pipeline as well as payment of the net changes in O&M expenditures. Note that the positive real-value amount of costs is greater than the positive nominal-value amount. This result occurs because in the nominal-value

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25 To allow for a staggered construction schedule and increase the accuracy of the results', the annuity equivalent is fashioned over a 57-year term for this component, not 50 years. This allows for all project segments to have a 50-year useful life, although one/some segments will not begin to produce benefits for another 7 years.

26 As noted previously, the District diverts water for both M&I and agricultural concerns, and technically one could allocate a proportionate share of the forecast water savings to M&I water use. That is, in the last 5-years, M&I water use has averaged 41% of total District diversions (i.e., 13,169 ac-ft of 32,111 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.

amount, the savings accruing from sale of land, reduced O&M expenses, and reduced energy use in the lengthy planning period offset a large portion of the initial investment cost, while the real (i.e., "discounted") dollars of land sales, reduced O&M costs, and energy savings offset a smaller portion of the initial investment cost. In the case of the real-value amount, the savings occurring during the latter years of the planning period are discounted significantly and thus do not offset as much of the initial investment costs.

NPV of All Water Savings. As detailed above, the total nominal water savings anticipated are 25,700 ac-ft (**Table 9**). The corresponding total real water savings expressed in 2005 water quantities are 10,478 ac-ft, assuming the previously-identified discount rate of 4.00% (**Table 9**).

Cost per Acre-Foot of Water Saved. The real net cost estimate of $2,892,573 correlates with the real water savings projection of 10,478 ac-ft; the respective annuity equivalents are $182,991 and 467 ac-ft (**Table 9**). The estimated cost of saving one ac-ft of water using the new pipeline comprising this project is $391.71 (**Table 9**). This value can be interpreted as the cost of leasing one ac-ft of water in year 2005. It is not the cost of purchasing the water right of one ac-ft. Following through with the economic and capital budgeting methodology presented in Rister et al. 2002, this value represents the costs per year in present-day dollars of saving one ac-ft of water each year into perpetuity through a continual replacement series of the new 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 annual Rio Grande diversions that will result from the installation and implementation of the new 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[27] of that factor across a range of 250 to 775 ac-ft (including the baseline 514 ac-ft) for the 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 $258.91 to $1,149.86 cost per ac-ft of savings around the baseline estimate of $391.71. These calculated values were derived by varying the reduction in

[27] Individual water savings for individual segments are linked to one another within RGIDECON©; this allows all water savings to vary proportionately in the sensitivity analyses.

annual Rio Grande diversions arising from off-farm water savings from the pipeline from as low as 250 ac-ft up to 775 ac-ft about the expected 514 ac-ft and by investigating a range of useful lives of the pipeline down from the expected 50 years to as short as only 10 years. As should be expected, shorter-useful lives than the anticipated 50-year productive life resulted in higher cost estimates, lower water savings than the predicted 514 ac-ft also increased cost estimates, and higher-than-expected water savings contributed to lower cost estimates.

Similarly, **Table 11** is a presentation of a range of cost estimates varying from $173.37 to $1,020.05 per ac-ft of savings around the baseline estimate of $391.71. These calculated values were derived by varying the reduction in annual Rio Grande diversions arising from off-farm water savings from the pipeline from as low as 250 ac-ft up to 775 ac-ft about the expected 514 ac-ft and by considering variations in the cost of the capital investment in the pipeline varying from $1,000,000 less than the expected $4,660,420 up to $1,000,000 more than the expected amount. As should be expected, both lower-than-the-anticipated $4,660,420 capital costs and/or higher-than-expected water savings contributed to lower cost estimates, while both higher investment costs and/or lower water savings than the predicted amounts increased the cost estimates.

The final set of sensitivity analysis conducted for the costs of water savings accounted for varying both the reduction in annual Rio Grande diversions arising from investment in the pipeline and the cost of energy. **Table 12** is an illustration of the results of varying those parameters from as low as 250 ac-ft up to 775 ac-ft about the expected 514 ac-ft of off-farm water savings and across a range of $0.0125 to $0.0375 per kwh energy costs about the expected $0.0247 per kwh level for diversion energy.[28] The resulting cost of water savings estimates ranged from a high of $777.50 per ac-ft down to a low of $253.16 per ac-ft. The lower cost results are associated with high water savings and high energy costs – the two factors combined contribute to energy cost savings which offset some of the initial capital costs of the new pipeline. The opposite effect is experienced with low energy usage per ac-ft of water savings and low water savings, i.e., higher costs estimates are calculated for these circumstances.

Cost of Energy Saved

Besides the estimated cost per ac-ft of water saved as a result of the pipeline's installation and implementation, another issue of interest is the cost of energy savings. Reduced water diversions from the Rio Grande will result as seepage and evaporation is reduced. These reduced diversions will result in less water being pumped (i.e., diverted and relifted), translating into energy savings. Both deterministic results based on the expected values for all parameters integrated into the RGIDECON© assessment and sets of sensitivity analyses for several pairs of the data parameters are presented below.

NPV of Net Cost Stream. Accounting for all capital purchase and construction costs, and changes in O&M expenditures, the nominal total cost of the 57-year planning period for the

[28] Note the range in energy costs are basis 'diversion energy.' Relift energy costs are linked, however, to the diversion energy costs within RGIDECON©; thus, allowing all energy costs to vary proportionately in the sensitivity analyses.

new pipeline is $2,205,330 (**Table 9**). Using the previously-identified discount rate of 6.125%, these nominal cost dollars translate into a present-day, real cost of $2,974,806 (**Table 9**). This amount represents, across the total 57-year planning period, the total net costs, in 2005 dollars, of purchasing and installing the 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.

NPV of All Energy Savings. As detailed above, the total nominal energy savings anticipated are 26,368,919,580 BTU (7,728,288 kwh) (**Table 9**). The corresponding total real energy savings expressed in 2005 energy quantities are 10,751,030,345 BTU (3,150,947 kwh) over the 50-year productive life of this component, assuming the previously-identified discount rate of 4.00% (**Table 9**).

Cost per BTU & kwh Saved. The real net cost estimate of $2,974,806 correlates with the real energy savings projection of 10,751,030,345 BTU (3,150,947 kwh); the respective annuity equivalents are $188,193 and 479,324,031 BTU (140,482 kwh) (**Table 9**). The estimated cost of saving one BTU of energy using the pipeline comprising this project is $0.0003926 ($1.340 per kwh) (**Table 9**). An interpretation of this value is that it is the cost of saving one BTU (kwh) of energy in year 2005. Following through with the economic and capital budgeting methodology presented in Rister et al. 2002, this value represents the costs per year in present-day dollars of saving one BTU (kwh) of energy into perpetuity through a continual replacement series of the pipeline with all of the attributes previously indicated.

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

The most critical assumption made in the baseline analysis in this respect is considered to be that pertaining to the amount of energy savings that will result from the installation and implementation of the new 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 1,026,028 BTU (300.71 kwh) current average usage (diversion and relift) per ac-ft of water savings paired with variances in three other fundamental factors: (a) expected useful life of the investment; (b) initial capital investment costs; and (c) off-farm water savings. Results on a BTU and kwh basis for these three sets of sensitivity analyses are presented in **Tables 13** and **14, 15** and **16,** and **17** and **18**, respectively.

Tables 13 and **14** reveal a range of $0.0002617 to $0.0007310 cost per BTU (and $0.893 to $2.494 per kwh) of energy savings around the baseline estimate of $0.0003926 per BTU ($1.340 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 1,026,028 BTU (300.71 kwh) current average usage per ac-ft of water savings and by investigating a range of useful lives of the capital investment in the pipeline down from the expected 50 years to as short as only 10 years. As should be expected, shorter-useful lives than the anticipated 50-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 \$0.0001788 to \$0.0006462 per BTU (and \$0.610 to \$2.205 per kwh) of energy savings around the baseline estimate of \$0.0003926 per BTU (\$1.340 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 1,026,028 BTU (300.71 kwh) current average usage per ac-ft of water savings and by considering variations in the cost of the capital investment in the pipeline varying from \$1,000,000 less than the expected \$4,660,420 up to \$1,000,000 more than the expected amount. As should be expected, both lower-than-the-anticipated \$4,660,420 capital costs and/or higher-than-expected energy savings contributed to lower cost estimates while both higher investment costs and/or lower energy savings than the expected 1,026,028 BTU (300.71 kwh) increased the cost estimates.

The final set of sensitivity analysis conducted for the costs of energy savings accounted for varying both the amount of energy used per ac-ft of water savings and the reduction in annual Rio Grande diversions arising from water savings from the new 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 1,026,028 BTU (300.71 kwh) current average usage per ac-ft of water savings and from as low as 250 ac-ft up to 775 ac-ft about the expected 514 ac-ft off-farm water savings for the pipeline. The resulting costs of energy savings estimates ranged from a high of \$0.0009541 per BTU (\$3.255 per kwh) down to a low of \$0.0001755 per BTU (\$0.599 per kwh). The lower cost estimates are associated with high energy usage per ac-ft of water savings and high water savings – the two factors combined contribute to energy cost savings. The opposite effect is experienced with low energy usage per ac-ft of water savings and low water savings, i.e., higher cost estimates are calculated for these circumstances.

Component #2: Laterals and Sub-Laterals

The second component evaluated in this analysis is installing multi-size pipe (i.e., 30", 24", and 18") in 13.46 miles of numerous laterals and sub-laterals. Results of the analysis for this component follow (**Table 19**).

Quantities of Water and Energy Savings

Critical values in the analysis are the quantities of water and energy anticipated being saved during the 50-year productive life of the pipeline.[29] On a nominal (i.e., non-discounted) basis, 57,500 ac-ft of irrigation water are projected to be saved; no M&I water savings are expected as a result of this project component.[30] Thus, the total nominal water savings anticipated are 57,500 ac-ft over the 50-year productive life of this component (**Table 19**). Using the 4% discount rate previously discussed, those nominal savings translate into 21,029 ac-ft of real irrigation savings and 0.0 ac-ft of real M&I water savings, representing a total real water savings of 21,029 ac-ft (**Table 19**).

On a nominal (i.e., non-discounted) basis, 58,996,609,955 BTU (17,290,917 kwh) of energy savings are projected to be saved in association with the forecast irrigation water savings (**Table 19**). Since there are no M&I-related energy savings, these values represent the total energy savings for this project. Using the 4% discount rate previously discussed, those nominal savings translate into 21,576,648,467 BTU (6,323,754 kwh) of real irrigation-related energy savings over the 50-year productive life of this project (**Table 19**).

Cost of Water Saved

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

NPV of Net Cost Stream. Accounting for all capital purchase and construction costs, changes in O&M expenditures, and credits for energy savings, the nominal total cost of the 56-year planning period for the new pipeline is $1,064,478 (**Table 19**). Using the previously-identified discount rate of 6.125%, these nominal cost dollars translate into present-day, real costs of $4,807,998 (**Table 19**). This amount represents, across the total 56-year planning period, the total net costs, in 2005 dollars, of purchasing and installing the pipeline as well as payment of the net changes in O&M expenditures. Note that the positive real-value amount of costs is greater than the positive nominal-value amount. This result occurs because in the

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29 To allow for a staggered construction schedule and increase the accuracy of the results', the annuity equivalent is fashioned over a 56-year term for this component, not 50 years. This allows for all project segments to have a 50-year useful life, although one/some segments will not begin to produce benefits for another 6 years.

30 As noted previously, the District diverts water for both M&I and agricultural concerns, and technically one could allocate a proportionate share of the forecast water savings to M&I water use. That is, in the last 5-years, M&I water use has averaged 41% of total District diversions (i.e., 13,169 ac-ft of 32,111 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.

nominal-value amount, the savings accruing from sale of land, reduced O&M expenses, and reduced energy use in the lengthy planning period offset a large portion of the initial investment cost, while the real (i.e., "discounted") dollars of land sales, reduced O&M costs, and energy savings offset a smaller portion of the initial investment cost. In the case of the real-value amount, the savings occurring during the latter years of the planning period are discounted significantly and thus do not offset as much of the initial investment costs.

NPV of All Water Savings. As detailed above, the total nominal water savings anticipated are 57,500 ac-ft (**Table 19**). The corresponding total real water savings expressed in 2005 water quantities are 21,029 ac-ft, assuming the previously-identified discount rate of 4.00% (**Table 19**).

Cost per Acre-Foot of Water Saved. The real net cost estimate of $4,807,998 correlates with the real water savings projection of 21,029 ac-ft; the respective annuity equivalents are $304,779 and 942 ac-ft (**Table 19**). The estimated cost of saving one ac-ft of water using the new pipeline comprising this project is $323.58 (**Table 19**). This value can be interpreted as the cost of leasing one ac-ft of water in year 2005. It is not the cost of purchasing the water right of one ac-ft. Following through with the economic and capital budgeting methodology presented in Rister et al. 2002, this value represents the costs per year in present-day dollars of saving one ac-ft of water each year into perpetuity through a continual replacement series of the new 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 annual Rio Grande diversions that will result from the installation and implementation of the 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[31] of that factor across a range of 575 to 1,725 ac-ft (including the baseline 1,149 ac-ft) for the 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 20, 21,** and **22**, respectively.

Table 20 reveals a range of $218.03 to $1,864.68 cost per ac-ft of savings around the baseline estimate of $323.58. These calculated values were derived by varying the reduction in

[31] Individual water savings for individual segments are linked to one another within RGIDECON©; this allows all water savings to vary proportionately in the sensitivity analyses.

annual Rio Grande diversions arising from off-farm water savings from the pipeline from as low as 575 ac-ft up to 1,725 ac-ft about the expected 1,149 ac-ft and by investigating a range of useful lives of the pipeline down from the expected 50 years to as short as only 10 years. As should be expected, shorter-useful lives than the anticipated 50-year productive life resulted in higher cost estimates, lower water savings than the predicted 1,149 ac-ft also increased cost estimates, and higher-than-expected water savings contributed to lower cost estimates.

Similarly, **Table 21** is a presentation of a range of cost estimates varying from $171.95 to $783.94 per ac-ft of savings around the baseline estimate of $323.58. These calculated values were derived by varying the reduction in annual Rio Grande diversions arising from water savings from the pipeline from as low as 575 ac-ft up to 1,725 ac-ft about the expected 1,149 ac-ft and by considering variations in the cost of the capital investment in the pipeline varying from $1,000,000 less than the expected $9,503,093 up to $1,000,000 more than the expected amount. As should be expected, both lower-than-the-anticipated $9,503,093 capital costs and/or higher-than-expected water savings contributed to lower cost estimates, while both higher investment costs and/or lower 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 annual Rio Grande diversions arising from investment in the pipeline and the cost of energy. **Table 22** is an illustration of the results of varying those parameters from as low as 575 ac-ft up to 1,725 ac-ft about the expected 1,149 ac-ft of off-farm water savings and across a range of $0.0125 to $0.00375 per kwh energy costs about the expected $0.0247 per kwh level for diversion energy.[32] The resulting cost of water savings estimates ranged from a high of $652.81 per ac-ft down to a low of $215.96 per ac-ft. The lower cost results are associated with high water savings and high energy costs – the two factors combined contribute to energy cost savings which offset some of the initial capital costs of the pipeline. The opposite effect is experienced with low energy usage per ac-ft of water savings and low water savings, i.e., higher costs are calculated for these circumstances.

Cost of Energy Saved

Besides the estimated cost per ac-ft of water saved as a result of the pipeline's installation and implementation, another issue of interest is the cost of energy savings. Reduced water diversions from the Rio Grande will result as seepage and evaporation is reduced. These reduced diversions will result in less water being pumped (i.e., diverted and relifted), translating into energy savings. Both deterministic results based on the expected values for all parameters integrated into the RGIDECON© assessment and sets of sensitivity analyses for several pairs of the data parameters are presented below.

NPV of Net Cost Stream. Accounting for all capital purchase and construction costs, and changes in O&M expenditures, the nominal total cost of the 56-year planning period for the new pipeline is $1,922,965 (**Table 19**). Using the previously-identified discount rate of 6.125%,

32 Note the range in energy costs are basis 'diversion energy.' Relift energy costs are linked, however, to the diversion energy costs within RGIDECON©; thus, allowing all energy costs to vary proportionately in the sensitivity analyses.

these nominal cost dollars translate into a present-day, real cost of $4,973,035 (**Table 19**). This amount represents, across the total 56-year planning period, the total net costs, in 2005 dollars, of purchasing and installing the 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.

NPV of All Energy Savings. As detailed above, the total nominal energy savings anticipated are 58,996,609,955 BTU (17,290,917 kwh) (**Table 19**). The corresponding total real energy savings expressed in 2005 energy quantities are 21,576,648,467 BTU (6,323,754 kwh) over the 50-year productive life of this component, assuming the previously-identified discount rate of 4.00% (**Table 19**).

Cost per BTU & kwh Saved. The real net cost estimate of $4,973,035 correlates with the real energy savings projection of 21,576,648,467 BTU (6,323,754 kwh); the respective annuity equivalents are $315,241 and 966,403,486 BTU (283,237 kwh) (**Table 19**). The estimated cost of saving one BTU of energy using the pipeline comprising this project is $0.0003262 ($1.113 per kwh) (**Table 19**). An interpretation of this value is that it is the cost of saving one BTU (kwh) of energy in year 2005. Following through with the economic and capital budgeting methodology presented in Rister et al. 2002, this value represents the costs per year in present-day dollars of saving one BTU (kwh) of energy into perpetuity through a continual replacement series of the pipeline with all of the attributes previously indicated.

