

RECLAMATION

Managing Water in the West

Hydraulic Laboratory Technical Memorandum PAP-1068

Preliminary Water Savings Verification Results for Florida Farmers Ditch Company Canal Lining Project

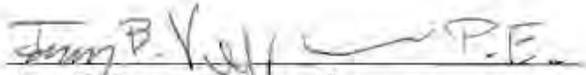


U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Hydraulic Investigations and Laboratory Services Group
Denver, Colorado

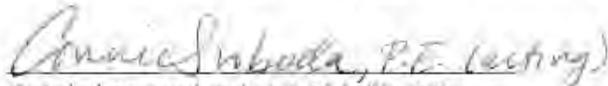
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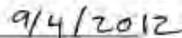
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Background

The Florida Farmers Ditch Company (FFDC) received a Reclamation WaterSmart Water and Energy Efficiency Grant in 2011 (WEEG-11-141) for funding of a canal lining project. This project was identified by Reclamation's Technical Service Center (TSC) staff as a good candidate for a water savings verification effort. The TSC has coordinated with the project Grant Officer's Technical Representative in Reclamation's Western Colorado Southern Division Area Office in Durango, Colorado and also worked with FFDC and its consultant in planning for the water savings verification activities.

Canal Lining Description

The project includes installation of shotcrete, PVC and geotextile lining, underdrains and earthwork within approximately 1.8 mile upper section of the Florida Farmers Ditch. The associated water savings estimate of 2,300 AFY is based on 2009 inflow/outflow measurements reported by Wright Water Engineers, Inc. (WWE, Florida Mesa Ditch Loss Study, October 2010). Figure 1 from this report shows the three sections of the Florida Farmers Ditch where measurements were taken (Reaches G, H and I). The section to be lined extends approximately 1.8 miles downstream from the canal's diversion point on the Florida River, including all of Reach G and approximately the upper 0.3 miles of Reach H. The current schedule for construction of the canal lining project will begin at the end of the irrigation season in September 2012.

Evaluation Plan

The plan for water savings verification consists of pre- and post-project inflow/outflow measurements to estimate pre- and post-lining seepage from the to-be-lined Florida Farmers Ditch section. Two sets of measurements were to be taken (early and late season) using two or more types of acoustic Doppler current profiler devices. Proposed measurement locations are near the canal's diversion point and liner terminus (designated as Reach G by WWE), and at operational turnouts within the to-be-lined section.

