

Agricultural Water Conservation Fund TWDB Contract No. 1413581739

Draft Final Report for Santa Cruz Irrigation No. 15 Shotcrete Lining of the N-Canal

by

Frank A. Ferris, PE

Ferris, Flinn & Medina, LLC

1405 North Stuart Place Road

Palm Valley, Texas 78552

Ph. (956) 364-2236

Fax. (956) 364-1023

Texas Board of Professional Engineers

Firm Registration No. F-897



Texas Water Development Board

P.O. Box 13231, Capitol Station

Austin, Texas 78711-3231

June 2019



This page is intentionally blank.



**Texas Water Development Board
Agricultural Water Conservation Fund
TWDB Contract No. 1413581739**

**Draft Final Report for
Santa Cruz Irrigation No. 15
Shotcrete Lining of the N Canal**

by

Frank A. Ferris, PE

FERRIS, FLINN & MEDINA, LLC

1405 North Stuart Place Road

Palm Valley, Texas 78552

Ph. (956) 364-2236

Fax. (956) 364-1023

Texas Board of Professional Engineers

Firm Registration No. F-897

June 2019

This project was funded in part by the U.S. Bureau of Reclamation WaterSMART; Water and Energy Efficiency Grants for FY 2015 – Funding Group I and by the Texas Water Development Board.

Texas Water Development Board

Table of Contents

1 Executive Summary	1
3 Application Phase Seepage Testing	5
4 Bureau of Reclamation WaterSMART Funding.....	6
5 Design Phase	7
6 Construction Phase.....	14
7 Post Construction Seepage Testing.....	20
8 Conservation Results	20
9 Project Cost	21
10 Economic Analysis of Conservation.....	22
11 Conclusion	24
12 Acknowledgements	24
13 References	24
14 Appendix	25

List of Figures

Figure 1 District location.....	2
Figure 2 Project location.	3
Figure 3 Seepage evaporation loss analysis.	6
Figure 4 Photograph of dilapidated liner.	8
Figure 5 Photograph of low bank area.....	9
Figure 6 Lining Plan and Stations.....	10
Figure 7 Lining Profile.	11
Figure 8 Cross Section at Station 88+00 – Fill.....	11
Figure 9 Cross Section at Station 62+00 – Cut.....	12
Figure 10 Liner Detail – Fill.....	12
Figure 11 Liner Detail – Cut	13
Figure 12 Expansion Joint Detail	13
Figure 13 Preparation of Phase I Canal for shotcrete.	15
Figure 14 Phase I shotcrete application.....	15
Figure 15 Shotcrete thickness gauge.	16
Figure 16 Shotcrete sample.....	16
Figure 17 Intermittent canal use.....	17
Figure 18 Completed Phase I Canal.....	18
Figure 19 Phase II Canal prepared for lining.....	19
Figure 20 Southern Trenchless applying shotcrete.....	19

Figure 21 Completed Phase II Canal. 20

List of Tables

Table 1 Water Use and Loss 2011-2015. 4
Table 2 Conservation results. 21
Table 3 Project cost and funding. 22
Table 4 Economic analysis of conservation. 23

This Draft Report is prepared by Frank A. Ferris, PE, Texas, License No. 70724 for review by the Santa Cruz Irrigation No. 15 and the Texas Water Development Board. The Final Report will bear the seal and signature of Frank A. Ferris, PE, as required by the Texas Engineering Practice Act. June 19, 2019.

1 Executive Summary

Santa Cruz Irrigation No. 15 (Santa Cruz) is an irrigation district located in Hidalgo County, Texas with 31,000 acres of irrigable land within its boundaries. The District delivers water to North Alamo Water Supply Corporation, a potable water supplier, for treatment and distribution to their customers. Santa Cruz relies on Hidalgo County Irrigation District No. 1 (HCID #1) to divert its water from the Rio Grande, and deliver to the south end of Santa Cruz. HCID #1 charges a 20% transition loss to the Santa Cruz water right account to compensate for losses in their transmission system. The Santa Cruz system has high losses as well, estimated to be another 20%, therefore, only 60% of the water diverted at River actually arrives at the farms. Since the District averages annual diversion from the Rio Grande of about 45,000 acre feet, 18,000 acre feet is lost to seepage and evaporation annually.

In 2014, the District was awarded a \$200,000 Agricultural Irrigation System Improvement Grant from the Texas Water Development Board to line a portion of the N-Canal, with a conservation goal of 670 acre feet per year. In 2015, the District was awarded a Bureau of Reclamation (BOR) WaterSMART: Water and Energy Efficiency Grant that increased the scope of the project by expanding the lining of the N-Canal and included energy efficiency improvements at Pump No. 15. The BOR funding amounted to \$300,000 and increased the overall project conservation goal to 951 acre feet per year.

The total project budget of \$1,250,000 was exceeded, with the excess funded by Santa Cruz, but the conservation measured greatly exceeded grant goals. Phase I, that portion funded by the TWDB at 30% and the BOR at 21% resulted in conservation of 843 acre feet annually. Analyzing the Phase I capital cost of \$669,899, reduced by the capitalized energy conservation savings of \$541,845, results in a net capital cost per acre foot of \$161 per acre foot. The portion of the project funded by the Texas Water Development Board was very economical when compared to the current market rate of an irrigation water right, about \$1,500 per acre feet. Including the Phase II project, the annual conservation was increased to 1,289 acre feet, far exceeding the project goal of 951 acre feet. The total project cost, to line 7,800 linear feet of the N-Canal and the energy conservation improvements at Pump Station 15, was \$1,425,677. Considering the capitalized energy cost savings of \$932,437, the net capital cost per acre foot conserved for the whole project is \$446, very economical compared to the market rate of \$1,500 per acre foot. This project would not have occurred without grant funding from the TWDB and the BOR.

2 Introduction

Santa Cruz Irrigation No. 15 (Santa Cruz), an irrigation district, is located in the Lower Rio Grande Valley Region with its main office in Edinburg, Texas. Figure 1 provides a general location map of Santa Cruz. Figure 2 provides the location of the project within the District boundaries, as well as, the location of the N-Canal. The District boundary encompasses 31,000 Ac. Santa Cruz currently serves 21,000 acres of irrigated farmland where farmers grow predominately citrus, fruit, vegetables, and hay.

Santa Cruz provides raw water to the potable water supplier of North Alamo Water Supply Corporation, is capable of supplying Sharyland WSC, and several out of District customers.

Santa Cruz has its water diverted from the Rio Grande by Hidalgo County Irrigation District No. 1 (HCID #1) and delivered to the southern boundary of Santa Cruz. Table 1 provides a history of water diverted by Santa Cruz from 2011 through 2015. Santa Cruz diverted an average of 44,713 acre feet per year; of that, 2,400 acre feet was for North Alamo Water Supply Corporation. Santa Cruz has very little excess water yearly and has implemented its own District allocation program in order to ensure that District farmers have the water necessary each year.

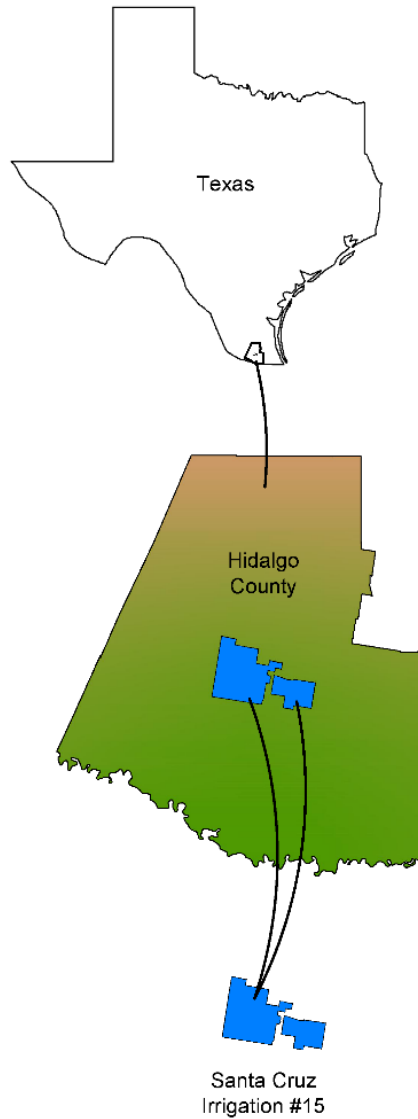


Figure 1 District location.

