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by:

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Background

The original *'final'* economic analysis reporting on the Lateral A Lining project was reported in July, 2003 in Texas Water Resources Institute TR-221R, entitled "*Economic and Conservation Evaluation of Capital Renovation Projects: Hidalgo County Irrigation District No. 2 (San Juan) – Relining Lateral A – Final*." Subsequent to that report's release, the project was installed and implemented within the District's water-delivery infrastructure system, with actual construction costs thereby becoming known. Further, the U.S. Bureau of Reclamation (USBR) was/is the agency tasked with oversight of federal legislation providing construction funding for up to a potential maximum 50% of this project's cost (U.S. Public Law 107-351). Additional funding was provided by the North American Development Bank for construction, as well as from the Texas Water Development Board (TWDB) for this district's use towards engineering planning and design costs.

To gauge this project's merit (with other, similar projects proposed by other irrigation districts (IDs)), three federally-required evaluation-criterion values and a 'comprehensive' estimate of the *cost-of-saving-water* were calculated and reported in TR-221R. In a subsequent review of the project's plan, the USBR and TWDB considered and relied upon these data in their evaluation processes.

As a follow-up and as part of due diligence to the oversight mandate, the USBR wishes to validate the original federally-required criteria and the comprehensive *cost-of-saving-water* estimate, to the extent possible, by using the actual construction costs (as opposed to the estimate used in TR-221R). The request by USBR for a follow-up analysis and a brief report on a revised 'final' key results, using the actual construction expense, was the impetus to this special report.

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Review of Project Data

The capital improvement project proposed (in July 2003) by the District to the USBR involved the relining of 7.26 miles of "Lateral A" with a geotextile membrane and a shotcrete cover, and reconstructing the farm turnouts to facilitate the use of portable meters. Expected water-saving benefits included reduced seepage and reduced demand from improved water management. Below are key data-input information on the project; for a detailed review, refer to the original report (Rister et al. 2003):

Table 1. Summary of Key Project Data Incorporated Into the Comprehensive Analysis.

Item	Value in Original Analysis (i.e., in TR-221R)	Value in This "Revised-Final" Analysis
Initial Construction Costs	$ 3,154,200	$ 2,168,606
Installation Time Period	1 year	same
Expected Useful Life	49 years	same
Net Change in Annual O&M ($)	$ 300	same
Annual Water Savings (ac-ft)		
off-farm (seepage)	1,333.2	same
on-farm (metering)	1,328.0	same
total	2,661.2	same
Cumulative Water Savings (ac-ft)		
nominal	130,399	same
real (i.e., time adjusted)	54,610	same
Annual Energy Savings		
BTU	577,591,532	same
kwh	169,282	same
$'s	$ 11,055	same

As shown in **Table 1**, the original estimated initial capital construction costs totaled $3,154,200 with the revised, actual value being $2,168,606 (Irlbeck). The installation period was projected to take one year with an ensuing expected useful life of 49 years. No losses of operations or other adverse impacts were anticipated (nor did they occur) as installation occurred in the 'off-season' for irrigating. These values remained unchanged in the revised analysis reported here.

Further, the net annual increase in operation and maintenance (O&M) expenses of $300 is assumed to remain applicable. As the Lateral A project replaces a leaky concrete-lined lateral with a new lined lateral, the base, annual O&M expenses are not expected to change. The net $300 increase represents anticipated repairs for portable flow meters (**Table 1**). Both *off-* and *on-farm* water savings are/were anticipated for the new lining, with the nominal total being 130,339 ac-ft over the 49-year productive life of this component and the real total (i.e., adjusted for social time preference) being 54,610 ac-ft. Annual *off-farm* water savings estimates are based on reduced seepage of 1,333.2 ac-ft. Annual *on-farm* water savings of 1,328.0 ac-ft are predicted from improved water management, which is based on reducing demand by 10% on 6,640 acres of irrigated crop land.

Associated estimates of annual energy savings (which effectively serve as a 'credit' against the initial construction costs) are 577,591,532 BTU (169,282 kwh). Multiplying these savings with historical

energy costs (incurred by the District) results in an annual energy savings of $11,055 (**Table 1**). Energy savings are/were based only on reduced Rio Grande diversions as relifting is not a factor in this project.