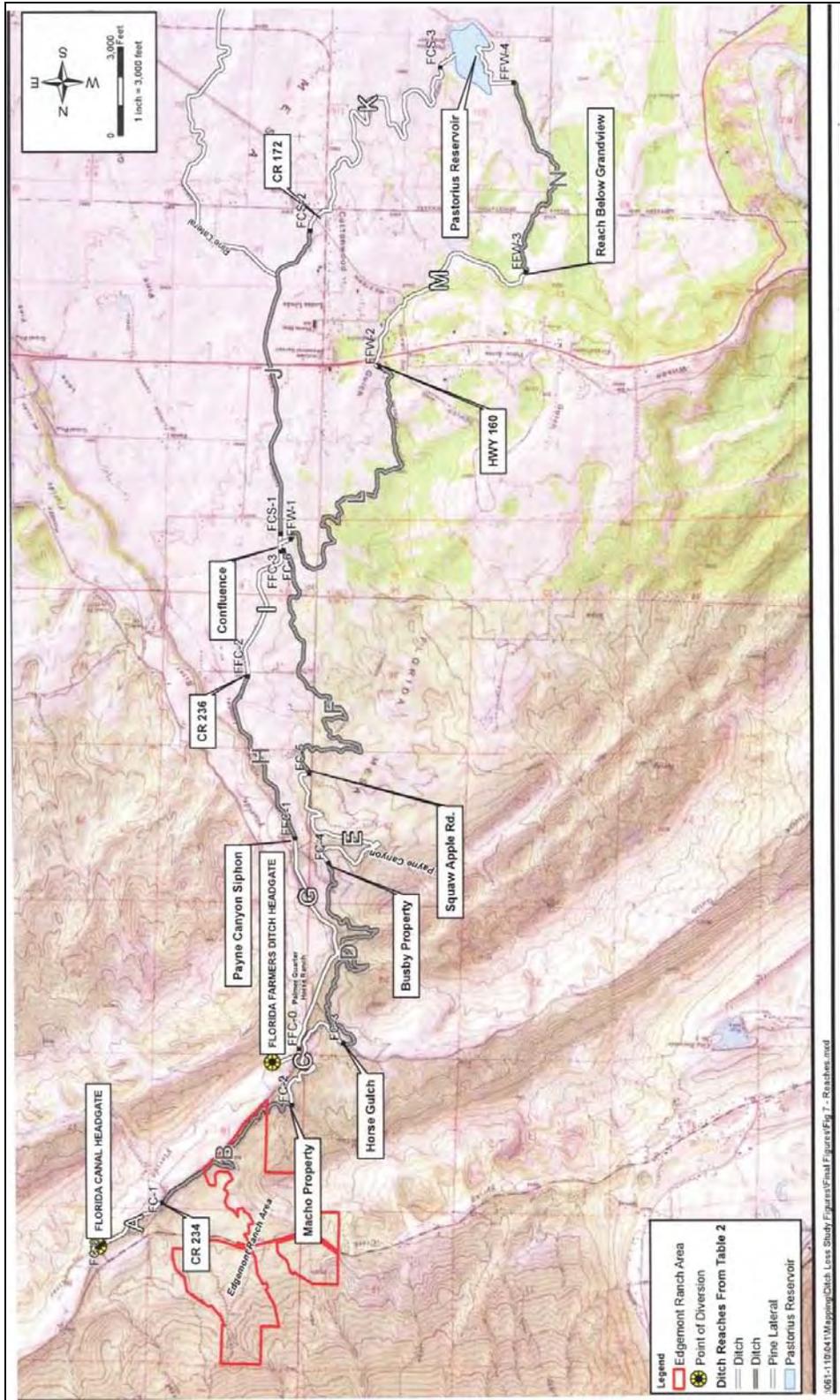


Figure 1. Map of Florida Farmers Ditch and key project locations (WWE 2009)

Following each measurement TSC will analyze the data, summarize the results, and provide this information to FFDC for review and feedback. Any revisions to the data analysis and/or adjustments to procedures will be mutually agreed to by TSC and FFDC. All findings will be summarized by TSC and reviewed by FFDC before submission to Reclamation's Policy and Administration Office.

Pre-Project Measurements on May 29, 2012

On May 29, 2012, Tracy Vermeyen, Hydraulic Engineer, TSC Hydraulic Investigations and Laboratory Services Group, traveled to the Florida Farmers project to perform discharge measurements at the start and end of the canal lining project. Mr. Charlie McCoy, Ditch Rider, met Mr. Vermeyen in Durango and escorted him to the measurement sites. They were joined by Ms. Bridget Nash, Water Resources Engineer, from Wright Water Engineers.

The first flow measurement location was at the downstream end of the canal lining project, located just upstream from the Payne Canyon Siphon (Figure 2). This site was located about 180 feet upstream from the siphon entrance and 300 feet downstream from the nearest bend in the canal alignment. The site was free of aquatic vegetation and the cross section was relatively uniform with a mean depth of about 3.2 feet. A moving-bed test did not detect any bed sediment transport which could compromise the discharge measurements. Flows were measured with a portable Teledyne/RD Instruments Streampro acoustic Doppler current profiler (Figure 2). A total of 12 Streampro discharge measurement transects (passes across the channel) were made and the results are summarized in Table 1. The average flow was 172.9 cubic feet per second (cfs) with a standard deviation of ± 4.2 cfs. The range of discharge measurements was 165 to 180 cfs.

Table 1. Summary of 12 Streampro discharge measurements at the downstream end of the canal lining project (near the Payne Canyon Siphon).