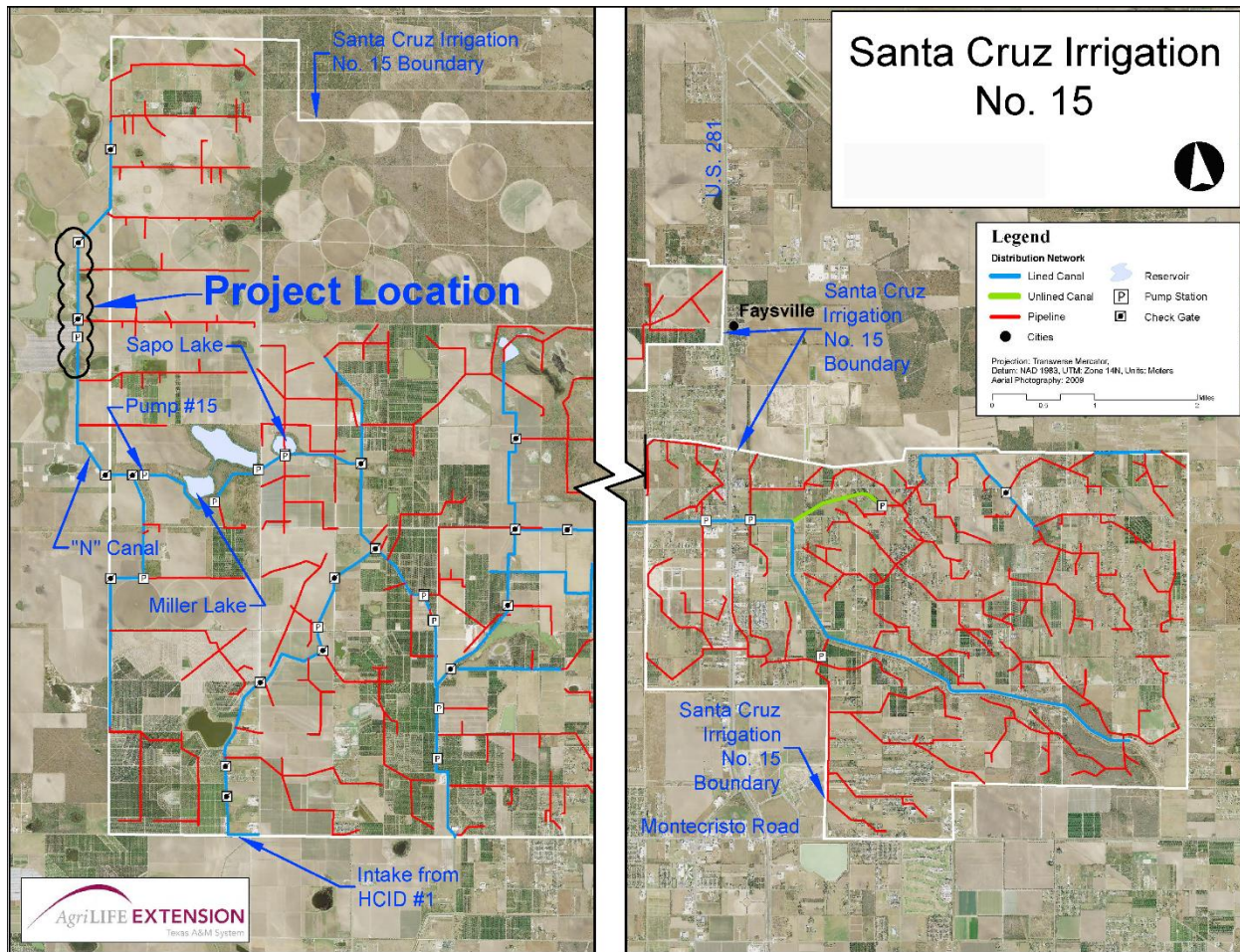


Figure 2 Project location.

Table 1 Water use and loss 2011-2015.

	Total metered at District #15 (Acre feet)	Total with losses charged by HCID #1 at 20% (Acre feet)	Municipal metered to North Alamo Water Supply Corporation (Acre feet)	Flood in District (estimated at 6" per acre) ^a (Acre feet)	Flood out of District (estimated at 6" per acre) ^a (Acre feet)
2011	49,353	61,691	2,721	13,690	194
2012	42,707	53,384	2,236	13,691	323
2013	38,360	47,950	2,169	9,403	80
2014	29,175	36,469	2,555	9,375	61
2015	19,255	24,069	2,379	2,879	0
Average	35,770	44,713	2,410	9,862	131

	Metered in District (Acre feet)	Metered out of District* (Acre feet)	Total Ag Water Delivered (Acre feet)	In District Losses (as a percentage of HCID #1 Meter) (Acre feet)		In District Plus HCID #1 Losses (as a percentage of amount diverted from Rio Grande) (Acre feet)	
2011	20,100	2,042	36,296	10,346	21%	22,684	37%
2012	18,802	1,680	34,496	5,976	14%	16,652	31%
2013	14,524	1,376	25,383	10,808	28%	20,398	43%
2014	10,549	720	20,705	5,915	20%	13,209	36%
2015	5,833	0	8,712	8,165	42%	12,979	54%
Average	13,962	1,164	25,118	8,242	25%	17,184	40%

^aOut of District delivered water after September 2014 not as easily identifiable by the more recent computer system. Actual out of District may be high, but Total AG Water Delivered is accurate.

The District has a contract with Hidalgo County Irrigation District No. 1 (HCID #1) to divert and deliver all of its water. The contract specifies a 20% loss is charged against the District's account for all water diverted. In other words, for each 1,000 acre feet diverted, only 800 acre feet is delivered and 200 acre feet is lost in the HCID #1 transmission system. The Santa Cruz system is old and has deteriorated such that losses within Santa Cruz average an additional 20% of the amount diverted from the Rio Grande (25% losses based on quantity delivered at the head of the Santa Cruz system).

A majority of the Santa Cruz system is open concrete lined canals over fairly permeable soils. Over time, the thin concrete lining has deteriorated, resulting in excessive seepage out of the canals. The N-Canal was identified as once of the most highly utilized canals with excessive seepage. The canal is also at grade in some areas resulting in high ground water levels that produce external hydraulic pressure on the thin concrete canal lining that exacerbates the cracking and subsequent seepage. The District developed a method to perform seepage testing on the canal and subsequently submitted an "Application to the Texas Water Development Board for an Agricultural Improvement Grant" (Application) which resulted in grant funding of \$200,000. Subsequently, the District was successful in obtaining funds from the US Bureau of Reclamation (BOR) for a WaterSMART grant that resulted in additional funding for the project funded by the Texas Water Development Board.

The BOR grant resulted in expansion of the project funded by the TWDB as they had goals in addition to conservation, including energy conservation and renewable energy. The portion funded by the TWDB is identified in this report as Phase I, also funded by BOR, and the expanded project, resulting from the BOR funding, is identified as Phase II. The Phase II project resulted in additional conservation, and may not have been possible without the TWDB grant, so its benefits are included herein.

3 Application Phase Seepage Testing

The District submitted an Application for funding in March of 2017. A requirement of the grant announcement was the ability to document and quantify the conservation that would result from the project. Santa Cruz accomplished this by performing seepage testing on the section of canal to be lined. To estimate the annual water losses, a controlled section of the canal was filled between the Check Gates near Pumps 14 & 15. The height of the water surface was then measured every 30 minutes, and using the cross sectional area of the canal and the length of the canal, the volume of water lost was computed. These results are presented in Attachments 3 & 4 of the Application. Figure 3 shows the test being performed. A bucket adjacent to the canal was used to measure the associated evaporation losses and account for them in the calculation of the canal seepage.