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

The most critical assumption made in the baseline analysis in this respect is considered to be that pertaining to the amount of energy savings that will result from the installation and implementation of the new pipeline in the water-delivery system. Thus, the cost per BTU (or kwh) of energy-saved sensitivity analyses consists of varying the amount of energy savings across a range of 80.0 percent up to 150.0 percent of the baseline 1,026,028 BTU (300.71 kwh) current average usage per ac-ft of water savings paired with variances in three other fundamental factors: (a) expected useful life of the investment; (b) initial capital investment costs; and (c) off-farm water savings. Results on a BTU and kwh basis for these three sets of sensitivity analyses are presented in **Tables 23** and **24, 25** and **26,** and **27** and **28**, respectively.

Tables 23 and **24** reveal a range of $0.0002175 to $0.0011682 cost per BTU (and $0.742 to $3.986 per kwh) of energy savings around the baseline estimate of $0.0003262 per BTU ($1.113 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 1,026,028 BTU (300.71 kwh) current average usage per ac-ft of water savings and by investigating a range of useful lives of the capital investment in the pipeline down from the expected 50 years to as short as only 10 years. As should be expected, shorter-useful lives than the anticipated 50-year productive life resulted in higher cost estimates, lower energy savings than the predicted 100% of current average usage also increased cost estimates, and higher-than-expected energy savings contributed to lower cost estimates.

Similarly, **Tables 25** and **26** are a presentation of a range of cost estimates varying from \$0.0001737 to \$0.0004897 per BTU (and \$0.593 to \$1.671 per kwh) of energy savings around the baseline estimate of \$0.0003262 per BTU (\$1.113 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 1,026,028 BTU (300.71 kwh) current average usage per ac-ft of water savings and by considering variations in the cost of the capital investment in the pipeline varying from \$1,000,000 less than the expected \$9,503,093 up to \$1,000,000 more than the expected amount. As should be expected, both lower-than-the-anticipated \$9,503,093 capital costs and/or higher-than-expected energy savings contributed to lower cost estimates while both higher investment costs and/or lower energy savings than the expected 1,026,028 BTU (300.71 kwh) increased the cost estimates.

The final set of sensitivity analysis conducted for the costs of energy savings accounted for varying both the amount of energy used per ac-ft of water savings and the reduction in annual Rio Grande diversions arising from water savings from piping the Laterals and Sub-Laterals. **Tables 27** and **28** are illustrations of the results of varying those parameters from as low as 80.0% up to 150.0% of the expected 1,026,028 BTU (300.71 kwh) current average usage per ac-ft of water savings and from as low as 575 ac-ft up to 1,725 ac-ft about the expected 1,149 ac-ft off-farm water savings for the pipeline. The resulting costs of energy savings estimates ranged from a high of \$0.0008064 per BTU (\$2.752 per kwh) down to a low of \$0.0001489 per BTU (\$0.508 per kwh). The lower cost estimates are associated with high energy usage per ac-ft of water savings and high water savings – the two factors combined contribute to energy cost savings. The opposite effect is experienced with low energy usage per ac-ft of water savings and low water savings, i.e., higher costs are calculated for these circumstances.

Component #3: Rehabilitate Diversion Pumping Plant

The third component evaluated in this analysis is rehabilitating the diversion pumping plant at the Rio Grande by replacing the gas engine with a 500 horsepower electric motor, complete with adjustable-speed drive and a soft start. Results of the analysis for this component follow (**Table 29**).

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

Since it is projected that no water will be saved with this component, such discussion is non-applicable. Thus, the results for this component are limited to those regarding energy savings. A critical value in the analysis is the quantity of energy anticipated being saved during the 25-year productive life of the new motor and soft-start. On a nominal (i.e., non-discounted) basis, 78,295,811,640 BTU (22,947,190 kwh) of energy savings are projected to be saved in association with the improvement in operation efficiency with the new motor and soft-start (**Table 29**). Since there are no M&I-related energy savings, these values represent the total energy savings for this project. Using the 4% discount rate previously discussed, those nominal savings translate into 48,925,737,148 BTU (14,339,313 kwh) of real irrigation-related energy savings over the 25-year productive life of this project (**Table 29**).

Cost of Water Saved

Since there are no expected water savings from this component, the economic and financial cost of saving water is non-applicable. Therefore, the sub-section discussions (as provided in other similar prior reports) on (a) the NPV of Net Cost Stream, (b) the NPV of All Water Savings, the (c) the Cost per Acre-Foot of Water Saved, and (d) the various sensitivity tables have been deleted and are not discussed here.

Cost of Energy Saved

The primary issue of interest regarding the new motor's installation and implementation is the cost of energy savings. Energy savings are anticipated as operational efficiency gains are realized with the new electric motor (and soft-start). 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.

NPV of Net Cost Stream. Accounting for all capital purchase and construction costs, and changes in O&M expenditures, the nominal total cost of the 25-year planning period for rehabilitating the diversion pumping plant is negative $188,807 (**Table 29**). Using the previously-identified discount rate of 6.125%, these nominal cost dollars translate into a present-day, real cost of negative $24,926 (**Table 29**). Here, note that 'negative costs' are synonymous with 'savings' attributed to the component. That is, we are being "paid" to save energy. This amount represents, across the total 25-year planning period, the total net costs (i.e., "savings" in this case), in 2005 dollars, of purchasing and installing the new motor as well as payment of the net changes in O&M expenditures, ignoring the changes in energy costs.

NPV of All Energy Savings. As detailed above, the total nominal energy savings anticipated are 78,295,811,640 BTU (22,947,190 kwh) (**Table 29**). The corresponding total real energy savings expressed in 2005 energy quantities are 48,925,737,148 BTU (14,339,313 kwh) over the 25-year productive life of this component, assuming the previously-identified discount rate of 4.00% (**Table 29**).

Cost per BTU & kwh Saved. The real net cost estimate of $(24,926) correlates with the real energy savings projection of 48,925,737,148 BTU (14,339,313 kwh); the respective annuity equivalents are $(1,940) and 3,061,155,211 BTU (897,173 kwh) (**Table 29**).[33] The estimated cost of saving one BTU of energy using the new electric motor and soft-start comprising this

[33] Notice the net real costs, and the related annuity equivalent are both 'negative costs'. This means they are in actuality a benefit and can be thought of as a cash inflow, as opposed to an outflow. This event occurs simply because the sum of net annual O&M savings (which are discounted at 6.125%) over the expected 25-years of useful life exceed the initial investment cost of $123,542.

project is -\$0.0000006, or -\$0.002 per kwh (**Table 29**). An interpretation of this value is that it is the cost of saving one BTU (kwh) of energy in year 2005. Since the cost of saving energy is negative, this infers the project not only saves energy, but does so at an economically-efficient level, such that a negative cost (i.e., a net benefit) is incurred; i.e., we are being "paid" to save energy. Following through with the economic and capital budgeting methodology presented in Rister et al. 2002, this value represents the costs per year in present-day dollars of saving one BTU (kwh) of energy into perpetuity through a continual replacement series of the electric motor with all of the attributes previously indicated.

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

The most critical assumption made in the baseline analysis in this respect is considered to be that pertaining to the amount of energy savings that will result from the installation and implementation of the new electric motor and soft-start at the Rio Grande diversion pumping plant. Thus, the cost per BTU (or kwh) of energy-saved sensitivity analyses consists of varying the amount of energy savings across a range of 80.0 percent up to 150.0 percent of the baseline estimated savings of 97,530 BTU (32.20 kwh) per ac-ft of water diverted at the Rio Grande, paired with variances in two other fundamental factors: (a) expected useful life of the investment; and (b) initial capital investment costs. Results on a BTU and kwh basis for these two sets of sensitivity analyses are presented in **Tables 30** and **31**, and **32** and **33**, respectively.

Tables 30 and **31** reveal a range of \$(0.0000004) to \$(0.0000010) cost per BTU (-\$0.001 to -\$0.003 per kwh) of energy savings for the new motor and soft-start around the baseline estimate of -\$0.0000006 per BTU (-\$0.002 per kwh). These calculated values were derived by varying the amount of energy saved per ac-ft of water diverted across a range as low as 80.0% up to 150.0% of the expected 97,530 BTU (28.58 kwh) average savings per ac-ft of water diverted and by investigating a range of useful lives of the capital investment in the motor and soft-start down from the expected 25 years to as short as only 15 years. As should be expected, shorter-useful lives than the anticipated 25-year productive life resulted in higher cost estimates, lower energy savings than the predicted 100% of current average savings also increased cost estimates, and higher-than-expected energy savings contributed to lower cost estimates.

Similarly, **Tables 32** and **33** are a presentation of a range of cost estimates varying from \$0.0000004 to -\$0.0000024 per BTU (\$0.001 to -\$0.008 per kwh) of energy savings around the baseline estimate of -\$0.0000006 per BTU (-\$0.002 per kwh). These calculated values were derived by varying the amount of energy saved per ac-ft of water diverted across a range as low as 80.0% up to 150.0% of the expected 97,530 BTU (28.58 kwh) average savings per ac-ft of water diverted and by considering variations in the cost of the capital investment in the motor and soft-start varying from $50,000 less than the expected $123,542 up to $50,000 more than the expected amount. As should be expected, both lower-than-the-anticipated $123,542 capital costs and/or higher-than-expected energy savings contributed to lower cost estimates while both higher investment costs and/or lower energy savings than the expected 97,530 BTU (28.58 kwh) increased the cost estimates.

Economic and Financial Evaluation Results Aggregated Across Components

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

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

Cost of Water Saved

Table 34 provides aggregated information on the cost of water saved, based on calculated values previously discussed, for the three components. The individual component measures are displayed in the table and then aggregated in the far-right column, indicating that the overall cost of water saved is **$325.20 per ac-ft**.[34]

Main Canal and Lateral 7N

The initial capital investment associated with the "Main Canal and Lateral 7N" capital renovation is $4,660,420 in 2005 nominal dollars (**Table 5**). Combining that cost with the changes in O&M expenditures over the 57-year planning horizon and calculating the net present

[34] Note component #3 does not save water, and hence there is no Annuity Equivalent Cost of Saving Water value. The aggregate Annuity Equivalent Cost of Saving Water does incorporate, however, the impact of the third component's NPV of its Net Cost Stream (i.e, initial construction costs, net changes in O&M and energy costs, etc.). That is, although component #3 is analyzed separately and it does not save any water, its impact (i.e., costs and savings) must be included when evaluating the three components as an entire, single project (Shaddix).

value (NPV) of that flow of funds contributes to the $2,892,573 value noted at the top of the 'Main Canal and Lateral 7N' column in **Table 34**. The nominal water savings anticipated during the 57-year planning period total 25,700 ac-ft; discounted into a real 2005 value, those savings are estimated to be 10,478 ac-ft (**Table 9**). Converting both of the real 2005 values into annuity equivalents per the methodology presented in Rister et al. 2002 results in an annual cost estimate of $182,991 to achieve 467 ac-ft of water savings per year (**Table 34**). Dividing the first annuity estimate by the second results in the annuity-cost estimate of $391.71 per ac-ft of water savings for the piping of the Main Canal and Lateral 7N (**Table 34**).

Laterals and Sub-Laterals

The initial capital investment associated with the "Laterals and Sub-Laterals" capital renovation is $9,503,093 in 2005 nominal dollars (**Table 5**). Combining that cost with the changes in O&M expenditures over the 56-year planning horizon and calculating the net present value (NPV) of that flow of funds contributes to the $4,807,998 value noted at the top of the 'Laterals and Sub-Laterals' column in **Table 34**. The nominal water savings anticipated during the 56-year planning period total 57,500 ac-ft; discounted into a real 2005 value, those savings are estimated to be 21,029 ac-ft (**Table 19**). Converting both of the real 2005 values into annuity equivalents per the methodology presented in Rister et al. 2002 results in an annual cost estimate of $304,779 to achieve 942 ac-ft of water savings per year (**Table 34**). Dividing the first annuity estimate by the second annuity estimate results in the annuity-cost estimate of $323.58 per ac-ft of water savings for the piping of the various laterals and sub-laterals (**Table 34**).

Rehabilitate Diversion Pumping Plant

The initial capital investment associated with the "Rehabilitate Diversion Pumping Plant" capital renovation is $123,542 in 2005 nominal dollars (**Table 5**). Combining that cost with the changes in O&M expenditures over the 25-year planning horizon and calculating the net present value (NPV) of that flow of funds contributes to the -$379,557 value noted at the top of the 'Rehabilitate Diversion Pumping Plant' column in **Table 34**. Converting the real 2005 value for the NPV cost stream into an annuity equivalent (per the methodology presented in Rister et al. 2002) results in an annual cost estimate of -$29,546 (**Table 34**). As the anticipated water savings are zero for this component, further discussion pertaining to results regarding water savings are deemed non-applicable (**Table 29**).

Aggregate Measure of Cost of Water Savings

Combining the costs of the three components of the District's proposed project results in a total NPV net cost (i.e., both initial investments and changes in O&M expenditures) estimate of $7,321,015 which translates into an annuity cost equivalent of $458,224 per year (**Table 34**). The total NPV of water savings is 31,508 ac-ft, representing an annuity equivalent of **1,409 ac-ft of water savings** (**Table 34**), representing about **4%** of current diversions. Performing the same math as used in calculating the costs of water savings for the individual components (i.e., dividing the annuity of the net cost stream by the annuity amount of water savings) produces the **$325.20 per ac-ft** water savings aggregate cost measure (**Table 34**).

Cost of Energy Saved

Table 35 provides aggregated information on the cost of energy saved, based on calculated values previously discussed, for the three components. The individual component measures are displayed in the table and then aggregated in the far-right column, indicating that the overall cost of energy saved is **$0.0001113 per BTU (or $0.380 per kwh)**.

<u>Main Canal and Lateral 7N</u>

The initial capital investment associated with the 'Main Canal and Lateral 7N' capital renovation is $4,660,420 in 2005 nominal dollars (**Table 5)**. Combining that cost with the changes in O&M expenditures over the 57-year planning horizon and calculating the net present value (NPV) of that flow of funds contributes to the $2,974,806 value noted at the top of the 'Main Canal and Lateral 7N' column in **Table 35.** This value is slightly higher than the corresponding $2,892,573 value in **Table 34** because of the ignoring of energy savings when calculating the 'Cost of Energy Saved'. The nominal energy savings anticipated during the 57-year planning period total 26,368,919,580 (7,728,288 kwh) (**Table 9**). Discounted into a real 2005 value, those savings are estimated to be 10,751,030,345 BTU (3,150,947 kwh) (**Table 9**). Converting both of the real 2005 values into annuity equivalents per the methodology presented in Rister et al. 2002 results in an annual cost estimate of $188,193 to achieve 479,324,031 BTU (140,482 kwh) of energy savings per year (**Table 35**). Dividing the first annuity estimate by the second results in the annuity-cost estimate of $0.0003926 per BTU ($1.340 per kwh) of energy savings for the piping of the Main Canal and Lateral 7N (**Table 35**).

<u>Laterals and Sub-Laterals</u>

The initial capital investment associated with the 'Laterals and Sub-Laterals' capital renovation is $9,503,093 in 2005 nominal dollars (**Table 5)**. Combining that cost with the changes in O&M expenditures over the 56-year planning horizon and calculating the net present value (NPV) of that flow of funds contributes to the $4,973,035 value noted at the top of the 'Laterals and Sub-Laterals' column in **Table 35.** This value is slightly higher than the corresponding $4,807,998 value in **Table 34** because of the ignoring of energy savings when calculating the 'Cost of Energy Saved'. The nominal energy savings anticipated during the 56-year planning period total 58,996,609,955 BTU (17,290,917 kwh) (**Table 19**). Discounted into a real 2005 value, those savings are estimated to be 21,576,648,467 BTU (6,323,754 kwh) (**Table 19**). Converting both of the real 2005 values into annuity equivalents per the methodology presented in Rister et al. 2002 results in an annual cost estimate of $315,241 to achieve 966,403,486 BTU (283,237 kwh) of energy savings per year (**Table 35**). Dividing the first annuity estimate by the second annuity estimate results in the annuity-cost estimate of $0.0003262 per BTU ($1.113 per kwh) of energy savings for the piping of the numerous laterals and sub-laterals (**Table 35**).

<u>Rehabilitate Diversion Pumping Plant</u>

The initial capital investment associated with the 'Rehabilitate Diversion Pumping Plant' capital renovation is $123,542 in 2005 nominal dollars (**Table 5)**. Combining that cost with the changes in O&M expenditures over the 25-year planning horizon and calculating the net present value (NPV) of that flow of funds contributes to the -$24,926 value noted at the top of the 'Rehabilitate Diversion Pumping Plant' column in **Table 35.** This value is higher than the corresponding -$29,546 value in **Table 34** because of the ignoring of energy savings when calculating the 'Cost of Energy Saved.' The nominal energy savings anticipated during the 25-year planning period total 78,295,811,640 BTU (22,947,190 kwh) (**Table 29**). Discounted into a real 2005 value, those savings are estimated to be 48,925,737,148 BTU (14,339,313 kwh) (**Table 29**). Converting both of the real 2005 values into annuity equivalents per the methodology presented in Rister et al. 2002 results in an annual cost estimate of -$1,940 to achieve 3,061,155,211 BTU (897,173 kwh) of energy savings per year (**Table 35**). Dividing the first annuity estimate by the second results in the annuity-cost estimate of -$0.0000006 per BTU (-$0.002 per kwh) of energy savings for rehabilitating the diversion pumping plant (**Table 35**).