Updated (Abridged) Results: *Cost-of-Saving-Water* and Three Legislative Values

As depicted in **Table 2**, the revised comprehensive cost-of-saving-water ($/ac-ft) with the new lining is estimated to be $49.47 per ac-ft, in contrast to the original estimate of $74.49. This value is determined by dividing the annuity equivalent of net costs for water savings of $125,745 per year by the annuity equivalent of water savings of 2,542 annual ac-ft (**Table 2**).

In addition, expected real (vs. nominal) values are indicated for the USBRs three principal evaluation measures specified in U.S. Public Law 106-576 (U.S. Public Law 106-576). The initial construction cost per ac-ft of water savings measure is $39.71 per ac-ft of water savings versus the original estimate of $57.76. The initial construction cost per BTU (kwh) of energy savings measure is $0.0001830 per BTU ($0.624 per kwh), versus the original estimate of $0.0002661 ($0.908 per kwh). The ratio of initial construction costs per dollar of total annual economic savings is estimated to be -9.83, rather than the initial -14.29 (**Table 2**).

Table 2. Summary of Intermediate Data and Abridged Results for Lateral A Project for the Original 2003 Estimate and the Revised 2005 Calculations.

	Lateral A Project [1, 2] (geotextile / shotcrete lining)	
	Original 2003 Analysis (i.e., in TR-221R)	"Revised-Final 2005" Analysis
~ Intermediate Calculations ~		
Annuity Equivalent of Net Cost Stream – Water Savings ($/yr)	$ 189,369	$ 125,745
Annuity Equivalent of Water Savings (ac-ft/yr)	2,542	. . . . . same
~ Abridged Results ~ [3]		
Comprehensive Cost-of-Saving-Water ($/ac-ft)	**$ 74.49**	**$ 49.47**
Legislative Evaluation Criteria [4]		
$ of ICC per ac-ft saved	$ 57.76	$ 39.71
$ of ICC per BTU saved	$ 0.0002661	$ 0.0001830
$ of ICC per kwh saved	$ 0.908	$ 0.624
$ of ICC per $ of annual savings	-14.291	-9.826

1 Note this table reports similar summary information as Table ES1 and Table A2 in the original report.

2 For sake of comparison, the 2005 abridged results were calculated as if the revised analysis was done in 2003 to provide a 'side-by-side' comparison, rather than imposing the effects of a different discount period (i.e., 2003-2052 vs 2005-2054).

3 Real values (vs nominal) which use a 4% discount factor and a 2.04% inflation rate.

4 Note ICC is abbreviation for 'Initial Construction Costs', which makes for a more reader-friendly table.

Sensitivity Analyses

Having known construction costs for this analysis reduces the total uncertainty about the exactness of the original results. Nonetheless, some uncertainty of the preciseness of this revised estimate persists, as other data-input uncertainties remain (e.g., water savings level, energy costs/savings, etc.).

The following sensitivity results (**Tables 3** and **4**) for the cost-of-saving-water are presented whereby two parameters are varied with all others remaining constant. This permits testing of the stability (or instability) of key input values and illustrates how sensitive results can be to variances in data input levels.

Table 3 reveals a range in the cost-of-saving-water from $28.17 to $107.59 (per ac-ft) around the baseline estimate of $49.47. These calculated values were derived by varying the water savings from the new lining from as low as 1,331 ac-ft up to 3,992 ac-ft (i.e., from as low as 50%, and as high as 150% of the expected 2,661.2 ac-ft) and by investigating a range of energy costs (i.e., value of savings) from $0.0325/kwh to $0.0980/kwh about the anticipated $0.0653/kwh. As expected, lower water savings and/or per-unit reductions in energy savings result in higher cost estimates. Conversely, higher reductions in per-unit energy savings and/or higher water savings provide for a lower cost estimate.

Table 4 reveals a range in the cost-of-saving-water from $31.06 to $222.05 (per ac-ft) around the baseline estimate of $49.47. These calculated values were derived by varying the water savings from the new lining from as low as 1,331 ac-ft up to 3,992 ac-ft (i.e., from as low as 50%, and as high as 150% of the expected 2,661.2 ac-ft) and by investigating a range of expected useful lives of the lining from the expected 49-year life, down to as low as only 10 years. As expected, shorter-useful lives and/or lower water savings (than the estimated baseline) result in higher cost estimates. Conversely, longer useful lives and/or higher water savings provide lower cost-of-saving-water estimates.