Transect	Start Bank	# Ens.	Start Time	Total Q ft ³ /s	Delta Q %	Top Q ft ³ /s	Meas. Q ft ³ /s	Bottom Q ft ³ /s	Left Q ft ³ /s	Left Dist. ft	Right Q ft ³ /s	Right Dist. ft	Width ft	Total Area ft ²
FFDC004	Left	101	13:14:37	173.294	0.24	26.579	126.275	17.892	0.761	1.00	1.788	1.00	21.28	77.67
FFDC005	Right	81	13:16:41	176.608	2.16	26.862	129.049	17.777	1.266	1.00	1.653	1.00	20.99	76.98
FFDC006	Left	73	13:18:19	174.059	0.68	26.777	126.511	17.913	0.847	1.00	2.011	1.00	21.64	78.40
FFDC007	Right	87	13:19:41	171.405	-0.85	26.807	124.285	17.570	1.155	1.00	1.587	1.00	22.07	80.20
FFDC008	Left	93	13:28:07	169.913	-1.72	26.198	123.758	17.304	0.931	1.00	1.722	1.00	21.36	77.27
FFDC009	Right	107	13:29:51	172.666	-0.12	26.518	125.623	17.636	1.421	1.00	1.468	1.00	21.61	78.55
FFDC010	Left	93	13:31:49	169.008	-2.24	26.115	123.338	16.796	0.853	1.00	1.906	1.00	21.46	77.90
FFDC011	Right	98	13:33:29	164.647	-4.76	25.487	119.832	16.408	1.435	1.00	1.485	1.00	21.30	77.42
FFDC012	Left	91	13:40:26	179.831	4.02	27.676	131.692	17.678	0.898	1.00	1.888	1.00	21.18	76.99
FFDC013	Right	94	13:42:05	177.943	2.93	27.523	128.770	18.463	1.700	1.00	1.487	1.00	21.49	78.11
FFDC014	Left	72	13:43:45	174.803	1.11	26.814	127.743	17.432	0.877	1.00	1.937	1.00	21.99	79.75
FFDC015	Right	81	13:45:04	170.382	-1.44	26.173	124.156	17.177	1.499	1.00	1.377	1.00	22.18	80.47
Average		89		172.880	0.00	26.627	125.919	17.504	1.137	1.00	1.692	1.00	21.54	78.31
Std Dev.		11		4.190	2.42	0.604	3.152	0.541	0.317	0.00	0.214	0.00	0.37	1.22
Std./ Avg.		0.12		0.02	0.00	0.02	0.03	0.03	0.28	0.00	0.13	0.00	0.02	0.02



Figure 2. Photograph of the flow measurement cross section upstream from the Payne Canyon Siphon (flow is from right to left). The Teledyne/RDI Streampro and tagline were temporarily installed for this flow measurement.

The second flow measurement location was upstream from the start of the canal lining project, located just downstream from a wood bridge (Figure 3). This site was located about 370 feet upstream from the 10-ft concrete Parshall Flume that measures the Florida Farmers Ditch diversion. The Colorado Division of Water Resources maintains a gaging station at this flume (see figure 4). The gaging station is about 1,000 feet below the head gate on the Florida River. The ditch upstream is straight and has a relatively uniform cross section (figure 4). The site was free from any significant aquatic vegetation and the cross section was relatively uniform with a mean depth of about 3.3 feet. A moving-bed test did not detect any bed sediment transport at the time of this flow measurement.

Discharge measurements, using a Streampro, were collected from 3:00 to 3:10 pm. A total of 8 discharge measurement transects (passes across the channel) were made and the average flow was 180.1 cfs with a standard deviation of ± 2.6 cfs (Table 2). The range of Streampro discharge measurements was 176 to 184 cfs. The discharge from the Colorado Division of Water Resources gaging station (FARMERCO) was reported to be 178 cfs at 3:00 and 3:15 p.m. The difference between the measured and reported discharge is 1.1 percent, which is well within the uncertainty range of both flow measurements. A review of the FARMERCO discharge records showed the flow was steady at 177 to 179 cfs for 24 hours prior to the Streampro measurements.



Figure 3. Photograph looking upstream from the wood bridge crossing the Florida Farmers Ditch above the flow measurement site.



Figure 4. Photograph of 10-ft concrete Parshall Flume and water stage recorder used to monitor Florida Farmers Ditch diversions (DWR Site: FARMERCO).

Table 2. Summary of 8 Streampro discharge measurements near the start of the canal lining project.

Transect	Start Bank	# Ens.	Start Time	Total Q ft ³ /s	Delta Q %	Top Q ft ³ /s	Meas. Q ft ³ /s	Bottom Q ft ³ /s	Left Q ft ³ /s	Left Dist. ft	Right Q ft ³ /s	Right Dist. ft	Width ft	Total Area ft ²
FFDCUS000	Left	67	14:58:37	179.434	-0.38	30.441	128.545	19.211	1.236	1.00	0.000	0.00	18.22	62.42
FFDCUS001	Right	79	14:59:54	181.800	0.93	30.794	127.945	19.706	2.119	1.00	1.201	1.00	19.74	64.23
FFDCUS002	Left	60	15:01:19	180.140	0.01	30.794	127.027	19.282	1.271	1.00	1.730	1.00	19.05	62.28
FFDCUS003	Right	60	15:02:24	178.092	-1.13	30.406	126.532	18.399	1.519	1.00	1.307	1.00	20.58	65.69
FFDCUS004	Left	78	15:05:01	178.410	-0.95	29.982	128.263	18.116	-0.177	1.00	2.260	1.00	20.26	65.78
FFDCUS005	Right	68	15:06:24	184.166	2.24	30.547	130.664	19.282	1.942	1.00	1.730	1.00	18.91	63.11
FFDCUS006	Left	69	15:07:38	176.185	-2.19	29.205	125.226	18.681	1.271	1.00	1.801	1.00	18.45	61.46
FFDCUS007	Right	57	15:08:53	182.753	1.46	30.441	129.393	19.211	2.225	1.00	1.483	1.00	19.20	63.75
Average		67		180.122	0.00	30.326	127.949	18.986	1.426	1.00	1.439	0.88	19.30	63.59
Std Dev.		8		2.649	1.47	0.520	1.698	0.533	0.760	0.00	0.668	0.35	0.83	1.58
Std./ Avg.		0.12		0.01	0.00	0.02	0.01	0.03	0.53	0.00	0.46	0.40	0.04	0.02