Aggregate Measure of Cost of Energy Savings

Combining the costs of the three components of the District's proposed project results in a total NPV net cost (i.e., both initial investments and changes in O&M expenditures) estimate of $7,922,915 which translates into an annuity cost equivalent of $501,494 per year (**Table 35**). The total NPV of energy savings is 81,253,415,960 BTU, representing an annuity equivalent of **4,506,882,727 BTU (1,320,892 kwh)** of energy savings. Performing the same math as used in calculating the costs of energy savings for the individual components (i.e., dividing the annuity of the net cost stream by the annuity amount of energy savings) produces the **$0.0001113 per BTU ($0.380 per kwh)** of energy savings aggregate cost measure (**Table 35**).

Limitations

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

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

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

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

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

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

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

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

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

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

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

Recommended Future Research

This analysis report is conditioned on the best information available, subject to the array of resource limitations and other problematic issues previously mentioned. Nonetheless, the results are highly useful for the USBRs appraisal and prioritization of the several Rio Grande Basin projects already or potentially authorized by Congress or submitted in a formal manner. Nonetheless, there are opportunities for additional research efforts that would provide valuable insight in a holistic manner of the greater issue of water resource management in the immediate Rio Grande Valley Basin area and beyond. These issues are related in large part to addressing the concerns noted in the "Limitations" section.

- A comprehensive economic impact study would provide an overall impact of the proposed renovations, thereby enhancing the economic strength of the analyses. Necessarily, it is suggested such an effort encompass a full cost-benefit assessment and potential alterations in cropping patterns, impacts of projected urban growth, distribution of water use across the Basin, etc. It is relevant to note that evaluation of Federal projects often employ a national perspective and consider such local impacts negligible. A more-localized perspective in the level of analyses results in greater benefits being estimated along with increased attention to the identity of 'winners' and 'losers' in the resulting adjustments that are anticipated. For example, while on a national perspective the issue of the 0.10 million ac-ft of water now owed to the U.S. may not be a high-priority issue, it certainly is viewed as a critical issue within the immediate Rio Grande Valley area.

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

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

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

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

- Identifying a prioritization process for ranking projects competing for limited funds could distinguish between project components, as well as consider other potential components besides those proposed by individual IDs (i.e., whereby such latter projects are identified in a regional context). Development of an economic mixed-integer programming model (Agrawal and Heady) is suggested as a reasonable and useful complement to ongoing and anticipated engineering activities. Such an effort would provide a focal point for identifying and assimilating data necessary for both individual and comprehensive, Valley-wide assessments in a timely fashion.

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

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

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

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

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

Summary and Conclusions

The District's proposed project consists of three components: Main Canal and Lateral 7N; Laterals and Sub-Laterals; and Rehabilitate Diversion Pumping Plant. Their required respective capital investment costs are $4,660,420, $9,503,093, and $123,542 (i.e., total of $14,287,055) in nominal terms. Installation periods and useful lives vary for each project component. Net annual O&M expenditures are expected to decrease by $89,878 (**Table 5**).

Off-farm water savings are expected from component #1 (Main Canal and Lateral 7N) with its expected water savings over its 50-year useful life being 25,700 nominal ac-ft, which translate into a 2005 basis of 10,478 real ac-ft (**Table 9**). *Off-farm* water savings are predicted for component #2 (Laterals and Sub-Laterals) with its expected water savings over its 50-year useful life being 57,500 nominal ac-ft, which translate into a 2005 basis of 21,029 real ac-ft (**Table 19**). No water savings are predicted to be forthcoming from component #3 (Rehabilitate Diversion Pumping Plant) (**Table 29**). Across the total project, nominal water savings are **83,200** ac-ft (**Tables 9, 19**, and **29**) and real 2005 savings are 31,508 ac-ft. On an average, annual, real basis, this totals **1,409 ac-ft** across all three components (**Table 34**).

Energy savings estimates associated with the **Main Canal and Lateral 7N** component are 26,368,919,580 BTU (7,728,288 kwh) in nominal terms and 10,751,030,345 BTU (3,150,947 kwh) in real 2005 terms (**Table 9**). Energy savings estimates associated with the **Laterals and Sub-Laterals** component are 58,996,609,955 BTU (17,290,917 kwh) in nominal terms and 21,576,648,467 BTU (6,323,754 kwh) in real 2005 terms (**Table 19**). Energy savings estimates associated with the **Rehabilitate Diversion Pumping Plant** component are 78,295,811,640 BTU (22,947,190 kwh) in nominal terms and 48,925,737,148 BTU (14,339,313 kwh) in real 2005 terms (**Table 29**). For the total project, nominal energy savings are 163,661,341,175 BTU (47,966,395 kwh) and real 2005 savings are 81,253,415,960 BTU (23,814,014 kwh) (**Table 9**, **19**, **29**, and **35**). On an average, annual, real basis, this totals **4,506,882,727 BTU (1,320,892 kwh)** across all three components **(Table 35)**.

Economic and financial costs of *water* savings forthcoming from component #1 are estimated at $391.71 per ac-ft (**Table 9**); those for component #2 are estimated at $323.58 per ac-ft (**Table 19**); and those for component #3 are estimated at $0.00 per ac-ft (**Table 29**). Sensitivity analyses indicate these estimates can be affected by variances in (a) the amount of reduction in annual Rio Grande diversions resulting from the installation and implementation of the project components; (b) the expected useful lives of the project components; (c) the initial capital investment costs of the project components; and (d) the value of BTU savings (i.e., cost of energy).

Economic and financial costs of *energy* savings forthcoming from component #1 are estimated at $0.0003926 per BTU ($1.340 per kwh) (**Table 9**); those for component #2 are estimated at $0.0003262 per BTU ($1.113 per kwh) (**Table 19**); and those for component #3 are estimated at -$0.0000006 per BTU (-$0.002 per kwh) (**Table 29**). Sensitivity analyses indicate factors of importance are (a) the amount of energy savings resulting from the installation and implementation; (b) the expected useful life of the investment; (c) the initial capital investment costs; and (d) the amount of *off*- and *on-farm* water savings.

Aggregation of the economic and financial costs of water and energy savings for the individual project components into cost measures for the total project result in estimates of **$325.20 per ac-ft** cost of water savings (**Table 34**) and **$0.0001113 per BTU ($0.380 per kwh)** cost of energy savings (**Table 35**). These estimates, similar to the other economic and financial cost estimates identified here, are based on methods described in Rister et al. 2002.

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Glossary

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

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

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

Canal lining: Concrete and/or a combination of concrete and synthetic plastic material placed in an earthen canal 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 as an indirect beneficial consequence from irrigation districts' capital improvement projects.

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

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

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

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

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

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

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

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

Soft-start: References a means to start a pump motor slowly, thereby avoiding a spike (or surge) in electricity needed by a district. Implementing a soft-start allows a district to be assessed electricity charges by its electric provider at a lower rate, and not the high (i.e., spiked) rate oftentimes realized without a soft-start mechanism.

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

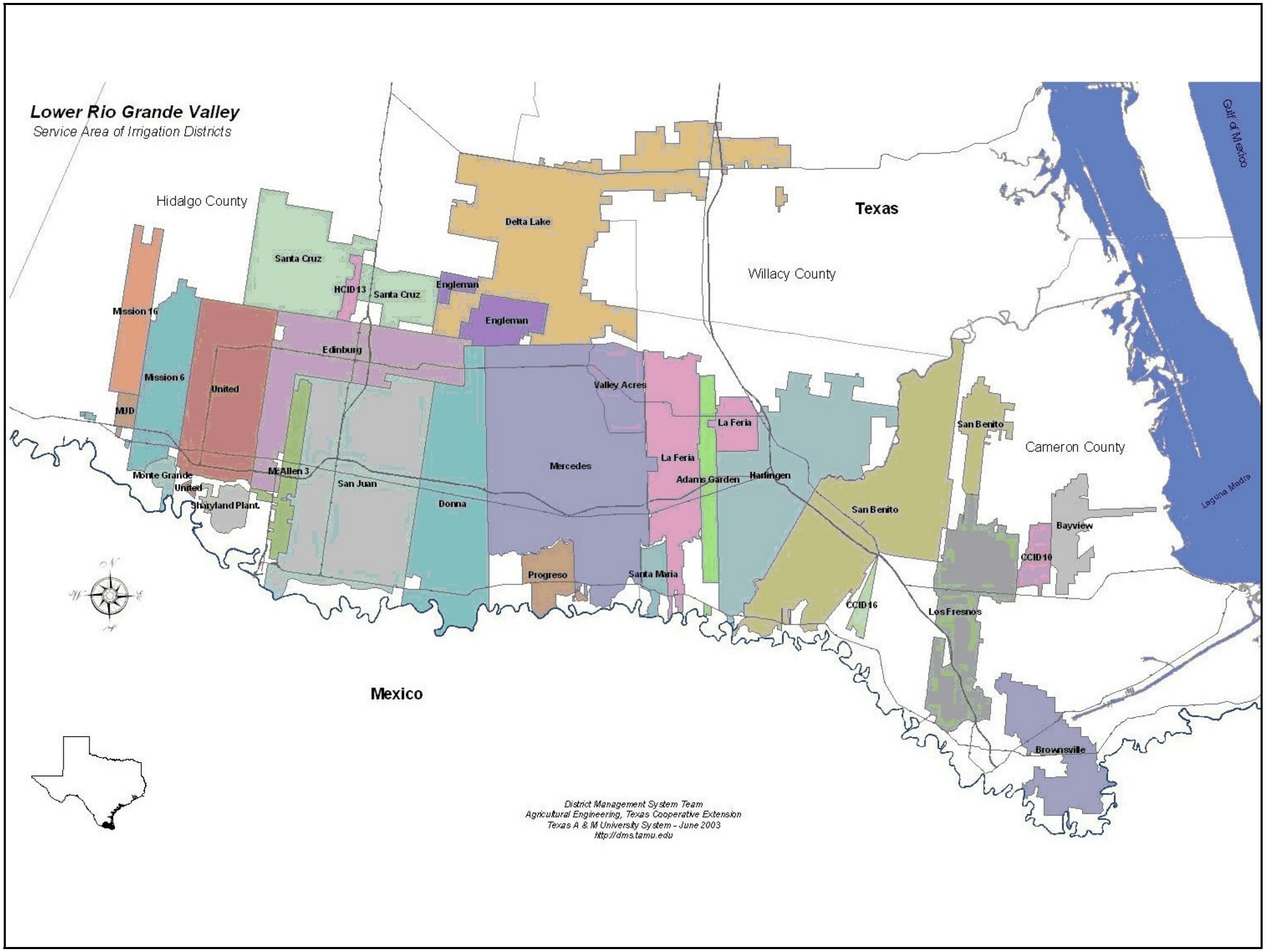

Exhibit 1. Illustration of Twenty-Eight Irrigation Districts in the Texas Lower Rio Grande Valley (Fipps et al.).

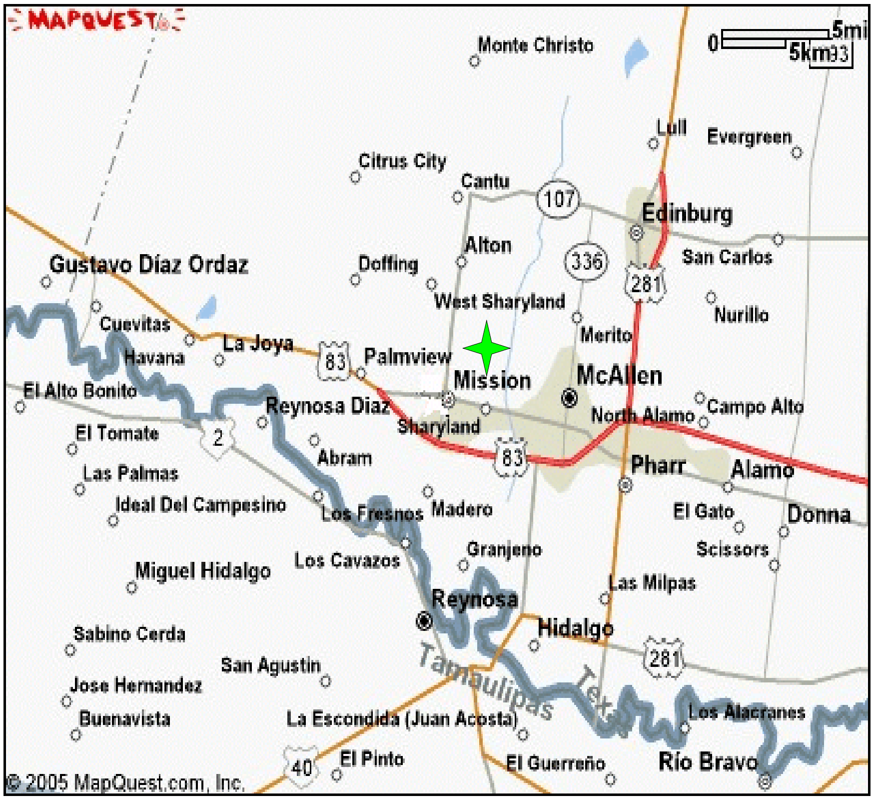

Exhibit 2. Mission, TX – Location of United Irrigation District's Office {green star} (MapQuest).

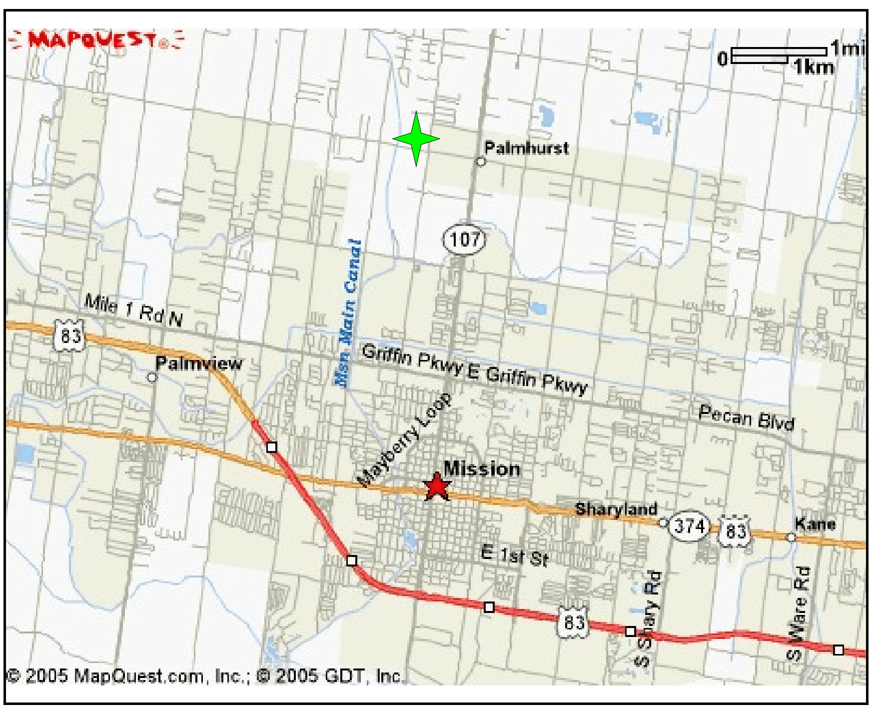

Exhibit 3. Detailed Location of United Irrigation District's Office in Mission, TX {green star} (MapQuest).

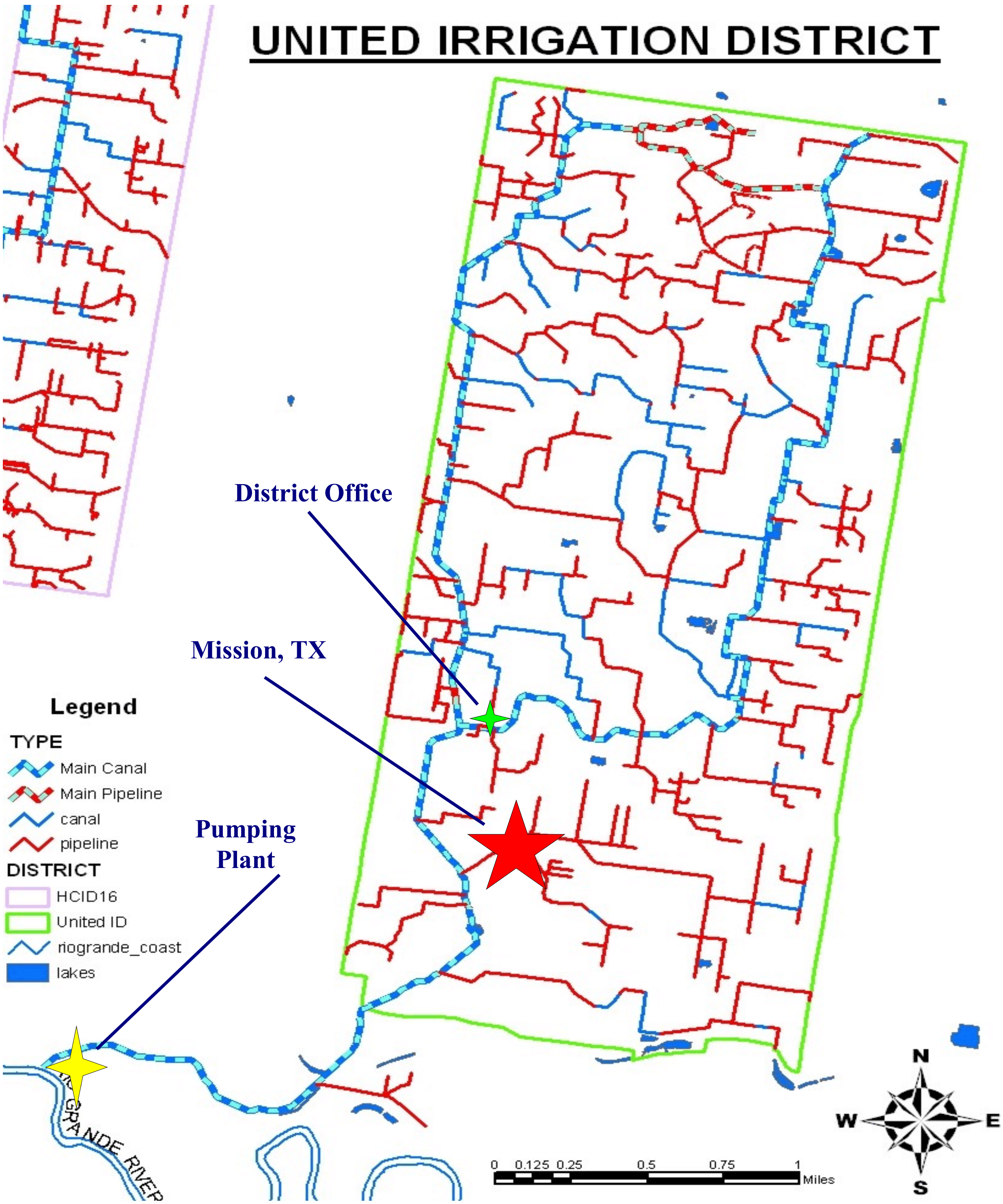

Exhibit 4. Illustrated Layout of United Irrigation District (Nieto).