Figure 3 Seepage evaporation loss analysis.

The annual volume of water lost in the 8,700 linear feet stretch of canal was estimated to be 938 acre feet.

A 20% loss is charged by Hidalgo County Irrigation District No. 1 (HCID #1) to account for losses in their system to deliver water to Santa Cruz from the Rio Grande. There is not much Santa Cruz can do to reduce losses in the HCID #1 System. An additional 10% loss was estimated for the loss in the delivery through the Santa Cruz system to the N-Canal. After factoring the additional 30% loss due to HCID #1 delivery losses and Santa Cruz transmission losses, the total annual water loss was estimated to be 1,340 acre feet in the test section. For the Phase I project, the District could only afford to line and re-grade a 4,350 linear feet section of the N-Canal that was determined to be in the worst shape. By lining this section, an estimated annual average of 670 acre feet was expected to be conserved (linear feet of the test section).

An additional benefit of energy conservation was identified in the application, by not pumping the lost water was then calculated. Based on previous projects this firm has completed, a total wire to water energy efficiency of 50% is believed to be a reasonable estimate of the energy efficiency of the system. These calculations are presented in Attachment 6 of the Application. Based on these parameters, the average annual anticipated energy savings by the Phase I project is 96,000 kilowatt hours. The annual direct cost savings to the District as a result of the conservation is also presented in Attachment 6, at approximately \$26.70 per acre foot, was projected to be approximately \$17,866 per year.

4 Bureau of Reclamation WaterSMART Funding

Prior to execution of the TWDB Grant Agreement, the District applied for a BOR WaterSMART Grant; A Water and Energy Efficiency Grant for FY 2015 – Funding Group I. The District expanded the project to include additional shotcrete lining of the N-Canal as well as increased the scope of the project to meet BOR funding goals, including energy conservation and renewable energy. The N-Canal lining was increased to 7,265 linear feet to result in an annual conservation of 951 acre feet per year.

In order to meet funding objectives, the Phase II project also involved addition of a Variable Frequency Drive (VFD) at the Santa Cruz Pump Station No. 15, which significantly reduced recirculation at the station and related energy loss. The WaterSMART grant also included a renewable energy component that resulted in the addition of two solar powered pumps at Pump Station No. 15. The resulting energy conservation from the Phase I and II components was estimated to be 177,280 Kwh per year. The water conservation, as a result of the BOR grant, increased the overall conservation goal to 951 acre feet per year. The total amount of funding from the BOR was \$300,000, or 24% of the total estimated cost for Phases I and II of \$1,250,000 at the time of the grant application.

5 Design Phase

The Design Phase began by performing a topographic survey of the canals. The canal profile revealed that areas of greater fill during the original construction of the canal had experienced greater settlement over time resulting in low spots in the canal bank that frequently overflowed. Those areas were also poorly drained causing the inability to farm adjacent properties. One objective of the new shotcrete liner was to restore the original canal grade, determined to be 0.015%. The primary objective of the design was to place a new fiber reinforced shotcrete liner over the existing 1 to 2 inch thick, dilapidated concrete liner. Figures 4 and 5 are photographs of the old liner that was in very poor condition. A shotcrete thickness of 3" with fibermesh, and a top beam of 8" width and 6" depth, with 2 #4 rebar, is a good design to refurbish old shotcrete liner. The fibermesh greatly reduces shrinkage cracking and reduces permeability. The shotcrete process is abrasive and etches the old concrete surface to allow the new concrete to bond well to the existing surface. Where old shotcrete liner had to be removed or was missing, the thickness was doubled to 6" with welded wire reinforcing to replace the old liner. It was determined that where old liner was missing or severely corroded, the old reinforcing was resting on soil and had corroded such that it no longer had strength. The new shotcrete system relied on the old liner and reinforcing to provide strength and ballast against negative hydraulic pressures that would occur when the canal level was low and adjacent ground water levels were high. Where the new liner was missing, the thickness increased to 6" and new reinforcing provides the necessary strength.

Figures 6 and 7 are a Plan and Profile of the canal lining plans. The proposed top of liner restored the original grade of the canal to prevent overflows that occurred in the former canal. The conservation from the reduction in overflow could not be calculated, and was not claimed in the grant application or final reports, but is certainly significant. Figure 8 is a cross section detail of the proposed liner at Station 88+00, an area where the former canal overflowed, where grade was restored. Figure 9 is a cross section of proposed liner at Station 62+00, an area where the former bank was cut to allow for proper maintenance of the canal. Figures 10 & 11 are liner details that show how the new liner was to be installed, filling of voids, installation of welded wire, top beam details, etc. Figure 12 is a detail for the waterstop planned for phases I & II. This particular waterstop, to be installed over old expansion joint locations, allows for movement in the shotcrete system. The waterstop is designed for use with shotcrete as its thickness resists damage from the shotcrete application process.



Figure 4 Photograph of dilapidated liner.



Figure 5 Photograph of low bank area.

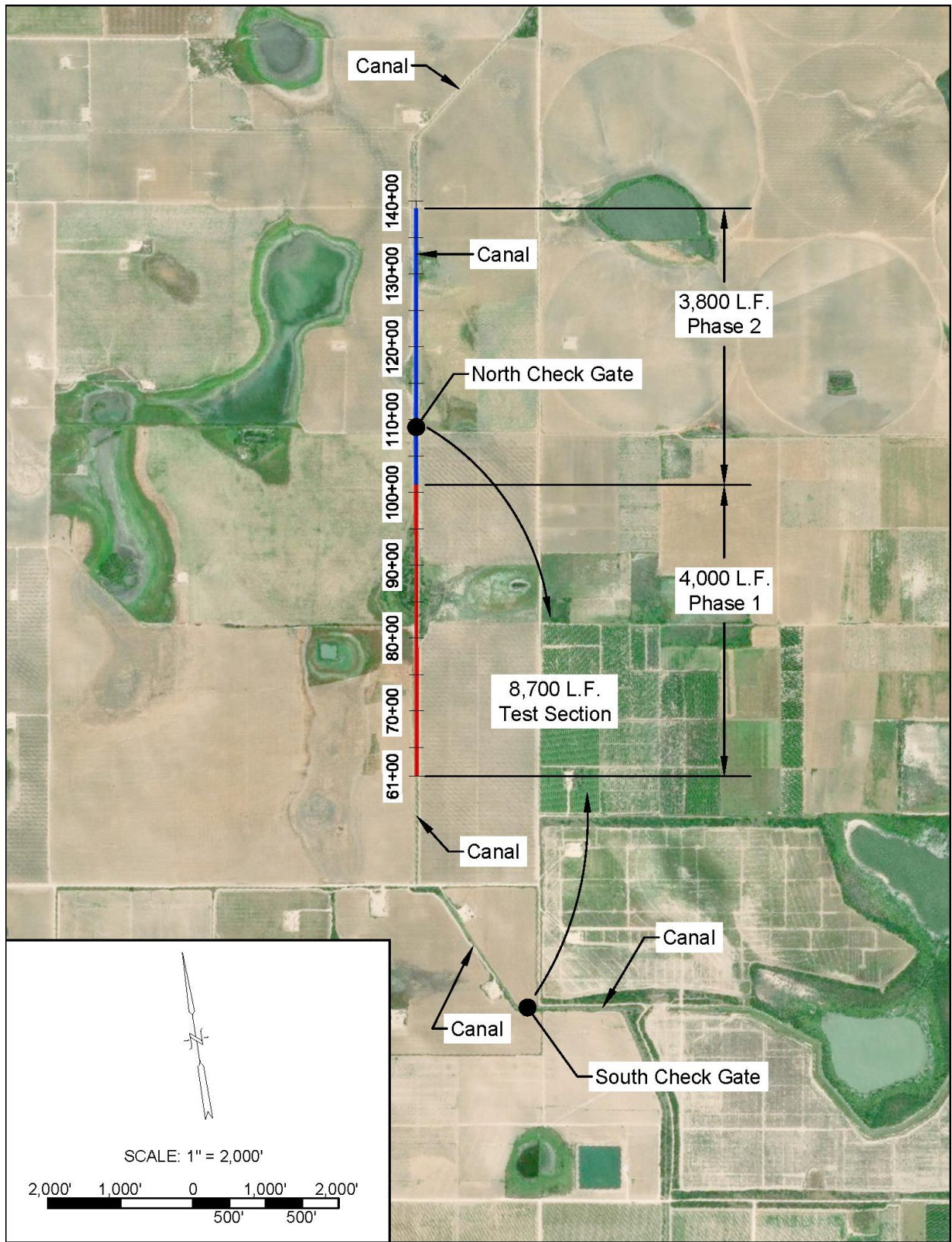


Figure 6 Lining Plan and Stations.