Table 3. Sensitivity Results of the *Cost-of-Saving-Water* with the Lateral A Lining – Varying the Amount of Annual Water Saved and Value of Energy Savings, 2005.

		variation in water saved									
		50%	60%	70%	80%	90%	**100%**	110%	120%	130%	150%
		Annual estimated water savings (ac-ft) for the Lateral A Project									
		1,331	1,597	1,863	2,129	2,395	**2,661.2**	2,927	3,193	3,460	3,992
Value of Energy Savings ($/kwh) [1]	$ 0.0325	$107.59	$89.18	$76.03	$66.17	$58.50	$52.36	$47.34	$43.15	$39.61	$33.95
	$ 0.0450	$106.48	$88.07	$74.92	$65.06	$57.39	$51.26	$46.24	$42.05	$38.51	$32.85
	$ 0.0600	$105.16	$86.75	$73.60	$63.74	$56.07	$49.93	$44.91	$40.73	$37.19	$31.52
	$ 0.0653	$104.69	$86.28	$73.13	$63.27	$55.60	**$49.47**	$44.44	$40.26	$36.72	$31.06
	$ 0.0700	$104.28	$85.87	$72.72	$62.86	$55.19	$49.05	$44.03	$39.85	$36.31	$30.64
	$ 0.0850	$102.95	$84.55	$71.40	$61.53	$53.86	$47.73	$42.71	$38.52	$34.98	$29.32
	$ 0.0980	$101.81	$83.40	$70.25	$60.39	$52.72	$46.58	$41.56	$37.38	$33.84	$28.17

[1] Variation represents only that for 'Diversion' energy as relifting water within the District's infrastructure system is not involved with this project.

Table 4. Sensitivity Results of the *Cost-of-Saving-Water* with the Lateral A Lining – Varying the Amount of Annual Water Saved and Expected Useful Life, 2005.

		variation in water saved									
		50%	60%	70%	80%	90%	**100%**	110%	120%	130%	150%
		Annual estimated water savings (ac-ft) for the Lateral A Project									
		1,331	1,597	1,863	2,129	2,395	**2,661.2**	2,927	3,193	3,460	3,992
Expected Useful Life (years)	10	$222.05	$183.01	$155.12	$134.20	$117.93	$104.92	$94.27	$85.39	$77.89	$65.87
	20	$142.87	$117.75	$99.80	$86.34	$75.88	$67.50	$60.65	$54.94	$50.11	$42.38
	25	$128.31	$105.75	$89.64	$77.55	$68.15	$60.63	$54.47	$49.35	$45.01	$38.06
	30	$119.26	$98.29	$83.31	$72.08	$63.34	$56.35	$50.63	$45.86	$41.83	$35.38
	40	$109.23	$90.02	$76.30	$66.01	$58.01	$51.61	$46.37	$42.00	$38.31	$32.40
	49	$104.69	$86.28	$73.13	$63.27	$55.60	**$49.47**	$44.44	$40.26	$36.72	$31.06

Conclusion

Results are sensitive to changes in data-input values. The original report (i.e, Rister et al. 2003) demonstrated this with a variety of useful sensitivity tables which showed energy savings, expected useful life, the amount of *off-* and *on-farm* water savings, as well as other variables to have varying impacts upon results. Noteworthy of mention, Table 11 (i.e., a results sensitivity table found on page 43 in the original report) identified a range of costs-of-saving-water values from $71.95 to $61.80 (per ac-ft) by reducing the initial capital investment cost by $100,000 and $500,000, respectively. As actual investment costs were $985,594 less than originally anticipated, the revised comprehensive cost-of-saving-water (reported herein) of $49.47 per ac-ft for the new lining was not within the range originally anticipated (and depicted in sensitivity analyses), although an inference of reduced cost-of-saving-water value could be made with such changes in initial costs.

Applying the actual construction costs for this project reduces the total uncertainty about the exactness of the revised results. Uncertainty still remains about other data-input values' exactness, however, and hence requires a reiterative point that results (original and improved/revised) are deterministic estimates. Nonetheless, the revised results herein are a refinement to the original results in Rister et al. 2003 and remain useful and comparable measures. Conjoined with data uncertainty and multiple analyses are an underlying theme and related inference that consistent and attentive methods of analysis, such as those documented in Rister et al. 2002, are warranted.

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