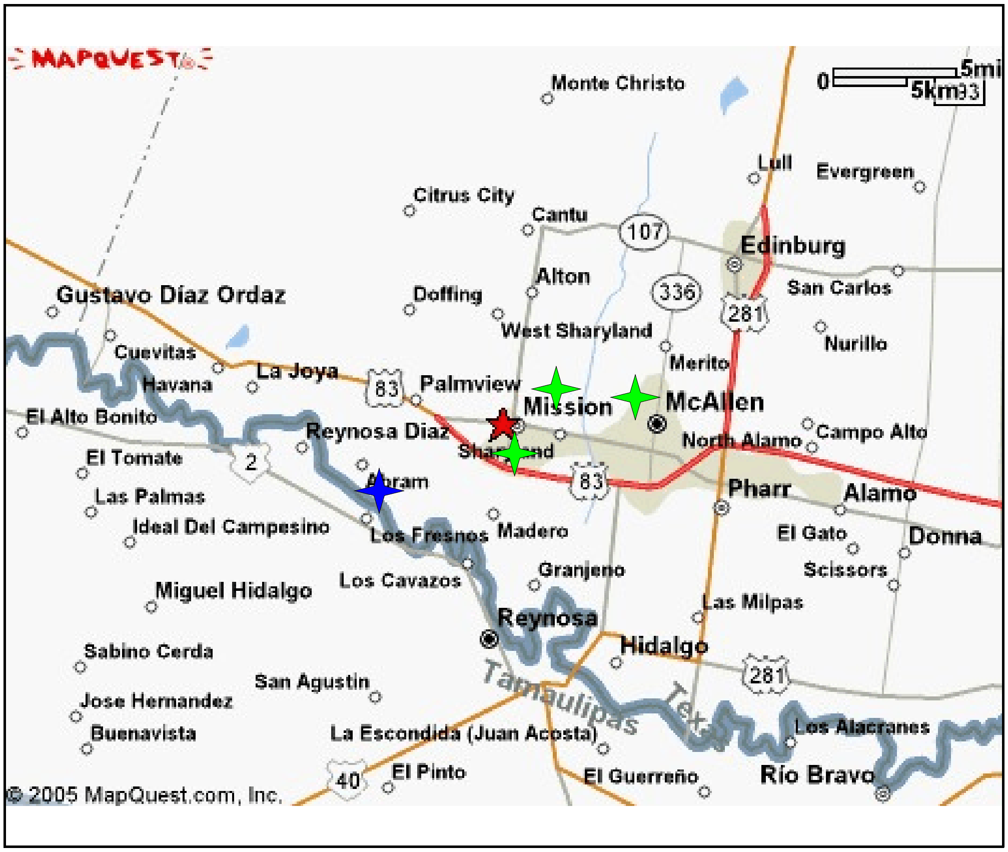

Exhibit 5. Location of Pumping Plant (blue) and the Municipalities and Water Supply Corporation Served by United Irrigation District (green) (MapQuest).

Tables

Table 1. Average Acreage Irrigated by United Irrigation District During 1999-2003.

Crop	crop year					5-year average	
	1999	2000	2001	2002	2003	acres	%
Fruit							
CITRUS	5,780.6	17,306.2	13,693.2	13,356.1	7,876.7	11,602.6	41.21 %
OTHER FRUITS		-	-	-	-	0.0	0.0 %
						11,602.6	**41.21 %**
Vegetables							
OTHER VEG.	7,816.7	16,014.5	3,626.2	2,102.7	1,365.1	6,185.0	21.97 %
ONIONS	382	3,283.0	2,480.2	2,486.1	1,630.9	2,052.4	7.29 %
PEPPERS	-	-	649.9	284.9	61.9	199.3	0.71 %
GREENS	90.6	146.7	89.9	248.4	391.5	193.4	0.69 %
CABBAGE	-	-	-	453.4	403.7	171.4	0.61 %
BEANS	1.5	36.0	7.1	37.7	14.5	19.4	0.07 %
CILANTRO	20.0	15.0	-	-	52.5	17.5	0.06 %
PARSLEY	-	-	-	-	56.0	11.2	0.04 %
CUCUMBERS	-			12.4	17.0	5.9	0.02 %
						8,855.6	**31.45 %**
Other							
LAKE	174.8	1,249.7	1,275.9	982.5	597.3	856.0	3.04 %
YARD-LOTS	210.4	872.4	924.9	1,032.3	717.0	751.4	2.67 %
GOLF COURSE	171.0	1,001.6	29.2	120.0	189.6	302.3	1.07 %
DRIP IRRIGATION	9.5	-	42.0	-	1,285.9	267.5	0.95 %
ALOE VERA	69.0	226.6	338.9	315.7	88.9	207.8	0.74 %
NURSERY	9.2	46.2	66.8	77.7	55.0	51.0	0.18 %
						2,436.0	**8.65 %**
Field crops - annual							
COTTON	38.8	3,705.0	991.1	449.2	1,230.8	1,283.0	4.56 %
SORGHUM	16.3	115.5	928.6	599.6	635.5	459.1	1.63 %
CORN	28.5	162.7	219.3	1,111.8	39.4	312.3	1.11 %
MISC. FIELD CROPS	5.2	25.5	41.5			14.4	0.05 %
						2,068.9	**7.35 %**
Pasture / Open							
PASTURE	197.8	2,136.3	2,029.8	2,193.3	874.2	1,486.3	5.28 %
OPEN LAND	33.8	72.9	85.2	287.9	17.0	99.4	0.35 %
						1,585.6	**5.63 %**
Melons							
ALL	594.5	2,635.0	280.6	214.3	585.3	861.9	3.06 %
						861.9	**3.06 %**
Field Crops - perennial							
SUGAR CANE	100.0	534.3	892.8	760.7	998.6	657.3	2.33 %
						657.3	**2.33 %**
Hay							
OTHER HAY	10.5	48.3	102.9	217.8	55.7	87.0	0.31 %
						87.0	**0.31 %**
Total	15,760.5	49,633.5	28,796.0	27,342.4	19,240.0	**28,154.5**	**100.0 %**

Source: As per district records (Nieto).

Table 2. Historic Water Use (acre-feet) for United Irrigation District, 1999-2003.

Use	1999	2000	2001	2002	2003	5 year average
	Fiscal Year (values in annual ac-ft)					
DMI [a]	12,819	14,551	13,649	13,435	11,391	13,169
Ag Irrigation	11,959	15,099	18,703	8,310	6,942	12,203
Conveyance Loss	8,133	10,045	6,360	3,921	5,240	6,740
Total	32,911	39,694	38,712	25,667	23,573	32,111

Source: Nieto and Gonzalez, data records from the District, received October 14, 2004.
[a] DMI sum of Sharyland & Mission categories; Ag irrigation sum of In-District & Out District categories.

Table 3. Selected Summary Information for United Irrigation District, 2005.

Item	Description / Data
Certificates of Adjudication (Type Use (Owner) \\ ac-ft):	Owned by United ID 0846-000; (Municipal/Industrial, \\ 10,565.000 ac-ft); A847-001 (Class A Irrigation \\ 64,463.525 ac-ft); B847-001 (Class B Irrigation \\ 513.487 ac-ft); Managed by United ID 0845-000 (Class A Irrigation (City of Mission) \\ 429.325 ac-ft); 0400-000 (Class B Irrigation (Dixie Mortgage) \\ 96.325 ac-ft); 0400-006 (Class B Irrigation (Dixie Mortgage) \\ 29.100 ac-ft); 0555-001 (Class B Irrigation (Santa Maria LTD) \\ 480.500 ac-ft); 0580-001 (Class B Irrigation (City of Mission) \\ 65.000 ac-ft); 0832-000 (Class B Irrigation (District #18) \\ 5,505.150 ac-ft); 0806-001(Municipal/Industrial, \\1,169.540 ac-ft); 0809-001(Municipal/Industrial, \\ 5,960.178 ac-ft); 0809-005 (Municipal/Industrial, \\ 1,295.510 ac-ft); 0828-003 (Municipal/Industrial, \\ 1,250.000 ac-ft); and 0849-000 (Municipal/Industrial \\ 5,300.000 ac-ft).
Municipalities Served (Max \\ '04 Actual Delivery ac-ft):	City of Mission (7,719.540 ac-ft \\ 7,541.090 ac-ft); Sharyland Water (7,255.688 ac-ft \\ 4,146.100 ac-ft); and City of McAllen (11,250.000 ac-ft \\ 955.260 ac-ft).
District Water Rates:	Irrigation: In-District - ($5.00 rate; $20.00 per ac-ft); Irrigation: Out-of-District - ($5.00 rate; $20.00 per ac-ft); Irrigation: City Claimants - ($5.00 rate; $20.00 per ac-ft); Irrigation: Relift Water - ($1.70 rate; $6.80 per ac-ft); Irrigation: Tank water (per 1,000 gal) - ($5.00 rate; $1,629.25 per ac-ft); Irrigation: Drip Meters - ($11.25 rate; $45.00 per ac-ft); Municipal: City of Mission - (per 1,000 gal) - $0.1568; Municipal: Sharyland Water - (per 1,000 gal) - $0.1460; and Municipal: City of McAllen - (per 1,000 gal) - $0.1460.
Average Lift at Rio Grande:	16' to 20'
Average Lift at Relift #1 and #2:	15' and 10', respectively

Source: Dunn, August 24, 2005.

Table 4. Data Summary for United Irrigation District's Proposed Project to the USBR, 2005.

Component / Construction Order / Segment		Current	Pipe Diameter to be Installed	Segment Length (ft)	Segment Length (miles)	Area Served (acres)	Construction Period Estimate: begin date	Construction Period Estimate: complete date	Construction Period Estimate: # of days
Component #1 - Main Canal & Lateral 7N									
2	Main Canal	canal	60" 54" 48" 42"	11,712	2.22	2,209	Dec 5, 2005	Feb 12, 2007	434
14	Lateral 7N	pipeline	36" 30" 24"	12,880	2.44	1,444	Feb 18, 2013	Jan 13, 2014	329
				24,592	4.66	3,653			
Component #2 - Laterals & Sub-Laterals									
1	Lateral 3¼ N – phase I	canal	24"	4,800	0.91	50	Jul 11, 2005	Nov 29, 2005	141
3	Lateral 3½N – phase I	canal	24"	2,400	0.45	n/a	Feb 26, 2007	May 29, 2007	92
4	Sharyland 3rd	canal	24"	10,210	1.93	2,848	Jun 4, 2007	Apr 30, 2008	331
5	Lateral 3½N – phase II	canal	24" 18"	6,803	1.29	459	May 7, 2008	April 16, 2009	344
	- interconnect w/ Sharyland 3rd	ground		4,570	0.87	n/a			
6	Lateral 3¼ N – phase II	canal	24" 18"	4,570	0.87	290	Apr 23, 2009	Sep 17, 2009	147
		pipeline		3,300	0.63	50			
7	Lateral 7-M	canal	30"	8,060	1.53	314	Sep 24, 2009	Jun 14, 2010	263
8	sub-Lateral 7M1	canal	24"	1,942	0.37	48	Jun 15, 2010	Oct 1, 2010	108
	- interconnect w/ Lat 5-N	ground		1,550	0.29	n/a			
9	Lateral 5-N	canal	24" 18"	6,980	1.32	406	Oct 7, 2010	Apr 20, 2011	195
10	sub-Lateral 5N3	pipeline	24"	2,740	0.52	300	Apr 27, 2011	Oct 24, 2011	180
	"	canal		2,740	0.52	242			
11	sub-Lateral 7M2	canal	30"	3,960	0.75	196	Oct 31, 2011	Mar 30, 2012	151
12	sub-Lateral 5N2	pipeline	24" 18"	1,940	0.37	60	Apr 5, 2012	Aug 1, 2012	118
	"	canal		1,890	0.36	141			
13	sub-Lateral 7M3	canal	18"	2,640	0.50	255	Aug 8, 2012	Dec 3, 2012	117
				71,095	13.46	5,659			
Component #3 - Diversion Pump									
A	rehabilitate 1st lift pump						May 15, 2006	Jun 9, 2006	25
	TOTAL			95,687	18.12	9,312			

Source: Gonzalez, July 11, 2005 and August 2, 2005.

Continued

Table 4, continued.

Component / Construction Order / Segment		Estimated Allocation of Construction Costs, by Year [a] 2005	2006	2007	2008	2009	2010	2011	2012	2013	Total	Water Savings (ac-ft) [b]
Component #1 - Main Canal & Lateral 7N												
2	Main Canal		$2,461,223								$2,461,223	486
14	Lateral 7N									$2,199,196	$2,199,196	28
											$4,660,420	514
Component #2 - Laterals & Sub-Laterals												
1	Lateral $3^1/_4$ N – phase I	$505,653									$505,653	89
3	Lateral 3½N – phase I			$292,023							$292,023	46
4	Sharyland 3rd			$797,288	$341,695						$1,138,983	292
5	Lateral 3½N – phase II - interconnect w/ S.L. 3rd				$931,695	$310,565					$1,242,260	130
6	Lateral $3^1/_4$ N – phase II					$829,723					$829,723	87
7	Lateral 7-M					$526,723	$790,085				$1,316,808	160
8	sub-Lateral 7M1 - interconnect w/ Lat 5-N						$572,281				$572,281	22
9	Lateral 5-N						$456,428	$456,428			$912,856	180
10	sub-Lateral 5N3 “							$1,058,251			$1,058,251	33
11	sub-Lateral 7M2							$194,065	$452,819		$646,884	51
12	sub-Lateral 5N2 “								$565,272		$565,272	25
13												34
											$9,503,093	1,149
Component #3 - Diversion Pump												
A	rehabilitate 1st lift pump		$123,542								$123,542	n/a
	TOTAL	$505,653	$2,584,765	$1,089,311	$1,273,390	$1,667,011	$1,818,794	$1,708,744	$1,440,190	$2,199,196	$14,287,055	1,663

[a] All dollar values reflect 5% inflation (i.e., basis calendar year 2005, inflated 5% annually thereafter) (Gonzalez).

[b] Water savings are annual amounts and in this analysis commence in the year immediately succeeding completion of segment construction (which varies for each segment).

Table 5. Summary of Time Requirements, Costs, and Water and Energy Savings Data for Three Project Components, United Irrigation District, 2005.

Item	Component #1 *Main Canal & Lat. 7*			Component #2 *Laterals & Sub-Laterals*			Component #3 *Rehabilitate Diversion Pump*			Aggregate
	yrs	Total Expenses / Revenues ($'s)	($/mile)	yrs	Total Expenses / Revenues ($'s)	($/mile)	yrs	Total Expenses / Revenues ($'s)	($/mile)	($'s)
Installation Period	≈ 1			≤ ≥ 1			≤ 1 month			
Useful Life	50			50			25			
Total Planning Period	57			56			25			
Initial Capital Investment Costs [a]		$ 4,660,420	$ 1,000,611		$ 9,503,093	$ 705,765		$ 123,542	n/a	$ 14,287,055
Initial Capital Investment Costs [b]		$ 3,686,029	$ 791,405		$ 7,349,634	$ 545,834		$ 123,542	n/a	$ 11,159,204
O&M Expenses [c]										
- Annual Increases		$ 8,853	$ 1,901		$ 25,593	$ 1,901		$ 4,902	n/a	$ 39,348
- Annual Decreases		$ 29,510	$ 6,336		$ 85,312	$ 6,336		$ 14,406	n/a	$ 129,227
Net Changes		$ (20,657)	$ (4,435)		$ (59,718)	$ (4,435)		$ (9,504)	n/a	$ (89,878)
Value of Extraordinary Impacts										
- Reclaimed Land/Property [d]		$ 375,600	$ 80,643		$ 1,466,400	$ 108,905		n/a	n/a	$ 1,842,000

Source: Nieto and Gonzalez (July 11, 2005; August 10, 2005; September 2, 2005).

[a] As each component has multiple segments to be constructed, over a period of several years (2005 to 2013), these effective nominal values are summed across the years in which costs are expected to be incurred. That is, project costs are expected to rise in future years and thus incorporate a 5% annual project-material cost inflation factor, basis CY 2005 (Gonzalez).