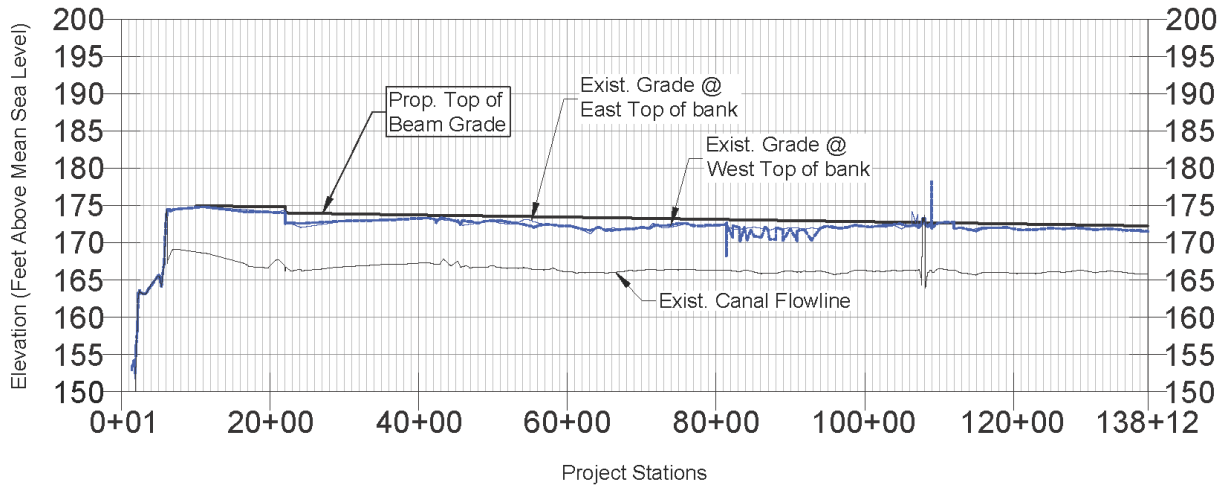


Figure 7 Lining Profile.