Turnout Flows

During the May 29, 2012 flow measurements, Mr. Vermeyen visited two small turnouts along Reach G. The turnout near the Horse Gulch siphon was delivering 0.25 cfs according to the 6-in Parshall Flume (figure 5). A field measurement was not taken because measurement of the low flow in the undefined channel would have been less accurate than the flume measurement. There was a second turnout near the Payne Canyon siphon, but it was shut-off during these flow measurements. The condition of these Florida Farmer Ditch flow measurement flumes were documented in a WWE report (WWE, May 4, 2012).



Figure 5. Photograph of 6-in Parshall Flume on Farmers Florida Ditch diversion near the Horse Gulch siphon, N37.28947° W107.79643°.

Observed Seepage

On May 29, 2012, Mr. McCoy took Mr. Vermeyen to an area of significant seepage from the Florida Farmers Ditch. The seepage site is located about 0.4 miles downstream from the gaging station. Figure 6 is a photograph of the seepage area located between the ditch and CO Rd 234. According to Mr. McCoy, this seepage was typical for this relatively high flow in the ditch.



Figure 6. Photograph of canal seepage from the Florida Farmers Ditch near N37.28796° W107.79712°.

Previous Seepage Loss Measurements

Florida Farmers Ditch Reach G - WWE used the tracer (salt)-dilution method to measure discharge in the Florida Farmers Ditch on July 14, 2009 (WWE, October 2009). Discharge at the headgate (DWR: FARMERCO) was 157.0 cfs as measured with the 10-foot Parshall Flume. WWE measured discharge of the Florida Farmers Ditch below the Payne Canyon siphon to be 143.3 cfs, with turnout diversions of 0.5 cfs in Reach G. The seepage loss was estimated to be 13.2 cfs, and the normalized loss was 0.055 cfs/mile/cfs. WWE states that “most of the loss in Reach G probably occurs near Palmer Quarter Horse Ranch where CO Rd 234 crosses the Florida River.”

May 29, 2012 Seepage Loss Estimate for Reach G of the Florida Farmers Ditch

Using the same methodology used by WWE – a normalized seepage loss was calculated in cfs (loss) per mile per cfs (flow) WWE, October 2010. A normalized seepage loss for Reach G was computed using a loss of 6.45 cfs over the reach length of 1.52 miles for a diversion flow rate of 180.1 ± 2.6 cfs. The normalized reach loss was computed to be 0.0235 cfs/mile/cfs. This loss is less than half than what was reported by WWE in its 2010 report, 0.055 cfs/mile/cfs. However, seepage rates are highly variable and difficult to measure over such a short reach. The one likely

reason for the difference is the methodology used to measure flowrates. Also, WWE did not report an uncertainty estimate for their tracer-dilution flow measurements to compare with the ± 3.9 cfs standard error of the Streampro measurements made upstream from the Payne Canyon Siphon. However, a higher seepage rate for this higher flow was anticipated especially since it was early in the irrigation season - 19 days after diversions started.

Conversely, WWE seepage measurements were made on July 14, 2009 at a diversion flow of $157 \text{ ft}^3/\text{sec}$.