[b] Effective Nominal totals discounted to present day values at a 6.125% annual rate, which is consistent with the methodology in other economic analyses (e.g., Rister et al. 2005).

[c] Basis 2005 dollars, with the total component amount indicated being that which is anticipated after all component segments are installed and implemented.

[d] Basis 2005 dollars, with an annual 4% property-appreciation factor used to adjust for future years' land sales. The timing of land sales correlates with individual project components being constructed and implemented.

Table 5, continued.

Item	Component #1 *Main Canal & Lat. 7*	Component #2 *Laterals & Sub-Laterals*	Component #3 *Rehabilitate Diversion Pump*	Aggregate
	– Annual Water Savings (ac-ft) –			
Annual Water Savings (net)				
off-farm	514	1,149	- 0 -	1,663
on-farm	- 0 -	- 0 -	- 0 -	- 0 -
TOTAL (ac-ft) [e]	514	1,149	- 0 -	1,663
	– Annual Energy Savings (BTU, kwh, $) –			
Annual Energy Savings (BTU)				
- diversion	200,522,168	448,639,092	3,131,832,466	3,780,993,726
- 1st relift	198,038,153	443,081,471	- 0 -	641,119,624
- 2nd relift	128,818,071	288,211,636	- 0 -	417,029,707
TOTAL (BTU) [e]	527,378,392	1,179,932,199	3,131,832,466	4,839,143,057
Annual Energy Savings (kwh)				
- diversion	58,770	131,489	917,888	1,108,147
- 1st relift	58,042	129,860	- 0 -	187,902
- 2nd relift	37,754	84,470	- 0 -	122,224
TOTAL (kwh) [e]	154,566	345,819	917,888	1,418,273
Annual Energy Savings ($)				
- diversion	$1,453	$3,252	$22,701	$27,406
- 1st relift	$1,509	$3,376	- 0 -	$4,885
- 2nd relift	$1,071	$2,397	- 0 -	$3,468
TOTAL ($) [e]	$4,034	$9,025	$22,701	$35,760

[e] Totals are after all component segments are installed and implemented; i.e., component's multiple segments are scheduled to be installed in a staggered fashion over several years and are thus affected by the differing time periods.

Table 6. Summary of Historical Water Diversions, and Energy Use and Expenses (1999-2003) for United Irrigation District's Rio Grande Diversion Pumping Plant.

Item	Fiscal Year 1999	2000	2001	2002	2003	Average
Electricity - diverted:						
- kwh used	279,200	254,592	328,704	404,352	265,728	306,515
- Btu equivalent	952,630,400	868,667,904	1,121,538,048	1,379,649,024	906,663,936	1,045,829,862
- total electric expense	$ 26,461	$ 25,217	$ 33,034	$ 33,565	$ 22,700	$ 28,195
Natural Gas - diverted:						
- kwh used	3,500,234	4,265,621	3,322,714	3,709,760	2,026,846	3,365,035
- Btu equivalent	11,942,800,000	14,554,300,000	11,337,100,000	12,657,700,000	6,915,600,000	11,481,500,000
- total natural gas expense	$ 89,590	$ 61,802	$ 64,805	$ 51,821	$ 45,019	$ 62,607
Total Energy - diverted:						
- kwh used	3,779,434	4,520,213	3,651,418	4,114,112	2,292,574	3,671,550
- Btu equivalent	12,895,430,400	15,422,967,904	12,458,638,048	14,037,349,024	7,822,263,936	12,527,329,862
- total energy expense	$ 116,051	$ 87,019	$ 97,839	$ 85,385	$ 67,718	$ 90,802
Water - diverted:						
- CFS pumped	16,592	20,011	19,516	12,940	11,884	16,188
- ac-ft equivalent	32,911	39,694	38,712	25,667	23,573	**32,111**
Calculations (diverted water):						
- kwh / ac-ft	114.84	113.88	94.32	160.29	97.25	114.34
- Btu / ac-ft	391,827	388,547	321,829	546,903	331,831	**390,121**
- avg. cost per kwh ($/kwh)	$ 0.031	$ 0.019	$ 0.027	$ 0.021	$ 0.030	$ 0.025
- avg. cost per Btu ($/Btu)	$ 0.0000090	$ 0.0000056	$ 0.0000079	$ 0.0000061	$ 0.0000087	$ 0.0000072
- avg. energy cost of water diverted at the Rio Grande ($/ac-ft)	$ 3.53	$ 2.19	$ 2.53	$ 3.33	$ 2.87	**$ 2.83**

Source: Per district records (Nieto, Dunn).

Table 7. Summary of Historical Water Diversions, and Energy Use and Expenses (1999-2003) for United Irrigation District's #1 Relift Pumping Station.

Item	Fiscal Year 1999	2000	2001	2002	2003	Average
Electricity - #1 relift:						
- kwh used	573,129	1,102,080	929,280	945,600	614,400	832,898
- Btu equivalent	1,955,516,148	3,760,296,960	3,170,703,360	3,226,387,200	2,096,332,800	2,841,847,294
- total electric expense	$ 33,816	$ 68,058	$ 71,303	$ 60,836	$ 50,732	$ 56,949
Natural Gas - #1 relift:						
- kwh used	3,044,138	2,231,272	2,033,206	2,490,856	1,990,739	2,358,042
- Btu equivalent	10,386,600,000	7,613,100,000	6,937,300,000	8,498,800,000	6,792,400,000	8,045,640,000
- total natural gas expense	$ 35,773	$ 35,935	$ 42,344	$ 8,736	$ 7,271	$ 26,012
Total Energy - #1 relift:						
- kwh used	3,617,267	3,333,352	2,962,486	3,436,456	2,605,139	3,190,940
- Btu equivalent	12,342,116,148	11,373,396,960	10,108,003,360	11,725,187,200	8,888,732,800	10,887,487,294
- total energy expense	$ 69,589	$ 103,993	$ 113,646	$ 69,573	$ 58,003	$ 82,961
Water - 31 relift: [a]						
- CFS relifted	14,601	17,610	17,174	11,387	10,458	14,246
- ac-ft equivalent	28,962	34,931	34,067	22,587	20,744	**28,258**
Calculations (#1 relift water):						
- kwh / ac-ft	124.90	95.43	86.96	152.14	125.58	112.92
- Btu / ac-ft	426,153	325,599	296,713	519,113	428,492	**385,288**
- avg. cost per kwh ($/kwh)	$ 0.019	$ 0.031	$ 0.038	$ 0.020	$ 0.022	$ 0.026
- avg. cost per Btu ($/Btu)	$ 0.0000056	$ 0.0000091	$ 0.0000112	$ 0.0000059	$ 0.0000065	$ 0.0000076
- avg. energy cost of water relifted at relift #1 ($/ac-ft)	$ 2.40	$ 2.98	$ 3.34	$ 3.08	$ 2.80	**$ 2.94**

Source: Per district records (Nieto, Dunn).

[a] Volume is not metered and is thus estimated by District management.

Table 8. Summary of Historical Water Diversions, and Energy Use and Expenses (1999-2003) for United Irrigation District's #2 Relift Pumping Station.

Item	Fiscal Year 1999	2000	2001	2002	2003	Average
Electricity - #2 relift:						
- kwh used	300,864	555,840	212,736	218,880	156,288	288,922
- Btu equivalent	1,026,547,968	1,896,526,080	725,855,232	746,818,560	533,254,656	985,800,499
- total electric expense	$ 16,482	$ 34,905	$ 17,512	$ 15,701	$ 10,810	$ 19,082
Natural Gas - #2 relift:						
- kwh used	1,030,100	423,974	1,035,639	1,366,149	596,161	890,404
- Btu equivalent	3,514,700,000	1,446,600,000	3,533,600,000	4,661,300,000	2,034,100,000	3,038,060,000
- total natural gas expense	$ 11,606	$ 7,210	$ 20,856	$ 18,978	$ 13,271	$ 14,384
Total Energy - #2 relift:						
- kwh used	1,330,964	979,814	1,248,375	1,585,029	752,449	1,179,326
- Btu equivalent	4,541,247,968	3,343,126,080	4,259,455,232	5,408,118,560	2,567,354,656	4,023,860,499
- total energy expense	$ 28,088	$ 42,115	$ 38,368	$ 34,679	$ 24,081	$ 33,466
Water - #2 relift: [a]						
- CFS relifted	8,296	10,006	9,758	6,470	5,942	8,094
- ac-ft equivalent	16,456	19,847	19,356	12,834	11,787	**16,056**
Calculations (#2 relift water):						
- kwh / ac-ft	80.88	49.37	64.50	123.51	63.84	73.45
- Btu / ac-ft	275,971	168,445	220,059	421,406	217,822	**250,619**
- avg. cost per kwh ($/kwh)	$ 0.021	$ 0.043	$ 0.031	$ 0.022	$ 0.032	$ 0.028
- avg. cost per Btu ($/Btu)	$ 0.0000062	$ 0.0000126	$ 0.0000090	$ 0.0000064	$ 0.0000064	$ 0.0000083
- avg. energy cost of water relifted at relift #2 ($/ac-ft)	$ 1.71	$ 2.12	$ 1.98	$ 2.70	$ 2.04	**$ 2.08**

Source: Per district records (Nieto, Dunn).

[a] Volume is not metered and is thus estimated by District management.

Table 9. Economic and Financial Evaluation Results Across Component #1's Useful Life – Piping 4.66 Miles of the Main Canal and Lateral 7N, 2005.

Results	Nominal Value	Real Value [a]
Water Savings (ac-ft)		
agriculture irrigation	25,700	10,478
municipal and industrial (M&I)	0	0
total ac-ft	25,700	10,478
annuity equivalent		467
Energy Savings (BTU)		
agriculture irrigation	26,368,919,580	10,751,030,345
municipal and industrial (M&I)	0	0
total BTU	26,368,919,580	10,751,030,345
annuity equivalent		479,324,031
Energy Savings (kwh)		
agriculture irrigation	7,728,288	3,150,947
municipal and industrial (M&I)	0	0
total kwh	7,728,288	3,150,947
annuity equivalent		140,482
NPV of Net Cost Stream (relevant to saving water) [b]	$1,842,751	$2,892,573
- annuity equivalent of net cost stream ($/yr)		$182,991
- cost of saving water ($/ac-ft)		$391.71
NPV of Net Cost Stream (relevant to saving energy) [c]	$2,205,330	$2,974,806
- annuity equivalent of net cost stream ($/yr)		$188,193
- cost of saving energy ($/BTU)		$0.0003926
- cost of saving energy ($/kwh)		$1.340

[a] Determined using a 4% discount factor.

[b] These are the net cost stream values (nominal and real) relevant to the cost of saving water (i.e., they include the initial capital investment costs, changes in O&M expenses, and energy cost savings) for the life of the project component.

[c] These are the net cost stream values (nominal and real) relevant to the cost of saving energy (i.e., they include the initial capital investment costs and changes in O&M expenses, and necessarily ignore any energy cost savings and the value of water) for the life of the project component.

Table 10. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings Obtained by Piping 4.66 Miles of the Main Canal and Lateral 7N, and the Expected Useful Life of the Capital Investment, UID, 2005.

		ac-ft of water loss prevented by piping 4.66 miles of Main Canal & Lateral 7N									
		250	300	350	400	475	**514**	575	625	675	775
Expected Useful life of Investment (years)	10	$1,149.86	$955.45	$816.59	$712.44	$597.33	$583.44	$490.56	$449.99	$415.43	$385.64
	20	$907.41	$753.99	$644.41	$562.22	$471.38	$460.42	$387.13	$355.11	$327.84	$304.32
	25	$850.25	$706.50	$603.82	$526.81	$441.69	$431.42	$362.74	$332.74	$307.19	$285.16
	30	$812.06	$674.76	$576.69	$503.14	$421.85	$412.04	$346.45	$317.79	$293.39	$272.35
	40	$767.06	$637.37	$544.74	$475.26	$398.47	$389.20	$327.25	$300.18	$277.13	$257.25
	50	$771.99	$641.47	$548.24	$478.32	$401.03	**$391.71**	$329.35	$302.11	$278.91	$258.91

Table 11. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings Obtained by Piping 4.66 Miles of the Main Canal and Lateral 7N, and the Initial Cost of the Capital Investment, UID, 2005.

		ac-ft of water loss prevented by piping 4.66 miles of Main Canal & Lateral 7N									
		250	300	350	400	475	**514**	575	625	675	775
Initial Capital Investment Cost ($)	$(1,000,000)	$523.93	$434.75	$371.05	$323.28	$270.48	$264.10	$221.50	$202.89	$187.04	$173.37
	$(500,000)	$647.96	$538.11	$459.65	$400.80	$335.76	$327.90	$275.43	$252.50	$232.97	$216.14
	$(250,000)	$709.97	$589.79	$503.94	$439.56	$368.40	$359.81	$302.39	$277.31	$255.94	$237.52
	$ -	$771.99	$641.47	$548.24	$478.32	$401.03	**$391.71**	$329.35	$302.11	$278.91	$258.91
	$250,000	$834.00	$693.15	$592.53	$517.08	$433.67	$423.61	$356.32	$326.92	$301.88	$280.29
	$500,000	$896.02	$744.83	$636.83	$555.84	$466.31	$455.51	$383.28	$351.73	$324.85	$301.68
	$1,000,000	$1,020.05	$848.18	$725.42	$633.35	$531.59	$519.31	$437.20	$401.34	$370.78	$344.44

Table 12. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings Obtained by Piping 4.66 Miles of the Main Canal and Lateral 7N, and the Value of Energy Savings, UID, 2005.

	ac-ft of water loss prevented by piping 4.66 miles of Main Canal & Lateral 7N										
		250	300	350	400	475	**514**	575	625	675	775
Value of Energy Savings ($/kwh)	$0.0125	$777.50	$646.98	$553.75	$483.82	$406.54	$397.21	$334.86	$307.62	$284.42	$264.41
	$0.0175	$775.24	$644.72	$551.49	$481.57	$404.29	$394.96	$332.61	$305.37	$282.17	$262.16
	$0.0225	$772.99	$642.47	$549.24	$479.32	$402.04	$392.71	$330.36	$303.12	$279.91	$259.91
	$0.0247	$771.99	$641.47	$548.24	$478.32	$401.03	**$391.71**	$329.35	$302.11	$278.91	$258.91
	$0.0275	$770.74	$640.22	$546.99	$477.07	$399.79	$390.46	$328.11	$300.87	$277.66	$257.66
	$0.0325	$768.49	$637.97	$544.74	$474.82	$397.54	$388.21	$325.86	$298.62	$275.41	$255.41
	$0.0375	$766.24	$635.72	$542.49	$472.57	$395.29	$385.96	$323.60	$296.36	$273.16	$253.16

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, UID, Piping the Main Canal and Lateral 7N, 2005.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		820,822	923,425	974,727	1,000,377	**1,026,028**	1,051,679	1,077,329	1,128,631	1,282,535	1,539,042
Expected Useful life of Investment (years)	10	$0.0007310	$0.0006498	$0.0006156	$0.0005998	$0.0005848	$0.0005705	$0.0005570	$0.0005316	$0.0004678	$0.0003899
	20	$0.0005769	$0.0005128	$0.0004858	$0.0004733	$0.0004615	$0.0004502	$0.0004395	$0.0004195	$0.0003692	$0.0003077
	25	$0.0005405	$0.0004805	$0.0004552	$0.0004435	$0.0004324	$0.0004219	$0.0004118	$0.0003931	$0.0003459	$0.0002883
	30	$0.0005163	$0.0004589	$0.0004347	$0.0004236	$0.0004130	$0.0004029	$0.0003933	$0.0003755	$0.0003304	$0.0002753
	40	$0.0004876	$0.0004335	$0.0004106	$0.0004001	$0.0003901	$0.0003806	$0.0003715	$0.0003546	$0.0003121	$0.0002601
	50	$0.0004908	$0.0004362	$0.0004133	$0.0004027	**$0.0003926**	$0.0003830	$0.0003739	$0.0003569	$0.0003141	$0.0002617

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, UID, Piping the Main Canal and Lateral 7N, 2005.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		820,822	923,425	974,727	1,000,377	**1,026,028**	1,051,679	1,077,329	1,128,631	1,282,535	1,539,042
Expected Useful life of Investment (years)	10	$2.494	$2.217	$2.100	$2.047	$1.995	$1.947	$1.900	$1.814	$1.596	$1.330
	20	$1.968	$1.750	$1.658	$1.615	$1.575	$1.536	$1.500	$1.431	$1.260	$1.050
	25	$1.844	$1.639	$1.553	$1.513	$1.475	$1.439	$1.405	$1.341	$1.180	$0.984
	30	$1.761	$1.566	$1.483	$1.445	$1.409	$1.375	$1.342	$1.281	$1.127	$0.939
	40	$1.664	$1.479	$1.401	$1.365	$1.331	$1.299	$1.268	$1.210	$1.065	$0.887
	50	$1.675	$1.488	$1.410	$1.374	**$1.340**	$1.307	$1.276	$1.218	$1.072	$0.893