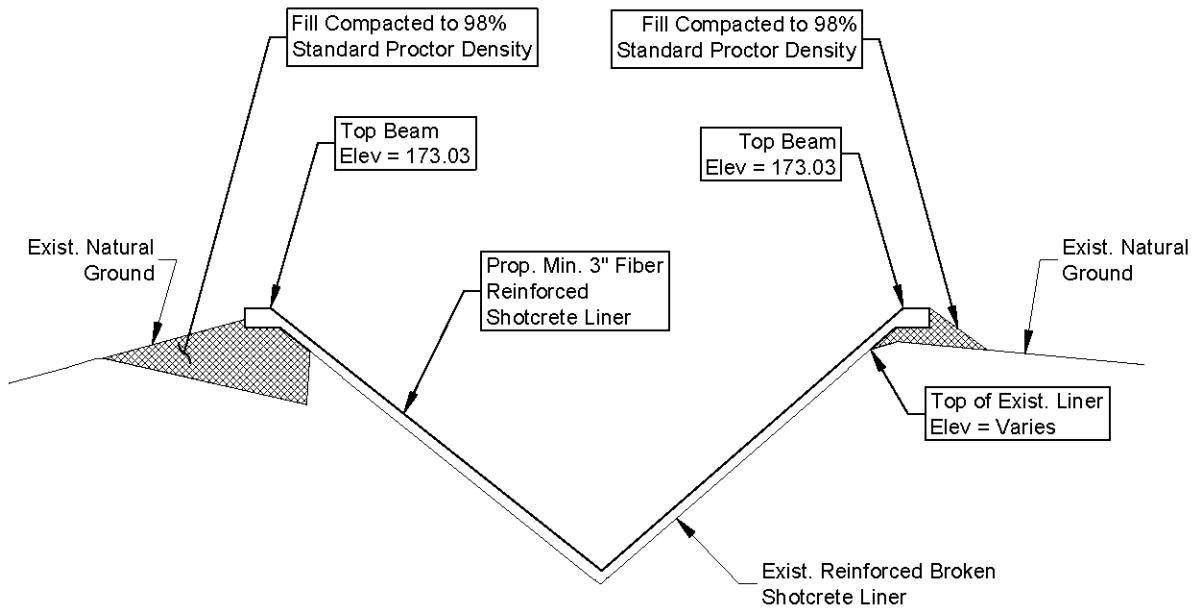


Figure 8 Cross Section at Station 88+00 – Fill

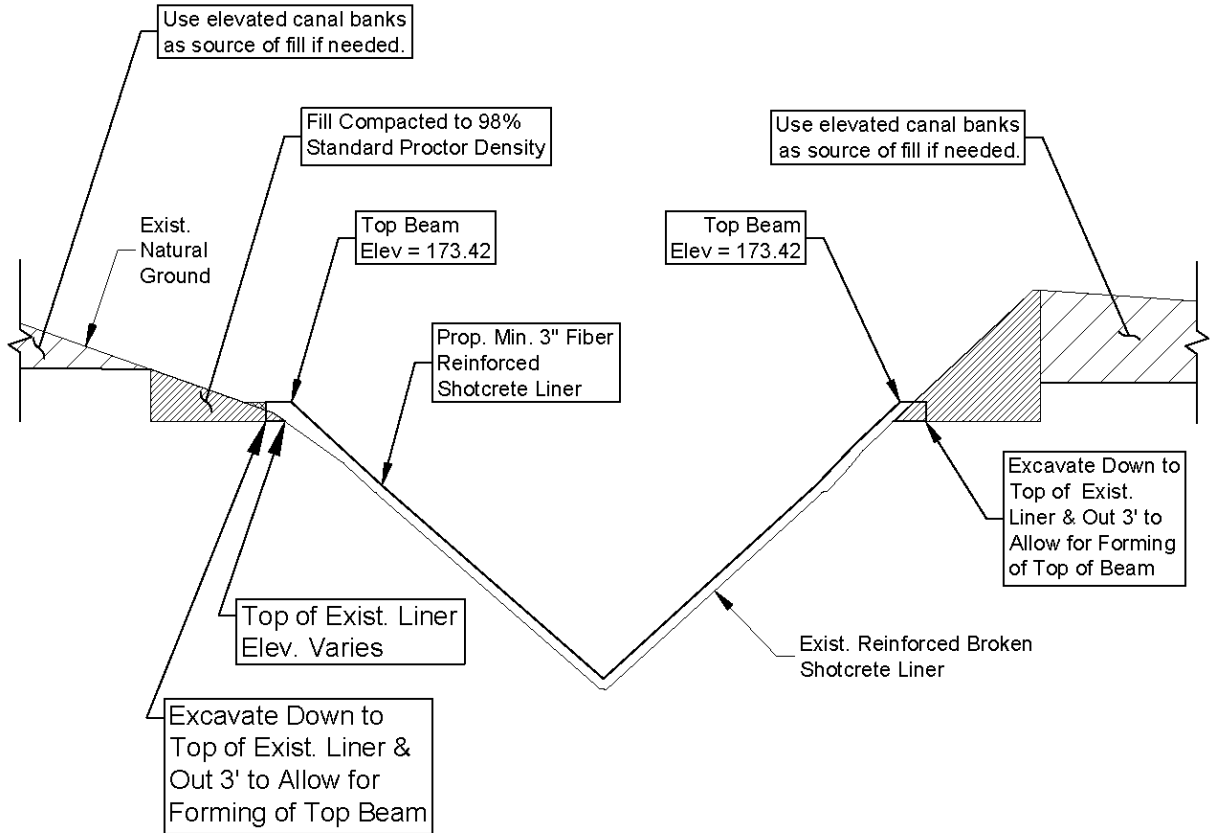


Figure 9 Cross Section at Station 62+00 – Cut

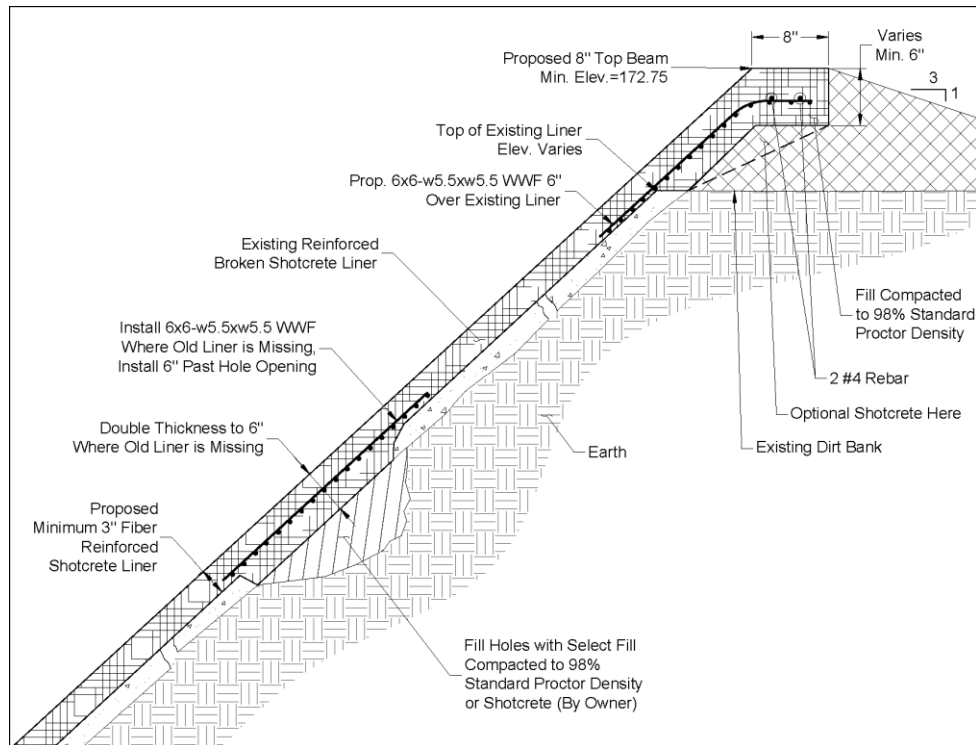


Figure 10 Liner Detail – Fill

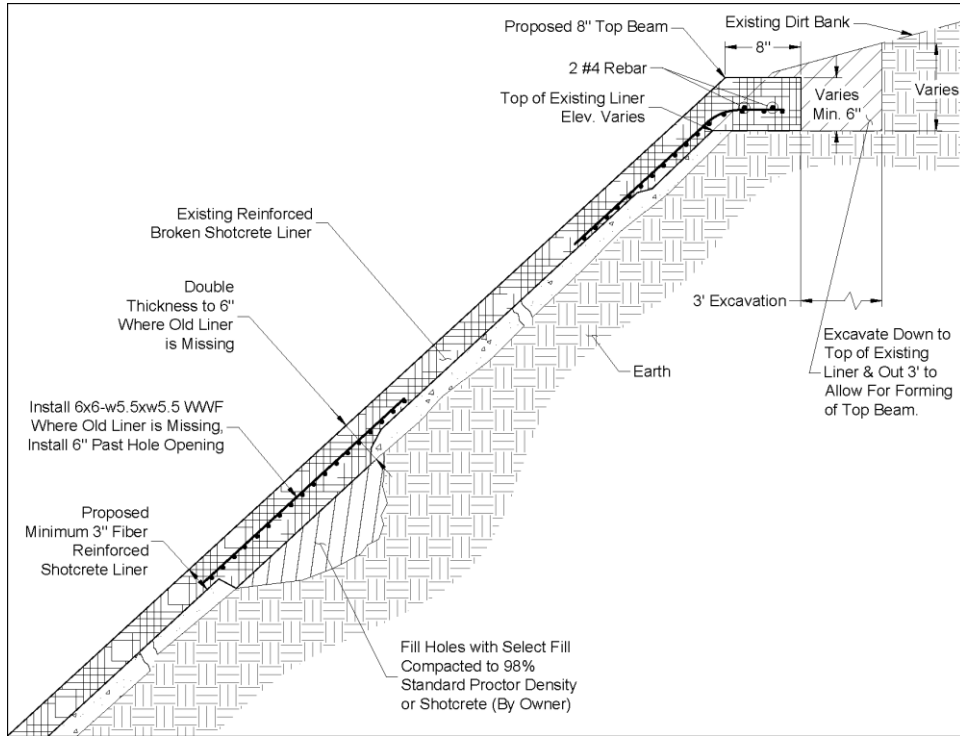


Figure 11 Liner Detail – Cut

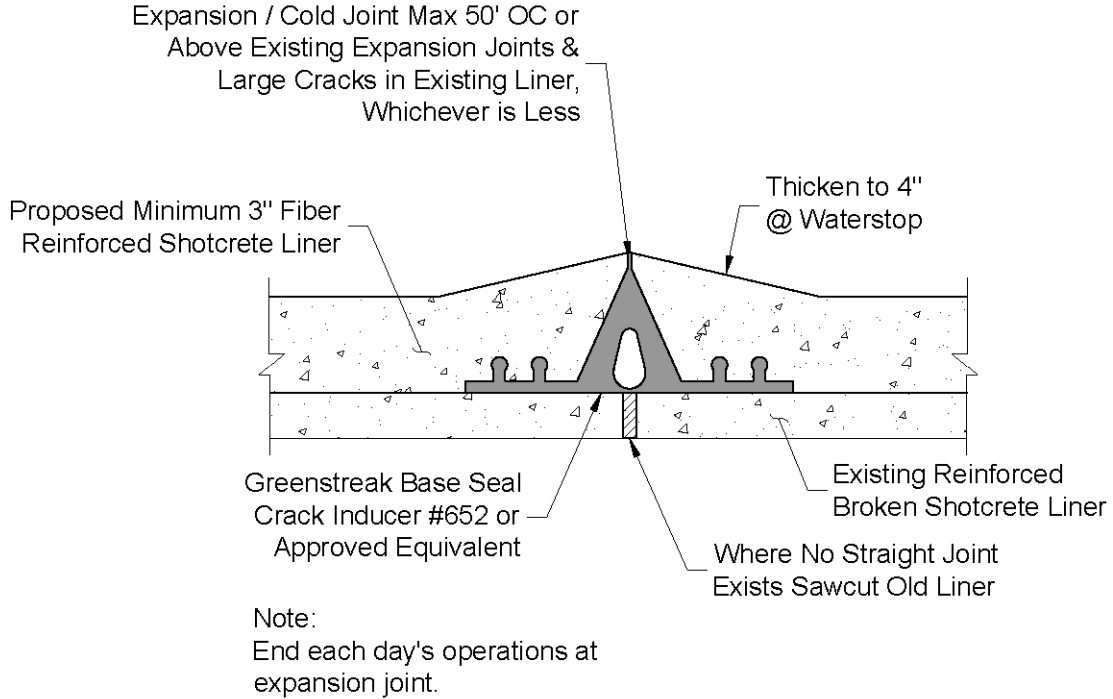


Figure 12 Expansion Joint Detail

The Construction Plans were approved by the Santa Cruz Irrigation No. 15 Board of Directors and the TWDB approved the Phase I shotcrete lining prior to bidding the project. Phase II shotcrete lining, funded only by the BOR and the District, was designed like Phase I with respect to the shotcrete lining. There were no significant design changes.