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, UID, Piping the Main Canal and Lateral 7N, 2005.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		820,822	923,425	974,727	1,000,377	**1,026,028**	1,051,679	1,077,329	1,128,631	1,282,535	1,539,042
Initial Capital Investment Cost ($)	$(1,00,000)	$0.0003353	$0.0002981	$0.0002824	$0.0002751	$0.0002683	$0.0002617	$0.0002555	$0.0002439	$0.0002146	$0.0001788
	$(500,000)	$0.0004130	$0.0003672	$0.0003478	$0.0003389	$0.0003304	$0.0003224	$0.0003147	$0.0003004	$0.0002644	$0.0002203
	$(250,000)	$0.0004519	$0.0004017	$0.0003806	$0.0003708	$0.0003615	$0.0003527	$0.0003443	$0.0003287	$0.0002892	$0.0002410
	$ -	$0.0004908	$0.0004362	$0.0004133	$0.0004027	**$0.0003926**	$0.0003830	$0.0003739	$0.0003569	$0.0003141	$0.0002617
	$250,000	$0.0005296	$0.0004708	$0.0004460	$0.0004346	$0.0004237	$0.0004134	$0.0004035	$0.0003852	$0.0003390	$0.0002825
	$500,000	$0.0005685	$0.0005053	$0.0004787	$0.0004665	$0.0004548	$0.0004437	$0.0004331	$0.0004135	$0.0003638	$0.0003032
	$1,000,000	$0.0006462	$0.0005744	$0.0005442	$0.0005302	$0.0005170	$0.0005044	$0.0004924	$0.0004700	$0.0004136	$0.0003447

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, UID, Piping the Main Canal and Lateral 7N, 2005.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		820,822	923,425	974,727	1,000,377	**1,026,028**	1,051,679	1,077,329	1,128,631	1,282,535	1,539,042
Initial Capital Investment Cost ($)	$(1,000,000)	$1.144	$1.017	$0.963	$0.939	$0.915	$0.893	$0.872	$0.832	$0.732	$0.610
	$(500,000)	$1.409	$1.253	$1.187	$1.156	$1.127	$1.100	$1.074	$1.025	$0.902	$0.752
	$(250,000)	$1.542	$1.371	$1.298	$1.265	$1.234	$1.203	$1.175	$1.121	$0.987	$0.822
	$ -	$1.675	$1.488	$1.410	$1.374	**$1.340**	$1.307	$1.276	$1.218	$1.072	$0.893
	$250,000	$1.807	$1.606	$1.522	$1.483	$1.446	$1.410	$1.377	$1.314	$1.157	$0.964
	$500,000	$1.940	$1.724	$1.633	$1.592	$1.552	$1.514	$1.478	$1.411	$1.241	$1.035
	$1,000,000	$2.205	$1.960	$1.857	$1.809	$1.764	$1.721	$1.680	$1.604	$1.411	$1.176

Table 17. Costs per BTU of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Reduced Water Losses by Piping 4.66 Miles of the Main Canal and Lateral 7N, UID, 2005.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		820,822	923,425	974,727	1,000,377	**1,026,028**	1,051,679	1,077,329	1,128,631	1,282,535	1,539,042
ac-ft of water loss for 4.66 miles of canal and lateral	250	$0.0009541	$0.0008481	$0.0008034	$0.0007828	$0.0007633	$0.0007446	$0.0007269	$0.0006939	$0.0006106	$0.0005088
	300	$0.0007951	$0.0007067	$0.0006695	$0.0006524	$0.0006360	$0.0006205	$0.0006058	$0.0005782	$0.0005088	$0.0004240
	350	$0.0006815	$0.0006058	$0.0005739	$0.0005592	$0.0005452	$0.0005319	$0.0005192	$0.0004956	$0.0004361	$0.0003635
	400	$0.0005963	$0.0005300	$0.0005021	$0.0004893	$0.0004770	$0.0004654	$0.0004543	$0.0004337	$0.0003816	$0.0003180
	475	$0.0005021	$0.0004463	$0.0004229	$0.0004120	$0.0004017	$0.0003919	$0.0003826	$0.0003652	$0.0003214	$0.0002678
	514	$0.0004908	$0.0004362	$0.0004133	$0.0004027	**$0.0003926**	$0.0003830	$0.0003739	$0.0003569	$0.0003141	$0.0002617
	575	$0.0004148	$0.0003687	$0.0003493	$0.0003404	$0.0003319	$0.0003238	$0.0003160	$0.0003017	$0.0002655	$0.0002212
	625	$0.0003816	$0.0003392	$0.0003214	$0.0003131	$0.0003053	$0.0002979	$0.0002908	$0.0002775	$0.0002442	$0.0002035
	675	$0.0003534	$0.0003141	$0.0002976	$0.0002899	$0.0002827	$0.0002758	$0.0002692	$0.0002570	$0.0002262	$0.0001885
	775	$0.0003290	$0.0002924	$0.0002770	$0.0002699	$0.0002632	$0.0002568	$0.0002507	$0.0002393	$0.0002106	$0.0001755

Table 18. Costs per kwh of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Reduced Water Losses by Piping 4.66 Miles of the Main Canal and Lateral 7N, UID, 2005.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		820,822	923,425	974,727	1,000,377	**1,026,028**	1,051,679	1,077,329	1,128,631	1,282,535	1,539,042
ac-ft of water loss for 4.66 miles of canal and lateral	250	$3.255	$2.894	$2.741	$2.671	$2.604	$2.541	$2.480	$2.367	$2.083	$1.736
	300	$2.713	$2.411	$2.284	$2.226	$2.170	$2.117	$2.067	$1.973	$1.736	$1.447
	350	$2.325	$2.067	$1.958	$1.908	$1.860	$1.815	$1.772	$1.691	$1.488	$1.240
	400	$2.035	$1.808	$1.713	$1.669	$1.628	$1.588	$1.550	$1.480	$1.302	$1.085
	475	$1.713	$1.523	$1.443	$1.406	$1.371	$1.337	$1.305	$1.246	$1.097	$0.914
	514	$1.675	$1.488	$1.410	$1.374	**$1.340**	$1.307	$1.276	$1.218	$1.072	$0.893
	575	$1.415	$1.258	$1.192	$1.161	$1.132	$1.105	$1.078	$1.029	$0.906	$0.755
	625	$1.302	$1.157	$1.097	$1.068	$1.042	$1.016	$0.992	$0.947	$0.833	$0.694
	675	$1.206	$1.072	$1.015	$0.989	$0.965	$0.941	$0.919	$0.877	$0.772	$0.643
	775	$1.123	$0.998	$0.945	$0.921	$0.898	$0.876	$0.855	$0.816	$0.718	$0.599

Table 19. Economic and Financial Evaluation Results Across Component #2's Useful Life – Piping 13.46 Miles of the Laterals and Sub-Laterals, 2005.

Results	Nominal Value	Real Value [a]
Water Savings (ac-ft)		
agriculture irrigation	57,500	21,029
municipal and industrial (M&I)	0	0
total ac-ft	57,500	21,029
annuity equivalent		942
Energy Savings (BTU)		
agriculture irrigation	58,996,609,955	21,576,648,467
municipal and industrial (M&I)	0	0
total BTU	58,996,609,955	21,576,648,467
annuity equivalent		966,403,486
Energy Savings (kwh)		
agriculture irrigation	17,290,917	6,323,754
municipal and industrial (M&I)	0	0
total kwh	17,290,917	6,323,754
annuity equivalent		283,237
NPV of Net Cost Stream (relevant to saving water) [b]	$1,064,478	$4,807,998
- annuity equivalent of net cost stream ($/yr)		$304,779
- cost of saving water ($/ac-ft)		$323.58
NPV of Net Cost Stream (relevant to saving energy) [c]	$1,922,965	$4,973,035
- annuity equivalent of net cost stream ($/yr)		$315,241
- cost of saving energy ($/BTU)		$0.0003262
- cost of saving energy ($/kwh)		$1.113

[a] Determined using a 4% discount factor.

[b] These are the net cost stream values (nominal and real) relevant to the cost of saving water (i.e., they include the initial capital investment costs, changes in O&M expenses, and energy cost savings) for the life of the project component.

[c] These are the net cost stream values (nominal and real) relevant to the cost of saving energy (i.e., they include the initial capital investment costs and changes in O&M expenses, and necessarily ignore any energy cost savings and the value of water) for the life of the project component.

Table 20. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings Obtained by Piping 13.46 Miles of Laterals and Sub-Laterals and the Expected Useful Life of the Capital Investment, UID, 2005.

	ac-ft of water loss prevented by piping 13.46 miles of laterals and sub-laterals										
		575	700	800	925	1,050	**1,149**	1,275	1,375	1,500	1,725
Expected Useful life of Investment (years)	10	$1,864.68	$1,675.03	$1,390.55	$1,187.36	$1,034.96	$927.08	$821.60	$780.96	$710.29	$624.66
	20	$982.93	$882.96	$733.00	$625.89	$545.56	$488.69	$433.09	$411.67	$374.41	$329.28
	25	$853.13	$766.36	$636.21	$543.24	$473.52	$424.16	$375.90	$357.31	$324.97	$285.79
	30	$776.08	$697.15	$578.75	$494.18	$430.75	$385.85	$341.95	$325.04	$295.62	$259.98
	40	$693.37	$622.85	$517.07	$441.51	$384.84	$344.73	$305.51	$290.39	$264.11	$232.27
	50	$650.84	$584.64	$485.35	$414.43	$361.24	**$323.58**	$286.77	$272.58	$247.91	$218.03

Table 21. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings Obtained by Piping 13.46 Miles of Laterals and Sub-Laterals and the Initial Cost of the Capital Investment, UID, 2005.

	ac-ft of water loss prevented by piping 13.46 miles of laterals and sub-laterals										
		575	700	800	925	1,050	**1,149**	1,275	1,375	1,500	1,725
Initial Capital Investment Cost ($)	$(1,000,000)	$517.73	$464.85	$385.52	$328.86	$286.36	$256.28	$226.87	$215.54	$195.83	$171.95
	$(500,000)	$584.28	$524.74	$435.44	$371.64	$323.80	$289.93	$256.82	$244.06	$221.87	$194.99
	$(250,000)	$617.56	$554.69	$460.39	$393.04	$342.52	$306.76	$271.79	$258.32	$234.89	$206.51
	$ -	$650.84	$584.64	$485.35	$414.43	$361.24	**$323.58**	$286.77	$272.58	$247.91	$218.03
	$250,000	$684.11	$614.59	$510.31	$435.82	$379.95	$340.41	$301.74	$286.84	$260.94	$229.55
	$500,000	$717.39	$644.54	$535.26	$457.21	$398.67	$357.23	$316.72	$301.11	$273.96	$241.06
	$1,000,000	$783.94	$704.44	$585.18	$500.00	$436.11	$390.88	$346.66	$329.63	$300.00	$264.10

Table 22. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings Obtained by Piping 13.46 Miles of Laterals and Sub-Laterals and the Value of Energy Savings, UID, 2005.

	ac-ft of water loss prevented by piping 13.46 miles of laterals and sub-laterals										
		575	700	800	925	1,050	**1,149**	1,275	1,375	1,500	1,725
Value of Energy Savings ($/kwh)	$0.0125	$652.81	$586.62	$487.33	$416.41	$363.21	$325.56	$288.75	$274.56	$249.89	$220.01
	$0.0175	$652.01	$585.81	$486.52	$415.60	$362.41	$324.75	$287.94	$273.75	$249.08	$219.20
	$0.0225	$651.20	$585.00	$485.71	$414.79	$361.60	$323.94	$287.13	$272.94	$248.28	$218.39
	$0.0247	$650.84	$584.64	$485.35	$414.43	$361.24	**$323.58**	$286.77	$272.58	$247.91	$218.03
	$0.0275	$650.39	$584.19	$484.90	$413.98	$360.79	$323.13	$286.32	$272.13	$247.47	$217.58
	$0.0325	$649.58	$583.38	$484.09	$413.17	$359.98	$322.33	$285.51	$271.33	$246.66	$216.77
	$0.0375	$648.77	$582.58	$483.28	$412.36	$359.17	$321.52	$284.70	$270.52	$245.85	$215.96

Table 23. Costs per BTU of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Expected Useful Life of the Capital Investment, UID, Piping Laterals and Sub-Laterals, 2005.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		820,822	923,425	974,727	1,000,377	**1,026,028**	1,051,679	1,077,329	1,128,631	1,282,535	1,539,042
Expected Useful life of Investment (years)	10	$0.0011682	$0.0010384	$0.0009838	$0.0009585	$0.0009346	$0.0009118	$0.0008901	$0.0008496	$0.0007477	$0.0006231
	20	$0.0006158	$0.0005474	$0.0005186	$0.0005053	$0.0004926	$0.0004806	$0.0004692	$0.0004479	$0.0003941	$0.0003284
	25	$0.0005345	$0.0004751	$0.0004501	$0.0004386	$0.0004276	$0.0004172	$0.0004072	$0.0003887	$0.0003421	$0.0002851
	30	$0.0004862	$0.0004322	$0.0004094	$0.0003989	$0.0003890	$0.0003795	$0.0003704	$0.0003536	$0.0003112	$0.0002593
	40	$0.0004344	$0.0003861	$0.0003658	$0.0003564	$0.0003475	$0.0003390	$0.0003310	$0.0003159	$0.0002780	$0.0002317
	50	$0.0004077	$0.0003624	$0.0003434	$0.0003346	**$0.0003262**	$0.0003182	$0.0003107	$0.0002965	$0.0002610	$0.0002175

Table 24. Costs per kwh of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Expected Useful Life of the Capital Investment, UID, Piping Laterals and Sub-Laterals, 2005.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		820,822	923,425	974,727	1,000,377	**1,026,028**	1,051,679	1,077,329	1,128,631	1,282,535	1,539,042
Expected Useful life of Investment (years)	10	$3.986	$3.543	$3.357	$3.271	$3.189	$3.111	$3.037	$2.899	$2.551	$2.126
	20	$2.101	$1.868	$1.769	$1.724	$1.681	$1.640	$1.601	$1.528	$1.345	$1.121
	25	$1.824	$1.621	$1.536	$1.496	$1.459	$1.423	$1.389	$1.326	$1.167	$0.973
	30	$1.659	$1.475	$1.397	$1.361	$1.327	$1.295	$1.264	$1.207	$1.062	$0.885
	40	$1.482	$1.317	$1.248	$1.216	$1.186	$1.157	$1.129	$1.078	$0.949	$0.790
	50	$1.391	$1.237	$1.172	$1.142	**$1.113**	$1.086	$1.060	$1.012	$0.890	$0.742

Table 25. Costs per BTU of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Initial Cost of the Capital Investment, UID, Piping Laterals and Sub-Laterals, 2005.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		820,822	923,425	974,727	1,000,377	**1,026,028**	1,051,679	1,077,329	1,128,631	1,282,535	1,539,042
Initial Capital Investment Cost ($)	$(1,00,000)	$0.0003258	$0.0002896	$0.0002743	$0.0002673	$0.0002606	$0.0002542	$0.0002482	$0.0002369	$0.0002085	$0.0001737
	$(500,000)	$0.0003668	$0.0003260	$0.0003088	$0.0003009	$0.0002934	$0.0002862	$0.0002794	$0.0002667	$0.0002347	$0.0001956
	$(250,000)	$0.0003873	$0.0003442	$0.0003261	$0.0003177	$0.0003098	$0.0003022	$0.0002950	$0.0002816	$0.0002478	$0.0002065
	$ -	$0.0004077	$0.0003624	$0.0003434	$0.0003346	**$0.0003262**	$0.0003182	$0.0003107	$0.0002965	$0.0002610	$0.0002175
	$250,000	$0.0004282	$0.0003807	$0.0003606	$0.0003514	$0.0003426	$0.0003342	$0.0003263	$0.0003115	$0.0002741	$0.0002284
	$500,000	$0.0004487	$0.0003989	$0.0003779	$0.0003682	$0.0003590	$0.0003502	$0.0003419	$0.0003264	$0.0002872	$0.0002393
	$1,000,000	$0.0004897	$0.0004353	$0.0004124	$0.0004018	$0.0003918	$0.0003822	$0.0003731	$0.0003562	$0.0003134	$0.0002612

Table 26. Costs per kwh of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Initial Cost of the Capital Investment, UID, Piping Laterals and Sub-Laterals, 2005.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		820,822	923,425	974,727	1,000,377	**1,026,028**	1,051,679	1,077,329	1,128,631	1,282,535	1,539,042
Initial Capital Investment Cost ($)	$(1,000,000)	$1.111	$0.988	$0.936	$0.912	$0.889	$0.868	$0.847	$0.808	$0.711	$0.593
	$(250,000)	$1.251	$1.112	$1.054	$1.027	$1.001	$0.977	$0.953	$0.910	$0.801	$0.667
	$(100,000)	$1.321	$1.174	$1.113	$1.084	$1.057	$1.031	$1.007	$0.961	$0.846	$0.705
	$ -	$1.391	$1.237	$1.172	$1.142	**$1.113**	$1.086	$1.060	$1.012	$0.890	$0.742
	$250,000	$1.461	$1.299	$1.230	$1.199	$1.169	$1.140	$1.113	$1.063	$0.935	$0.779
	$500,000	$1.531	$1.361	$1.289	$1.256	$1.225	$1.195	$1.167	$1.114	$0.980	$0.817
	$1,000,000	$1.671	$1.485	$1.407	$1.371	$1.337	$1.304	$1.273	$1.215	$1.069	$0.891