Both phases of the project were advertised and bid in accordance with Texas Water Code and Texas Local Government Code requirements.

6 Construction Phase

The construction of the shotcrete liner was difficult to schedule. The N-Canal is heavily utilized, all year long, as there is intense farming of fruit, vegetables and citrus requiring irrigation out of the section to be lined. Many of the crops were irrigated with drip irrigation and chemicals were applied through drip, even during wet periods. The best windows to shotcrete were late summer, when it was too hot for all crops, and winter. The District would shut down the canal and perform the bulk cleaning of the canal, dirt and mud removal and the general contractor performed final cleaning and shotcrete. The Phase I project, about 4,000 liner feet, took three shutdowns to complete. The actual days of construction for the liner were not that long, but scheduling the work took about a year for each phase. Phase I, 4,000 linear feet, was complete in about one year. Substantial completion occurred by the end of 2015, allowing for conservation calculation for the year 2016, presented in Section 8 of this report.

Phase I Construction Contract was awarded to Foremost Paving, Inc., for a final Contract Amount of \$620,552.07. Foremost Paving, Inc., was the most experienced contractor for this type of work in South Texas. Photographs of the Phase I construction progress to follow. Figure 13 shows a section of the N-Canal being prepared for shotcrete liner. Note that the left side is bare dirt, where the former liner was deteriorated beyond repair, and removed. Figure 14 is a photograph of the Contractor placing new shotcrete liner over the existing prepared liner. This Contractor used a shotcrete spray end mounted on an excavator. The thickness of the new shotcrete was checked to verify the specified minimum thickness of 3" as shown in Figure 15. One section of the new shotcrete cracked, so a section was removed by saw cutting the area that cracked to verify thickness. Figure 16 is a photograph of the removed section. The new shotcrete thickness at the sample location was 3 3/4" thick, while the old liner was just over 1" thick. The horizontal crack was determined to be caused by voids below the old concrete liner and settlement of the bottom linear feet of the new liner. The crack was limited in length and repaired by the general contractor before release of final payment. The longest canal shutdown window when the general contractor could work was about two – three weeks. Part of that time was needed to dewater and clean the canal. Figure 17 displays a period when the canal had to be placed back into service to satisfy irrigation demands during the construction period. As long as the shotcrete had set, under water curing of shotcrete is ideal. Figure 18 is the completed Phase I canal as viewed from the north end.



Figure 13 Preparation of Phase I Canal for shotcrete.



Figure 14 Phase I shotcrete application.



Figure 15 Shotcrete thickness gauge.



Figure 16 Shotcrete sample.



Figure 17 Intermittent canal use.



Figure 18 Completed Phase I Canal.

Phase II included the shotcrete lining of an additional 3,800 linear feet of shotcrete lining. This section was not funded by the TWDB, but Santa Cruz likely would not have been able to construct Phase II without the initial TWDB grant for Phase I, so it is included in this final report. Phase II was completed by the end of 2017, so the associated additional conservation is included in the 2018 conservation estimate. Figure 19 is a photograph of a section of the Phase II canal prepared for shotcrete lining. The Phase II Contract was awarded to Southern Trenchless. The general contractor used different application equipment, but did an excellent job. Figure 20 is Southern Trenchless applying shotcrete to the Phase II canal. Figure 21 is the complete Phase II canal from the north end.



Figure 19 Phase II Canal prepared for lining.



Figure 20 Southern Trenchless applying shotcrete.



Figure 21 Completed Phase II Canal.

7 Post Construction Seepage Testing

Shortly after the final completion of Phase I, seepage testing was performed on completed sections of the canal. The test method, data and conservation calculation are provided in the “Report on Post Lining Seepage Test for Lining of the N-Canal.” A summary of that report is provided here. During the application phase, testing was performed on an 8,700 linear foot section of the canal between two check gates. Figure 6 shows the test section. It was determined that the 8,700 linear foot test section seeped at a rate of 938 acre feet per year. The post lining test, after 4,000 linear feet were lined, revealed a seepage rate of 243 acre feet per year. The lining of 4,000 linear feet reduced the seepage by 695 acre feet per year. The seepage was reduced by more than linear feet, even though less than linear feet of the canal was lined, because the worst, most dilapidated part of the test section was lined. The seepage test method is quite simple, the canal is filled and the change in water level and evaporation are monitored, both at several location along the canal. The change in level overtime adjusted for evaporation, multiplied by the water level surface area, results in a seepage rate.

8 Conservation Results

The net change in seepage rate of the test section, 695 acre feet per year was converted to a net total annual conservation by considering the number of days per year the canal operates and adding the transmission losses to deliver the water to the location of the N-Canal. The canal operates about 310 days out of the year, so multiplying 695 by the ratio of 310 days to 365 days per year yields annual seepage at the N-Canal of 590 acre feet per year.

HCID #1 charges a 20% loss to the Santa Cruz delivery point, and Santa Cruz has an estimated 10% loss in transmission from the HCID #1 delivery point to the N-Canal, so a total 30% loss is included in the total annual conservation, resulting from the Phase I lining of the N-Canal, of 843 acre feet.

The appendix includes water conservation reporting for the years 2016 and 2017. The appendix also includes Watermaster year end statements for the District’s irrigation Certificate of Adjudication statement that identifies annual diversion at the Rio Grande in box labeled “AWR Ytd”. The acronym is an abbreviation for Authorized Water Right (charged) year to date. Also included in the appendix is the year end statement for 2018. For the year end 2018, additional conservation resulting from the completion of Phase II is also included from the “Final Report – RP15AP00127, WaterSMART: Water and Efficiency Grants for 2015 – Funding Group I, Santa Cruz Irrigation District No. 15, Shotcrete Lining of the N-Canal,” (BOR Final Report). The total conservation resulting from Phases I & II is 1,289 acre feet per year.

Table 2 presents the conservation results. Phase I resulted in conservation of 2% of Santa Cruz diversions, while phase II increased the conservation to just over 3%.

Table 2 Conservation results.

N-Canal phases completed	Year and Volume (acre feet)		
	2016 I	2017 I	2018 I & II
Total diversion	39,778	43,770	37,193
Amount conserved by TWDB project	843	843	1,289
Annual diversion without project	40,621	44,613	38,482
Percent conserved	2.1%	1.9%	3.3%

9 Project Cost

Initially, Santa Cruz had developed a project to line the N-Canal, about linear feet of the Test Section, described in this report as Phase I, funded by the TWDB. The District was successful in obtaining a grant from the BOR, under the WaterSMART program for Phase I, which expanded the scope to include lining of the N-Canal to Phase II and energy conservation at Pump No. 15.

Table 3 provides a total project cost for each phase of the project as well as the source of funds. The cost includes all project related costs through the end of the BOR Final Report, more or less the end of 2017. Costs include construction, surveying, engineering, testing and reporting. The District elected to spend more than costs identified in the grant applications, but conservation was higher than application goals. In general, the TWDB funds 30% of the Phase I canal, lining while the BOR funded 21%. For the overall project, the TWDB funding amounts to 14%, while the BOR share was 21%.

Table 3 Project cost and funding.

	TWDB funding	BOR funding	District funding	Total	Percentage of total
Phase I canal lining	\$200,000	\$140,964	\$328,935	\$669,899	46.99%
	29.86%	21.04%	49.10%	100.00%	
Phase II canal lining		\$113,878	\$427,299	\$547,177	37.96%
Subtotal N-Canal	\$200,000	\$254,842	\$756,233	\$1,211,076	84.95%
	16.51%	21.04%	62.44%	100.00%	
Energy conservation work for WaterSMART grants		\$45,158	\$169,444	\$214,601	15.05%
Total project	\$200,000	\$300,000	\$925,677	\$1,425,677	100.00%
	14.03%	21.04%	64.93%	100.00%	

10 Economic Analysis of Conservation

Table 4 presents an economic analysis of the cost of the project as it relates to conservation. Phase I includes the cost and conservation associated with lining the first 4,000 linear feet of the N-Canal. The capital cost per acre foot conserved is \$795 per acre foot. Since the market value of an irrigation right is about \$1,500 per acre foot, considering capital cost alone, the project is feasible. From the final BOR report, the energy conservation associated with not pumping the conserved water is about \$17,243 per year, based on a long term energy cost of \$0.13 per kilowatt hour. This energy cost includes cost of energy transmission, demand charges, etc. Capitalizing the annual energy cost savings for a term of 50 years at 2% results in a capitalized energy cost savings of \$541,851.