Table 27. Costs per BTU of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Reduced Water Losses By Piping 13.46 Miles of Laterals and Sub-Laterals, UID, 2005.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		820,822	923,425	974,727	1,000,377	**1,026,028**	1,051,679	1,077,329	1,128,631	1,282,535	1,539,042
ac-ft of water loss prevented by piping 13.46 miles of laterals and sub-laterals	575	$0.0008064	$0.0007168	$0.0006791	$0.0006617	$0.0006452	$0.0006294	$0.0006144	$0.0005865	$0.0005161	$0.0004301
	700	$0.0007258	$0.0006452	$0.0006112	$0.0005955	$0.0005806	$0.0005665	$0.0005530	$0.0005279	$0.0004645	$0.0003871
	800	$0.0006048	$0.0005376	$0.0005093	$0.0004963	$0.0004839	$0.0004721	$0.0004608	$0.0004399	$0.0003871	$0.0003226
	925	$0.0005184	$0.0004608	$0.0004366	$0.0004254	$0.0004147	$0.0004046	$0.0003950	$0.0003770	$0.0003318	$0.0002765
	1,050	$0.0004536	$0.0004032	$0.0003820	$0.0003722	$0.0003629	$0.0003540	$0.0003456	$0.0003299	$0.0002903	$0.0002419
	1,149	$0.0004077	$0.0003624	$0.0003434	$0.0003346	**$0.0003262**	$0.0003182	$0.0003107	$0.0002965	$0.0002610	$0.0002175
	1,275	$0.0003629	$0.0003226	$0.0003056	$0.0002978	$0.0002903	$0.0002832	$0.0002765	$0.0002639	$0.0002323	$0.0001935
	1,375	$0.0003456	$0.0003072	$0.0002910	$0.0002836	$0.0002765	$0.0002697	$0.0002633	$0.0002514	$0.0002212	$0.0001843
	1,500	$0.0003156	$0.0002805	$0.0002657	$0.0002589	$0.0002525	$0.0002463	$0.0002404	$0.0002295	$0.0002020	$0.0001683
	1,725	$0.0002792	$0.0002481	$0.0002351	$0.0002290	$0.0002233	$0.0002179	$0.0002127	$0.0002030	$0.0001787	$0.0001489

Table 28. Costs per kwh of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Reduced Water Losses By Piping 13.46 Miles of Laterals and Sub-Laterals, UID, 2005.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		820,822	923,425	974,727	1,000,377	**1,026,028**	1,051,679	1,077,329	1,128,631	1,282,535	1,539,042
ac-ft of water loss prevented by piping 13.46 miles of laterals and sub-laterals	575	$2.752	$2.446	$2.317	$2.258	$2.201	$2.148	$2.096	$2.001	$1.761	$1.468
	700	$2.476	$2.201	$2.085	$2.032	$1.981	$1.933	$1.887	$1.801	$1.585	$1.321
	800	$2.064	$1.834	$1.738	$1.693	$1.651	$1.611	$1.572	$1.501	$1.321	$1.101
	925	$1.769	$1.572	$1.490	$1.451	$1.415	$1.381	$1.348	$1.286	$1.132	$0.943
	1,050	$1.548	$1.376	$1.303	$1.270	$1.238	$1.208	$1.179	$1.126	$0.991	$0.825
	1,149	$1.391	$1.237	$1.172	$1.142	**$1.113**	$1.086	$1.060	$1.012	$0.890	$0.742
	1,275	$1.238	$1.101	$1.043	$1.016	$0.991	$0.966	$0.943	$0.901	$0.792	$0.660
	1,375	$1.179	$1.048	$0.993	$0.968	$0.943	$0.920	$0.898	$0.858	$0.755	$0.629
	1,500	$1.077	$0.957	$0.907	$0.883	$0.861	$0.840	$0.820	$0.783	$0.689	$0.574
	1,725	$0.952	$0.847	$0.802	$0.782	$0.762	$0.743	$0.726	$0.693	$0.610	$0.508

Table 29. Economic and Financial Evaluation Results Across Component #3's Useful Life – Rehabilitation of the Rio Grande Diversion Pumping Plant, 2005.

Results	Nominal Value	Real Value [a]
Water Savings (ac-ft)		
agriculture irrigation	n/a	n/a
municipal and industrial (M&I)	n/a	n/a
total ac-ft	n/a	n/a
annuity equivalent		n/a
Energy Savings (BTU)		
agriculture irrigation	78,295,811,640	48,925,737,148
municipal and industrial (M&I)	0	0
total BTU	78,295,811,640	48,925,737,148
annuity equivalent		3,061,155,211
Energy Savings (kwh)		
agriculture irrigation	22,947,190	14,339,313
municipal and industrial (M&I)	0	0
total kwh	22,947,190	14,339,313
annuity equivalent		897,173
NPV of Net Cost Stream (relevant to saving water) [b]	($934,885)	($379,557)
- annuity equivalent of net cost stream ($/yr)		($29,546)
- cost of saving water ($/ac-ft)		n/a
NPV of Net Cost Stream (relevant to saving energy) [c]	($188,807)	($24,926)
- annuity equivalent of net cost stream ($/yr)		($1,940)
- cost of saving energy ($/BTU)		($0.0000006)
- cost of saving energy ($/kwh)		($0.002)

[a] Determined using a 4% discount factor.

[b] These are the net cost stream values (nominal and real) relevant to the cost of saving water (i.e., they include the initial capital investment costs, changes in O&M expenses, and energy cost savings) for the life of the project component.

[c] These are the net cost stream values (nominal and real) relevant to the cost of saving energy (i.e., they include the initial capital investment costs and changes in O&M expenses, and necessarily ignore any energy cost savings and the value of water) for the life of the project component.

Table 30. 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, UID, Rehabilitating the Rio Grande Diversion Pumping Plant, 2005.

		variation in BTU of all energy 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 via pump/motor replacement									
		78,024	87,777	92,654	95,092	**97,530**	99,968	102,407	107,283	121,913	146,295
Expected Useful life of Investment (years)	15	$(0.0000010)	$(0.0000009)	$(0.0000008)	$(0.0000008)	$(0.0000008)	$(0.0000008)	$(0.0000008)	$(0.0000007)	$(0.0000006)	$(0.0000005)
	18	$(0.0000009)	$(0.0000008)	$(0.0000008)	$(0.0000007)	$(0.0000007)	$(0.0000007)	$(0.0000007)	$(0.0000007)	$(0.0000006)	$(0.0000005)
	20	$(0.0000009)	$(0.0000008)	$(0.0000007)	$(0.0000007)	$(0.0000007)	$(0.0000007)	$(0.0000007)	$(0.0000006)	$(0.0000005)	$(0.0000005)
	22	$(0.0000008)	$(0.0000007)	$(0.0000007)	$(0.0000007)	$(0.0000007)	$(0.0000006)	$(0.0000006)	$(0.0000006)	$(0.0000005)	$(0.0000004)
	24	$(0.0000008)	$(0.0000007)	$(0.0000007)	$(0.0000006)	$(0.0000006)	$(0.0000006)	$(0.0000006)	$(0.0000006)	$(0.0000005)	$(0.0000004)
	25	$(0.0000008)	$(0.0000007)	$(0.0000007)	$(0.0000007)	**$(0.0000006)**	$(0.0000006)	$(0.0000006)	$(0.0000006)	$(0.0000005)	$(0.0000004)

Table 31. 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, UID, Rehabilitating the Rio Grande Diversion Pumping Plant, 2005.

		variation in BTU of all energy 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 via pump/motor replacement									
		78,024	87,777	92,654	95,092	**97,530**	99,968	102,407	107,283	121,913	146,295
Expected Useful life of Investment (years)	15	$(0.003)	$(0.003)	$(0.003)	$(0.003)	$(0.003)	$(0.003)	$(0.003)	$(0.002)	$(0.002)	$(0.002)
	18	$(0.003)	$(0.003)	$(0.003)	$(0.003)	$(0.002)	$(0.002)	$(0.002)	$(0.002)	$(0.002)	$(0.002)
	20	$(0.003)	$(0.003)	$(0.002)	$(0.002)	$(0.002)	$(0.002)	$(0.002)	$(0.002)	$(0.002)	$(0.002)
	22	$(0.003)	$(0.002)	$(0.002)	$(0.002)	$(0.002)	$(0.002)	$(0.002)	$(0.002)	$(0.002)	$(0.001)
	24	$(0.003)	$(0.002)	$(0.002)	$(0.002)	$(0.002)	$(0.002)	$(0.002)	$(0.002)	$(0.002)	$(0.001)
	25	$(0.003)	$(0.002)	$(0.002)	$(0.002)	**$(0.002)**	$(0.002)	$(0.002)	$(0.002)	$(0.002)	$(0.001)

Table 32. 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, UID, Rehabilitating the Rio Grande Diversion Pumping Plant, 2005.

		variation in BTU of all energy 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 via pump/motor replacement									
		78,024	87,777	92,654	95,092	**97,530**	99,968	102,407	107,283	121,913	146,295
Initial Capital Investment Cost ($)	$(50,000)	$(0.0000024)	$(0.0000021)	$(0.0000020)	$(0.0000020)	$(0.0000019)	$(0.0000019)	$(0.0000018)	$(0.0000017)	$(0.0000015)	$(0.0000013)
	$(25,000)	$(0.0000016)	$(0.0000014)	$(0.0000013)	$(0.0000013)	$(0.0000013)	$(0.0000012)	$(0.0000012)	$(0.0000012)	$(0.0000010)	$(0.0000008)
	$(10,000)	$(0.0000011)	$(0.0000010)	$(0.0000009)	$(0.0000009)	$(0.0000009)	$(0.0000009)	$(0.0000008)	$(0.0000008)	$(0.0000007)	$(0.0000006)
	$ -	$(0.0000008)	$(0.0000007)	$(0.0000007)	$(0.0000007)	**$(0.0000006)**	$(0.0000006)	$(0.0000006)	$(0.0000006)	$(0.0000005)	$(0.0000004)
	$10,000	$(0.0000005)	$(0.0000004)	$(0.0000004)	$(0.0000004)	$(0.0000004)	$(0.0000004)	$(0.0000004)	$(0.0000003)	$(0.0000003)	$(0.0000003)
	$25,000	$0.0000000	$0.0000000	$0.0000000	$0.0000000	$0.0000000	$0.0000000	$0.0000000	$0.0000000	$0.0000000	$0.0000000
	$50,000	$0.0000008	$0.0000007	$0.0000007	$0.0000007	$0.0000006	$0.0000006	$0.0000006	$0.0000006	$0.0000005	$0.0000004

Table 33. 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, UID, Rehabilitating the Rio Grande Diversion Pumping Plant, 2005.

		variation in BTU of all energy 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 via pump/motor replacement									
		78,024	87,777	92,654	95,092	**97,530**	99,968	102,407	107,283	121,913	146,295
Initial Capital Investment Cost ($)	$(50,000)	$(0.008)	$(0.007)	$(0.007)	$(0.007)	$(0.007)	$(0.006)	$(0.006)	$(0.006)	$(0.005)	$(0.004)
	$(25,000)	$(0.005)	$(0.005)	$(0.005)	$(0.004)	$(0.004)	$(0.004)	$(0.004)	$(0.004)	$(0.003)	$(0.003)
	$(10,000)	$(0.004)	$(0.003)	$(0.003)	$(0.003)	$(0.003)	$(0.003)	$(0.003)	$(0.003)	$(0.002)	$(0.002)
	$ -	$(0.003)	$(0.002)	$(0.002)	$(0.002)	**$(0.002)**	$(0.002)	$(0.002)	$(0.002)	$(0.002)	$(0.001)
	$10,000	$(0.002)	$(0.001)	$(0.001)	$(0.001)	$(0.001)	$(0.001)	$(0.001)	$(0.001)	$(0.001)	$(0.001)
	$25,000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
	$50,000	$0.003	$0.002	$0.002	$0.002	$0.002	$0.002	$0.002	$0.002	$0.002	$0.001

Table 34. Summary of Economic and Financial Results for the Cost of Saving Water, by Component and Aggregated, UID, 2005.

Economic / Conservation Measures	Project Component [a]			Aggregate
	Main Canal & Lateral 7N	Laterals & Sub-Laterals	Rehabilitate Diversion Pumping Plant	
NPV of Net Cost Stream ($) [b]	$ 2,892,573	$ 4,807,998	($ 379,557)	$ 7,321,015
- annuity equivalent of net cost stream ($/yr)	$ 182,991	$ 304,779	($ 29,546)	$ 458,224
NPV of All Water Savings (ac-ft)	10,478	21,029	0	31,508
- annuity equivalent of all water savings stream (ac-ft/yr)	467	942	0	1,409
Annuity Equivalent of Costs ($/ac-ft) of Water Savings [c]	$ 391.706	$ 323.583	n/a	$ 325.200

[a] All values are basis 2005 and are real (i.e., as opposed to nominal); thus, incorporating the economic and financial influences of time and inflation.

[b] For each component and the aggregate, these values are the net present value (NPV) of the cost stream relevant to the cost of saving water (i.e., they include the initial capital investment costs, changes in O&M expenses, and energy cost savings). Since the third component does not save water, its contribution to the project's aggregate Annuity Equivalent of Costs ($/ac-ft) is only included in the aggregate; and not in the individual component column.

[c] Assumes perpetual timeline and replacement with identical technology.

Table 35. Summary of Economic and Financial Results for the Cost of Saving Energy, by Project Component and Aggregated, UID, 2005.

Economic / Conservation Measures	Project Component [a]			Aggregate
	Main Canal & Lateral 7N	Laterals & Sub-Laterals	Rehabilitate Diversion Pumping Plant	
NPV of Net Cost Stream ($) [b]	$ 2,974,806	4,973,035	($ 24,926)	$ 7,922,915
- annuity equivalent of net cost stream ($/yr)	$ 188,193	315,241	($ 1,940)	$ 501,494
NPV of All Energy Savings (BTU)	10,751,030,345	21,576,648,467	48,925,737,148	81,253,415,960
- annuity equivalent of all energy savings stream (BTU/yr)	479,324,031	966,403,486	3,061,155,211	4,506,882,727
- annuity equivalent of all energy savings stream (kwh/yr)	140,482	283,237	897,173	1,320,892
Annuity Equivalent of Costs ($/BTU) of Energy Savings [c]	$ 0.0003926	$ 0.0003262	($ 0.0000006)	$ 0.0001113
Annuity Equivalent of Costs ($/kwh) of Energy Savings [c]	$ 1.340	$ 1.113	($ 0.002)	$ 0.380

[a] All values are basis 2005 and are real (as opposed to nominal); thus, incorporating the economic and financial influences of time and inflation.

[b] For each component and the aggregate, these values are the net present value (NPV) of the cost stream relevant to the cost of saving energy (i.e., they include the initial capital investment costs and changes in O&M expenses, and necessarily ignore any energy cost savings and the value of water).

[c] Assumes perpetual timeline and replacement with identical technology.

Appendices

Appendix A: Results – Legislated Criteria, by Component

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

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

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

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

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

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

Component #1: Main Canal and Lateral 7N

Component #1 of the District's USBR project primarily consists of piping 4.66 miles of Main Canal and Lateral 7N. Details on the cost estimates and related projections of associated water and energy savings are presented in the main body of this report (**Tables 4, 5**, and **9**). Below, a summary of the calculated values and results corresponding to the legislated criteria are presented, with nominal and their discounted (i.e., real) transformations presented.

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

Summary Calculated Values

The initial construction costs associated with the purchase and installation of component #1 amount to $4,660,420 in nominal terms, and $3,686,029 in real terms. All expenditures are assumed to occur according to the schedule depicted in **Table 4**. Further, the nominal construction costs provided (**Tables 4, 5** and **A1**) are for the year in which construction spending occurs. That is, the nominal and real values in **Table A1** are different because the future costs are discounted.

A total of 25,700 ac-ft of nominal off-farm water savings are projected to occur during the productive life of the new pipeline, with associated energy savings of 26,368,919,580 BTU (7,728,288 kwh). Using the 4% discount rate, the present or real value of such anticipated savings become 10,478 ac-ft and 10,751,030,345 BTU (3,150,947 kwh) (**Table A1**).

The accrued annual net changes in O&M expenditures over the new pipeline's productive life are a total decrease of $2,817,669. Using the 2002 Federal discount rate of 6.125%,[35] this anticipated net decrease in expenditures represents a real cost reduction of $793,456 (**Table A1**). As noted in the main body of the text, this anticipated net cost savings stems from land sales, 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 $181.34 in a nominal sense and $351.78 in real terms, while the initial construction costs per BTU (kwh) of energy saved are $0.0001767 ($0.603) in a nominal sense and $0.0003429 ($1.170) in real terms (**Table A2**). The estimated real values are higher (than the nominal values) because future water and energy savings are discounted and construction costs are not because they occur at the onset, i.e., with the real or present values, the discounting of the denominators (i.e., ac-ft of water; BTU (or kwh) of energy) increases the ratio of $/water saved and $/energy saved.

Changes in both energy savings and other O&M expenditures forthcoming from the new pipeline 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 -1.65 of construction costs per dollar reduction in nominal operating expenditures, suggesting construction costs are more than the expected nominal decreases in O&M costs during the planning period for the installed pipeline. On a real basis, this ratio measure is -4.65 (**Table A2**), signifying construction costs are substantially higher than the expected real values of economic savings in O&M during the planning period.

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35 In order to maintain consistency across projects being analyzed by the authors in calendar years 2002-2005, the 2002 Federal discount rate of 6.125% is also applied to this analysis and report.

Component #2: Laterals and Sub-Laterals

Component #2 of the District's USBR project consists of piping 13.46 miles of laterals and sub-laterals. Details on the cost estimates and related projections of associated water and energy savings are presented in the main body of this report (**Tables 4, 5**, and **19**). Below, a summary of the calculated values and results corresponding to the legislated criteria are presented, with nominal and their discounted (i.e., real) transformations presented.