Table 4 Economic analysis of conservation.

	Phase I N-Canal lining	Phases I & II N-Canal lining and energy improvements
Project cost	\$669,899	\$1,425,677
Annual conservation (acre feet)	843	1,289
Cost per acre foot conserved	\$795	\$1,106
Annual energy conservation not pumping conserved water (kilowatt hours per year)	132,640	184,613
Annual energy conservation from energy improvements (kilowatt hours per year)		\$43,642
Annual energy cost savings at a long term energy cost of \$0.13 per kilowatt hour	\$17,243	\$29,673
Capitalized value of energy savings assuming 2% interest rate for a term of 50 years	(\$541,845)	(\$932,437)
Net project capital cost considering capitalized energy savings	\$128,054	\$493,240
Net capital cost per acre foot conserved	\$161	\$446
Estimated market value of irrigation water rights per acre foot.	\$1,500	\$1,500
Annualized net capital cost per acre foot conserved assuming 2% interest for a 50 year life	\$5.13	\$14.19
Estimated market value of irrigation water (spot market) per acre foot	\$30	\$30

After deducting capitalized energy cost savings, the net capital cost per acre foot conserved is only \$161, much less than the current market capital value of a Lower Rio Grande irrigation water right per acre foot of \$1,500. The values in this report, utilized for the economic analysis, were based on the experiences of the writer, who has 34 years of experience working with water districts and water utilities in South Texas. If the net capital cost per acre foot is annualized at 2% interest for a term of 50 years, the annual cost per acre foot is \$5.13 acre foot per year. The average spot market cost per acre foot of irrigation water is about \$30 per acre foot, so the project expenditures were well spent.

The second column of the Table 4 analyzes the total project cost, including phases I and II lining of the N-Canal, and the energy conservation improvements funded by the BOR. The BOR contribution to the project would not have been possible without the energy conservation improvements, so those costs are included, as well as, a consideration of the power cost savings. The project capital cost per acre foot conserved amounts to \$1,106 per acre foot, still less than the market value of a water right, feasible. After capitalizing energy cost savings, the net capital cost per acre foot conserved is \$446 per acre foot, very feasible. The annualized net cost per acre foot, at an interest rate of 2% and a term of 50 years is \$14.19 per acre foot, much less than the market rate for water of \$30.00 per acre foot.

11 Conclusion

The Santa Cruz Irrigation No. 15 conserved an annual average of 843 acre feet per year by lining 4,000 linear feet of the N-Canal, funded by a \$200,000 grant from the Texas Water Development Board. After considering energy cost savings, the net capital cost per acre foot of this portion of the project was \$161 per acre foot, much less than the current market rate of \$1,500 per acre foot of Rio Grande irrigation water rights. Santa Cruz was able to expand the project through a \$300,000 grant provided by the Bureau of Reclamation under their WaterSMART program, which increased the lining of the N-Canal such that total annual conservation averaged 1,289 acre feet per year. The Bureau of Reclamation project included the energy conservation improvements that resulted in a net capital cost per acre foot of \$446 per acre foot, also very economical when compared to the capital value of an irrigation water right. There were additional benefits to the project such as, less subsurface water in fields adjacent to the N-Canal, improving crop yields.

12 Acknowledgements

The District personnel were quite instrumental in acquiring the information to compile the water use information. In addition, they performed much of the canal cleaning work. The District farmers supplied by the N-Canal were helpful in scheduling the shutdowns necessary to complete the work. The District Board of Directors and General Manager had the foresight to support this project, which placed a temporary strain on cash flow, but ultimately proved to be a very worthwhile endeavor.

13 References

- Ferris, F.A., 2014, Application to the Texas Water Development Board for an Agricultural Irrigation System Improvement Grant.
- Ferris, F.A., 2016, Report on Post Lining Seepage Test for Lining of the N-Canal.
- Ferris, F.A., 2017, Final Report-RP15AP00127, WaterSMART: Water and Energy Efficiency Grants for FY 2015-Funding Group I, Santa Cruz Irrigation District No. 15 Shotcrete Lining of the N-Canal, Installation of a Variable Frequency Drive at Pump 15, Solar Powered Alternative at Pump 15.

14 Appendix

FERRIS, FLINN & MEDINA, LLC

E N G I N E E R S S U R V E Y O R S

August 28, 2017

524-002

Cameron G. Turner
Team Leader – Agricultural Water Conservation
Conservation & Innovative Water Technologies
Texas Water Development Board
cameron.turner@twdb.texas.gov

Re: SCID No. 15, Contract No. 1413581739
Water Savings for 2016 and Total District Usage

Dear Mr. Turner,

The District conducted seepage tests before and after the Shotcrete Lining of the N-Canal. The calculated conservation, based on the performed seepage testing, as outlined in the "Report on Post Lining Seepage Tests for Lining the N-Canal," is 843 acre feet (AcFt) for 2016, including transmission losses. The project was completed near the end of 2015. Attached is the District's 2016 Year End Statement for its Certificate of Adjudication No. A804-000, which provides a total diversion at the river for 2016 of 39,778.29 AcFt. Without funding from the Texas Water Development Board, the District would have diverted an additional 843 acre feet or 2.1%.

Total 2016 Diversion	39,778 AcFt
Amount Conserved by TWDB Project	843 AcFt
2016 Diversion without Project	40,621 AcFt
Percent Conserved	2.1%

Please let me know if you need additional information.

Respectfully,
SCID No. 15 District Engineer
FERRIS, FLINN & MEDINA, LLC



Frank A. Ferris, PE
President

cc: Jose Hinojosa

1405 North Stuart Place Road • Palm Valley, Texas 78552 • (956) 364-2236 • Fax (956) 364-1023
TBPE Firm Reg. No. F-897 • TBPLS Firm Reg. No. 100-370-00 • www.ferrisandflinn.com

Texas Water Development Board Report #1413581739

01/17/2017

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY
RIO GRANDE WATER DIVISION - LOWER
MONTHLY REPORT STATEMENT
FOR THE PERIOD OF 11/27/2016 - 12/31/2016

10:00 AM

Adjudication Certificate: A804-000

Authorized Water Right: 75,080.0000

Owner name: SANTA CRUZ I.D. #15

Storage Limit: 105,862.8000

Diverter name: SANTA CRUZ I.D. #15

Use Type: IRR

SANTA CRUZ I.D. #15
PO BOX 599
EDINBURG TX 78540-0599

Previous Month Summary	
UB: 37,914.1300	YTD: 37,165.8700
CB: 0.0000	YTD: 215.0000
SB: 92,404.3648	NC YTD: 0.0000
SOLD: 0.0000	

**TOTAL ANNUAL
DIVERSION - 2016**

New Balances

	Useable	Storage	Contract	AWR Ytd	NC Ytd	Sold Ytd	Contract Ytd
	35,301.7100	94,044.5115	0.0000	39,778.2900	0.0000	0.0000	215.0000

Transactions

Code	Useable	Storage	Contract	AWR Wtr	NC Wtr	Sold Wtr	Contract Wtr
ADJUST	175.1400	175.1400	0.0000	-175.1400	0.0000	0.0000	0.0000
ALLOC	0.0000	4,252.5667	0.0000	0.0000	0.0000	0.0000	0.0000
DIVERT	-2,787.5600	-2,787.5600	0.0000	2,787.5600	0.0000	0.0000	0.0000
Totals:	-2,612.4200	1,640.1467	0.0000	2,612.4200	0.0000	0.0000	0.0000

Falcon and Amistad Reservoir Information

In Falcon and Amistad Reservoirs (63.67%)	2,159,731.0000 AF
Dead Storage	4,600.0000 AF
Reserved for Municipal / Domestic /Industrial	225,000.0000 AF
Reserved for Lower Rio Grande	1,519,352.8853 AF
Allocation for Lower Rio Grande	72,577.5139 AF
Reserved for Middle Rio Grande	245,010.2479 AF
Allocation for Middle Rio Grande	2,204.0834 AF
Reserved for Operational Uses	75,000.0000 AF
Unallocated Water	15,986.2695 AF

Comments

ALLOCATION RATES: Class A = 0.056640473 * * * Class B = 0.033317925

Rio Grande WAC Meeting on January 31, 2017 @ 1:30 PM at the TCEQ Harlingen Regional Office. Conference call is available - Toll Free Access Number: 1-877-820-7831 then Enter Participant Pass Code: 207085 #

January 16th is a State Holiday - the office will be closed.
The next monthly report period ends on January 28, 2017.

Jose G. Luna - Rio Grande Watermaster

FERRIS, FLINN & MEDINA, LLC

E N G I N E E R S S U R V E Y O R S

June 1, 2018

524-002

Cameron G. Turner
Team Leader – Agricultural Water Conservation
Conservation & Innovative Water Technologies
Texas Water Development Board
cameron.turner@twdb.texas.gov

Re: SCID No. 15, Contract No. 1413581739
Water Savings for 2017 and Total District Usage

Dear Mr. Turner,

The District conducted seepage tests before and after the Shotcrete Lining of the N-Canal. The calculated conservation, based on the performed seepage testing, as outlined in the "Report on Post Lining Seepage Tests for Lining the N-Canal," is 843 acre feet (AcFt) for 2017, including transmission losses. The project was completed near the end of 2015. Attached is the District's 2017 Year End Statement for its Certificate of Adjudication No. A804-000, which provides a total diversion at the river for 2017 of 43,770 AcFt. Without funding from the Texas Water Development Board, the District would have diverted an additional 843 acre feet or 1.9%.

Total 2016 Diversion	43,770 AcFt
Amount Conserved by TWDB Project	843 AcFt
2016 Diversion without Project	44,613 AcFt
Percent Conserved	1.9%

Please let me know if you need additional information.

Respectfully,
SCID No. 15 District Engineer
FERRIS, FLINN & MEDINA, LLC


Frank A. Ferris, PE
President

cc: Jose Hinojosa

Texas Water Development Board Report #1413581739

01/12/2018

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY
RIO GRANDE WATER DIVISION - LOWER
MONTHLY REPORT STATEMENT
FOR THE PERIOD OF 11/26/2017 - 12/30/2017

10:00 AM

Adjudication Certificate: A804-000

Authorized Water Right: 74,872.9800

Owner name: SANTA CRUZ I.D. #15

Storage Limit: 105,570.9018

Diverter name: SANTA CRUZ I.D. #15

Use Type: IRR

SANTA CRUZ I.D. #15
PO BOX 599
EDINBURG TX 78540-0599

Previous Month Summary	
UB: 32,178.4660	YTD: 42,694.5140
CB: 0.0000	YTD: 809.0000
SB: 103,335.9811	NC YTD: 0.0000
SOLD: 0.0000	

2017 Annual
Water Use

New Balances

	Useable	Storage	Contract	AWR Ytd	NC Ytd	Sold Ytd	Cntret Ytd
	31,103.0370	105,570.9018	0.0000	43,769.9430	0.0000	0.0000	809.0000

Transactions

Code	Useable	Storage	Contract	AWR Wtr	NC Wtr	Sold Wtr	Cntret Wtr
ADJUST	231.8810	231.8810	0.0000	-231.8810	0.0000	0.0000	0.0000
ALLOC	0.0000	3,310.3497	0.0000	0.0000	0.0000	0.0000	0.0000
DIVERT	-1,307.3100	-1,307.3100	0.0000	1,307.3100	0.0000	0.0000	0.0000
Totals:	-1,075.4290	2,234.9207	0.0000	1,075.4290	0.0000	0.0000	0.0000

Falcon and Amistad Reservoir Information

In Falcon and Amistad Reservoirs (66.18%)	2,244,856.0000 AF
Dead Storage	4,600.0000 AF
Reserved for Municipal / Domestic /Industrial	225,000.0000 AF
Reserved for Lower Rio Grande	1,585,597.9072 AF
Allocation for Lower Rio Grande	78,156.2673 AF
Reserved for Middle Rio Grande	249,763.8237 AF
Allocation for Middle Rio Grande	1,252.9910 AF
Reserved for Operational Uses	75,000.0000 AF
Unallocated Water	25,485.0107 AF

Comments

ALLOCATION RATES: Class A = 0.066048222 * * * Class B = 0.038851895

Rio Grande WAC Meeting on Tuesday, February 6, 2018 @ 1:30 PM at the TCEQ Harlingen Regional Office. Conference call is available - Toll Free Access Number: 1-844-368-7161 then Enter Participant Pass Code: 176075 #
January 15th is a State Holiday. The office will be closed.
The next monthly report period ends on January 27, 2018.

Jose G. Luna
Rio Grande Watermaster

Texas Water Development Board Report #1413581739

01/16/2019

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY
RIO GRANDE WATER DIVISION - LOWER
MONTHLY REPORT STATEMENT
FOR THE PERIOD OF 11/25/2018 - 12/29/2018

10:00 AM

Adjudication Certificate: A804-000

Authorized Water Right: 74,872.9800

Owner name: SANTA CRUZ I.D. #15

Storage Limit: 105,570.9018

Diverter name: SANTA CRUZ I.D. #15

Use Type: IRR

SANTA CRUZ I.D. #15
PO BOX 599
EDINBURG TX 78540-0599

Previous Month Summary
UB: 39,266.0682 YTD: 35,606.9118
CB: 0.0000 YTD: 300.0000
SB: 105,570.9018 NC YTD: 0.0000
SOLD: 0.0000

New Balances

TOTAL ANNUAL DIVERSION - 2018

	Useable	Storage	Contract	AWR Ytd	NC Ytd	Sold Ytd	Contract Ytd
	37,679.7482	105,570.9018	0.0000	37,193.2318	0.0000	0.0000	300.0000

Transactions

Code	Useable	Storage	Contract	AWR Wtr	NC Wtr	Sold Wtr	Contract Wtr
ADJUST	230.8700	230.8700	0.0000	-230.8700	0.0000	0.0000	0.0000
ALLOC	0.0000	1,586.3200	0.0000	0.0000	0.0000	0.0000	0.0000
DIVERT	-1,817.1900	-1,817.1900	0.0000	1,817.1900	0.0000	0.0000	0.0000
Totals:	-1,586.3200	0.0000	0.0000	1,586.3200	0.0000	0.0000	0.0000

Falcon and Amistad Reservoir Information

In Falcon and Amistad Reservoirs (63.67%)	2,159,731.0000 AF
Dead Storage	4,600.0000 AF
Reserved for Municipal / Domestic /Industrial	225,000.0000 AF
Reserved for Lower Rio Grande	1,487,322.8622 AF
Allocation for Lower Rio Grande	95,719.9258 AF
Reserved for Middle Rio Grande	229,256.3056 AF
Allocation for Middle Rio Grande	12,773.0672 AF
Reserved for Operational Uses	75,000.0000 AF
Unallocated Water	30,058.8392 AF

Comments

ALLOCATION RATES: Class A = 0.085660019 * * * Class B = 0.050388246

***** PRACTICE WATER CONSERVATION *****

Pay assessments fees promptly. Delinquent accounts are not authorized to divert water.

Pump Operation Reports are due within 5 days after the end of the certification period. Please submit reports promptly.

January 21st is a State Holiday. The office will be closed.
The next monthly report period ends on January 26, 2019.

Jose G. Luna - Rio Grande Watermaster