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

Summary Calculated Values

The initial construction costs associated with the purchase and installation of component #2 amount to $9,503,093 in nominal terms, and $7,349,634 in real terms. Further, the nominal construction costs provided (**Tables 4, 5** and **A3**) are for the year in which construction spending occurs. That is, the nominal and real values in **Table A3** are different because the future costs are discounted.

A total of 57,500 ac-ft of nominal *off-farm* water savings are projected to occur during the productive life of the new pipeline, with associated energy savings of 58,996,609,955 BTU (17,290,917 kwh). Using the 4% discount rate, the present or real value of such anticipated savings become 21,029 ac-ft and 21,576,648,467 BTU (6,323,754 kwh) (**Table A3**).

The accrued annual net changes in O&M expenditures over the new pipeline's productive life are a total decrease of $8,438,616. Using the 2002 Federal discount rate of 6.125%, this anticipated net decrease in expenditures represents a real cost reduction of $2,541,635 (**Table A3**). As noted in the main body of the text, this anticipated net cost savings stems from land sales, 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 $165.27 in a nominal sense and $349.39 in real terms, while the initial construction costs per BTU (kwh) of energy saved are $0.0001611 ($0.550) in a nominal sense and $0.0003406 ($1.162) in real terms (**Table A4**). The estimated real values are higher (than the nominal values) because future water and energy savings are discounted and construction costs are not because they occur at the onset, i.e., with the real or present values, the discounting of the denominators (i.e., ac-ft of water; BTU (or kwh) of energy) increases the ratio of $/water saved and $/energy saved.

Changes in both energy savings and other O&M expenditures forthcoming from the new pipeline result in anticipated net decreases in annual costs (**Table A3**). Dividing the initial construction costs by the decreases in operating costs results in a ratio measure of -1.13 of construction costs per dollar reduction in nominal operating expenditures, suggesting construction costs are more than the expected nominal decreases in O&M costs during the planning period for the installed pipeline. On a real basis, this ratio measure is -2.89 (**Table A4**), signifying construction costs are much higher than the expected real values of economic savings in O&M during the planning period.

Component #3: Rehabilitate Diversion Pumping Plant

Component #3 of the District's USBR project consists of rehabilitating the Rio Grande diversion pumping plant. Details on the cost estimates and related projections of associated water and energy savings are presented in the main body of this report (**Tables 4, 5**, and **29**). Below, a summary of the calculated values and results corresponding to the legislated criteria are presented, with nominal and their discounted (i.e., real) transformations presented.

The principal evaluation criteria specified in the Public Law 106-576 legislation, transformed according to Hamilton, are presented in **Table A6** (which are determined by the calculated values reported in **Table A5**, which are derived in RGIDECON©, using the several input parameters described in the main body of this report).

<u>Summary Calculated Values</u>

The initial construction costs associated with the purchase and installation of the new pumping plant equipment/motors amount to $123,542. 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 0 ac-ft of nominal water savings are projected to occur during the productive life of the new motor. Energy savings from the new motor amount to 78,295,811,640 BTU (22,947,190 kwh). Using the 4% discount rate, the present or real value of such anticipated savings become 0 ac-ft and 48,925,737,148 BTU (14,339,313 kwh) (**Table A5**).

The accrued annual net changes in O&M expenditures over the motor's productive life are a total decrease of $1,058,427. Using the 2002 Federal discount rate of 6.125%, this anticipated net decrease in expenditures represents a real cost reduction of $503,099 (**Table A5**). 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.

<u>Criteria Stated in Legislated Guidelines</u>

The estimated initial construction costs per ac-ft of water saved are $0 in a nominal sense and $0 in real terms, while the initial construction costs per BTU (kwh) of energy saved are $0.0000016 ($0.005) in a nominal sense and $0.0000025 ($0.009) in real terms (**Table A6**). 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 diversion-pump motor installation result in anticipated net decreases in annual costs (**Table A5**). Dividing the initial construction costs by the decreases in operating costs results in a ratio measure of -0.117 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 motor. On a real basis, this ratio measure is -0.246 (**Table A6**), signifying construction costs are substantially lower than the expected real values of economic savings in O&M during the planning period.

Summary of Legislated Criteria Results for the Individual Components

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

In the main body, the comprehensive assessment indicates component #2 is the most economical source of *water savings*, then component #1, with component #3 not ranking in this area (**Table A7**). The comprehensive costs of *energy savings* ranked results are: component #3, component #2, and component #1, respectively (**Tables 35** and **A7**).

Here, in the legislated criteria results, the 'Laterals and Sub-Laterals' is again the most economical in terms of dollars of initial construction costs per ac-ft of *water savings*, with the 'Main Canal and Lateral 7N' ranked second (**Tables A2**, **A4**, and **A7**). With respect to cost of *energy savings*, the 'Rehabilitate Diversion Pump Plant' is the most economical, out-performing the 'Laterals and Sub-Laterals' and the 'Main Canal and Lateral 7N' in terms of dollars of initial construction costs per BTU of energy saved (**Tables A2**, **A4**, **A6**, and **A7**). Finally, for the construction costs per dollar of economic savings in annual O&M criterion, the anticipated results provide for a ranking identical to previous BTU/energy ranking; i.e., 'Rehabilitate Diversion Pump Plant', 'Laterals and Sub-Laterals', and 'Main Canal and Lateral 7N', respectively ranked (**Table A7**). It is difficult to determine the absolute rank order of these three components, however, since either a low construction cost requirement and/or a high increase in O&M expenditures result in a low ratio of the two designated calculated values. Similarly, a high construction cost requirement and/or a low increase in O&M expenditures result in a high ratio of the two designated calculated values. The resulting paradox is apparent.[36]

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

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

Caveat to Interpretation of Legislated Criteria Results

The proper interpretation of the third legislated ratio (i.e., dollars of initial construction cost divided by dollars of economic savings) for any component can be somewhat difficult and involves recognition that the most desired value is negative and close to zero (**Exhibit 6**). That is, a negative ratio signifies a net real reduction in future expenses (i.e., O&M and energy), while a positive ratio signifies a net real increase in future expenses. Also, whether the value of the ratio is *less than* or *greater than* negative 1 makes a difference. That is, if less than negative one (e.g., -3.45), it infers that construction costs are *greater than* the sum of real expected annual economic savings (which are on a "current dollar basis"). Likewise, if the value is greater than negative one and less than zero (e.g., -.74), it infers construction costs are *less than* the sum of real expected annual economic savings. Of course, if the value is positive (i.e., greater than zero), it infers that in addition to initial construction costs, the project component will incur net increases in real future operating and maintenance costs (i.e., not realize net real economic savings over the life of the project). Finally, a negative value close to zero indicates a relatively low required investment to achieve a dollar of savings in O&M expenses.

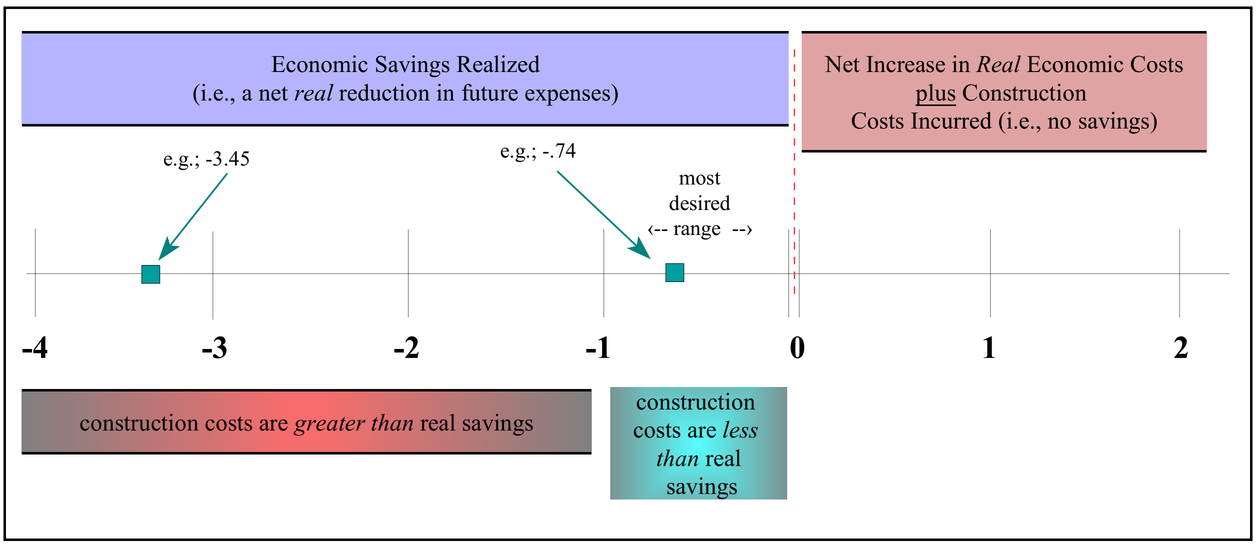

Exhibit A1. Graphical Interpretation of the Ratio "Dollars of Initial Construction Cost" Divided by "Dollars of Economic Savings" as Required by Federal Legislation.

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

Appendix B: Results – Legislated Criteria, Aggregated Across Components

As noted in Rister et al. 2002, aggregation of evaluation results for independent projects into an appraisal of one comprehensive project is not a common occurrence. Adaptations in analytical methods are necessary to account for the variations in useful lives of the individual components. The approach used in aggregating the legislated criteria results presented in Appendix A into one set of uniform measures utilizes the present value methods followed in the calculation of the economic and financial results reported in the main body of the text, but does not include the development of annuity equivalent measures. These compromises in approaches are intended to maintain the spirit of the legislated criteria's intentions. Here in Appendix B, only real, present value measures are presented and discussed, thereby designating all values in terms of 2005 equivalents. **Differences in useful lives across project components are not fully represented, however, in these calculated values.**

Table B1 contains the summary measures for the three respective individual components and a summed aggregate value for each measure. The project as a whole requires an initial capital construction investment of $11,159,204. In total, 31,508 ac-ft of real water savings are estimated. Real energy savings are anticipated to be 81,253,415,960 BTUs (23,814,014 kwh). The net change in real total annual O&M expenditures is a decrease of $3,838,189.

Derivation of the aggregate legislated criteria measures for the project as a whole entails use of the Aggregate column values presented in **Table B1** and calculations similar to those used to arrive at the measures for the independent project components. The resulting aggregate initial construction costs per ac-ft of water savings measure is $354.30 per ac-ft of water savings (**Table B2**). Note that this amount is slightly higher than the comprehensive economic and financial value of **$325.20 per ac-ft** identified in **Table 34** and discussed in the main body of this report. The difference in these values is attributable both to the incorporation of both initial capital costs and changes in operating expenses in the latter value and its treatment of the differences in the useful lives of the respective components of the proposed project.

The resulting aggregate initial construction costs per BTU (kwh) of energy savings measure is $0.0003376 per BTU ($1.152 per kwh) (**Table B2**). These cost estimates are much higher than the **$0.0001113 per BTU ($0.380 per kwh)** comprehensive economic and financial cost estimates identified in **Table 35** for reasons similar to those noted above with respect to the estimates of costs of water savings.

The final aggregate legislated criterion of interest is the amount of initial construction costs per dollar of total annual economic savings. The estimate for this ratio measure is -3.44, indicating that (a) the net change in annual O&M expenditures is negative, i.e., a reduction in O&M expenditures is anticipated; and (b) $3.44 of initial construction costs are expended for each such dollar reduction in O&M expenditures, with the latter represented in total real dollars accrued across the three project components' respective planning periods.

Appendix Tables

Table A1. Summary of Calculated Values, Component #1 – Main Canal and Lateral 7N, UID, 2005.

Item	Nominal PV	Real NPV
Dollars of Initial Construction Costs	$ 4,660,420	$ 3,686,029
Ac-Ft of Water Saved	25,700	10,478
BTU of Energy Saved	26,368,919,580	10,751,030,345
kwh of Energy Saved	7,728,288	3,150,947
$ of Annual Economic Savings [a]	($ 2,817,669)	($ 793,456)

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

Table A2. Legislated Evaluation Criteria, Component #1 – Main Canal and Lateral 7N, UID, 2005.

Criteria	Nominal PV	Real NPV
Dollar of Initial Construction Costs per Ac-Ft of Water Saved	$ 181.34	$ 351.78
Dollar of Initial Construction Costs per BTU of Energy Saved	$ 0.0001767	$ 0.0003429
Dollar of Initial Construction Costs per kwh of Energy Saved	$ 0.603	$ 1.170
$ of Initial Construction Costs per $ of Annual Economic Savings [a]	-1.654	-4.646

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

Table A3. Summary of Calculated Values, Component #2 – Laterals and Sub-Laterals, UID, 2005.

Item	Nominal PV	Real NPV
Dollars of Initial Construction Costs	$ 9,503,093	$ 7,349,634
Ac-Ft of Water Saved	57,500	21,029
BTU of Energy Saved	58,996,609,955	21,576,648,467
kwh of Energy Saved	17,290,917	6,323,754
$ of Annual Economic Savings [a]	($ 8,438,616)	($ 2,541,635)

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

Table A4. Legislated Evaluation Criteria, Component #2 – Laterals and Sub-Laterals, UID, 2005.

Criteria	Nominal PV	Real NPV
Dollar of Initial Construction Costs per Ac-Ft of Water Saved	$ 165.27	$ 349.49
Dollar of Initial Construction Costs per BTU of Energy Saved	$ 0.0001611	$ 0.0003406
Dollar of Initial Construction Costs per kwh of Energy Saved	$ 0.550	$ 1.162
$ of Initial Construction Costs per $ of Annual Economic Savings [a]	-1.126	-2.892

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

Table A5. Summary of Calculated Values, Component #3 – Rehabilitating the Rio Grande Diversion Pumping Plant, UID, 2005.

Item	Nominal PV	Real NPV
Dollars of Initial Construction Costs	$ 123,542	$ 123,542
Ac-Ft of Water Saved	0	0
BTU of Energy Saved	78,295,811,640	48,925,737,148
kwh of Energy Saved	22,947,190	14,339,313
$ of Annual Economic Savings [a]	$ (1,058,427)	$ (503,099)

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

Table A6. Legislated Evaluation Criteria, Component #3 – Rehabilitating the Rio Grande Diversion Pumping Plant, UID, 2005.

Criteria	Nominal PV	Real NPV
Dollar of Initial Construction Costs per Ac-Ft of Water Saved	n/a	n/a
Dollar of Initial Construction Costs per BTU of Energy Saved	$ 0.0000016	$ 0.0000025
Dollar of Initial Construction Costs per kwh of Energy Saved	$ 0.005	$ 0.009
$ of Initial Construction Costs per $ of Annual Economic Savings [a]	-0.117	-0.246

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

Table A7. Summary of Ranked Order of Project Components, by Comprehensive Economic Criteria and Individual Legislative Criteria, UID, 2005.

Project Component	Composite Economic Criteria		Individual Legislative Criteria (P.L. 106-576)		
	Water Savings	Energy Savings	$ ICC per ac-ft[a] Water Saved	$ ICC per BTU Energy Saved	$ ICC per $ Annual Economic Savings
#1 - Main Canal and Lateral 7N	2nd	3rd	2nd	3rd	3rd
#2 - Laterals and Sub-Laterals	1st	2nd	1st	2nd	2nd
#3 - Rehabilitate Diversion Pump Plant	--	1st	--	1st	1st

[a] Note the abbreviation ICC stands for 'Initial Construction Cost'; the abbreviation allows for a more user-friendly table heading. Also, the legislative-criteria rankings are as per Hamilton's suggested convention, as discussed in Appendix A.

Table B1. Summary of Calculated Values, Aggregated by All Project Components, UID, 2005.

Economic / Conservation Measures	Project Component: Main Canal & Lateral 7N	Project Component: Laterals & Sub-Laterals	Project Component: Rehabilitate Diversion Pumping Plant	Aggregate
Dollars of Initial Construction Costs ($)	$ 3,686,029	$ 7,349,634	$ 123,542	$ 11,159,204
Ac-Ft of Water Saved (ac-ft)	10,478	21,029	0	31,508
BTU of Energy Saved (BTU)	10,751,030,345	21,576,648,467	48,925,737,148	81,253,415,960
kwh of Energy Saved (kwh)	3,150,947	6,323,754	14,339,313	23,814,014
$ of Total Net Economic Savings [a]	$ (793,456)	$ (2,541,635)	$ (503,099)	$ (3,838,189)

[a] As the total net economic savings over the course of each component's life, positive (+) values here indicate net added costs, while negative (-) values indicate net savings.

Table B2. Legislated Results Criteria, Real Values, Aggregated Across All Project Components, UID, 2005.

Economic Measures	Project Component: Main Canal & Lateral 7N	Project Component: Laterals & Sub-Laterals	Project Component: Rehabilitate Diversion Pumping Plant	Aggregate
Dollar of Initial Construction Costs per Ac-Ft of Water Saved ($/ac-ft)	$ 351.78	$ 349.49	n/a	$ 354.30
Dollar of Initial Construction Costs per BTU of Energy Saved ($/BTU)	$ 0.0003429	$ 0.0003406	$ 0.0000025	$ 0.0003376
Dollar of Initial Construction Costs per kwh of Energy Saved ($/kwh)	$ 1.170	$ 1.162	$ 0.009	$ 1.152
Dollar of Initial Construction Costs per Dollar of Total Net Economic Savings [a, b]	-4.646	-2.892	-0.246	-3.442

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

[b] Interpretation and discussion of these values are provided in the sub-section of Appendix A entitled: *Caveat to Interpretation of Legislated Criteria Results* on page 85.

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