Pre-Project Measurements on July 31, 2012

On July 31, 2012, Tracy Vermeyen traveled to the Florida Farmers project to perform a second set of discharge measurements at the start and end of the canal lining project. Mr. Charlie McCoy, Ditch Rider, met Vermeyen in Durango and escorted him to the measurement sites. Flow measurements were repeated at the end of the canal lining project, located just upstream from the Payne Canyon Siphon (Figure 1). The site was still free of aquatic vegetation and the cross section was relatively uniform with a mean depth of about 2.3 ft. The water was clear enough to see the bottom which was primarily gravel and cobbles. A moving-bed test did not detect any bed sediment transport which could compromise the discharge measurements. Flows were measured with the same Teledyne/RD Instruments Streampro acoustic Doppler current profiler used on May 29, 2012. A total of 8 Streampro discharge measurement transects (passes across the channel) were made from 11:35 until 11:57 a.m (table 3). The average flow was $121.3 \text{ ft}^3/\text{sec}$ with a standard deviation of $\pm 3.4 \text{ ft}^3/\text{sec}$. The range of discharge measurements was 117 to $127 \text{ ft}^3/\text{sec}$.

Table 3. Summary of Streampro discharge measurements at the downstream end of the canal lining project. Transect FFDCDS013 data is highlighted in red because it is 5% greater than the average discharge.

Transect	Start Bank	#Ens.	Start Time	Total Q ft ³ /s	Delta Q %	Top Q ft ³ /s	Meas. Q ft ³ /s	Bottom Q ft ³ /s	Left Q ft ³ /s	Left Dist. ft	Right Q ft ³ /s	Right Dist. ft	Width ft	Total Area ft ²
FFDCDS007	Right	81	11:35:39	122.477	1.00	27.961	77.769	14.369	1.021	1.50	1.357	1.50	22.65	51.28
FFDCDS008	Left	73	11:37:35	120.904	-0.29	27.036	76.726	13.886	1.569	1.50	1.688	1.50	22.79	52.23
FFDCDS010	Left	51	11:41:20	119.156	-1.74	25.446	76.256	12.884	2.526	1.50	2.044	1.50	20.95	50.25
FFDCDS011	Right	73	11:48:08	124.336	2.54	27.480	79.895	13.927	1.508	1.50	1.526	1.50	22.02	50.82
FFDCDS012	Left	71	11:50:19	118.092	-2.61	25.928	75.257	13.315	1.762	1.50	1.830	1.50	22.05	51.79
FFDCDS013	Right	72	11:52:24	127.350	5.02	28.233	81.442	14.865	1.498	1.50	1.312	1.50	22.70	52.12
FFDCDS014	Left	71	11:54:25	117.270	-3.29	25.669	74.196	13.401	1.451	1.50	2.552	1.50	21.63	50.51
FFDCDS015	Right	74	11:56:18	120.499	-0.63	27.083	76.626	13.741	1.531	1.50	1.518	1.50	21.90	50.50
Average		70		121.260	0.00	26.855	77.271	13.799	1.608	1.50	1.728	1.50	22.09	51.19
Std Dev.		9		3.362	2.77	1.059	2.384	0.623	0.425	0.00	0.412	0.00	0.63	0.78
Std. Avg.]		0.13		0.03	0.00	0.04	0.03	0.05	0.26	0.00	0.24	0.00	0.03	0.02

The second flow measurement was at the same location used on May 29, 2012 (Figure 2). This site was located about 370 ft upstream from the 10-ft concrete Parshall Flume that measures the Florida Farmers Ditch diversion. The water was clear enough to see the bottom, which was primarily sand and gravel. The site was still free from any significant aquatic vegetation and the cross section was relatively uniform with a mean depth of depth about 2.8 ft. A moving-bed test did not detect any bed sediment transport.

Discharge measurements, using a Streampro, were collected from 12:37 to 12:49 p.m. A total of 8 discharge measurement transects (passes across the channel) were made and the average flow was 125.6 ft³/sec with a standard deviation of ±2.0 ft³/sec (Table 4). The range of Streampro discharge measurements was 123 to 129 ft³/sec. The discharge from the Colorado Division of Water Resources gaging station (FARMERCO) was reported to be 125 ft³/sec at 12:30, 12:45, and 1:00 p.m. The difference between the measured and reported discharge is 0.5 percent which is well within the uncertainty range of both flow measurements. A review of the FARMERCO discharge records showed the flow was steady at 124 to 125 ft³/sec for 12 hours prior to the Streampro measurements.

Table 4. Summary of Streampro discharge measurements near the upstream end of the canal lining project.

Transect	Start Bank	# Ens.	Start Time	Total Q ft ³ /s	Delta Q %	Top Q ft ³ /s	Meas. Q ft ³ /s	Bottom Q ft ³ /s	Left Q ft ³ /s	Left Dist. ft	Right Q ft ³ /s	Right Dist. ft	Width ft	Total Area ft ²
FFDCUS000	Left	64	12:37:25	124.667	-0.71	29.104	64.398	24.849	1.714	1.00	4.602	2.00	17.79	49.23
FFDCUS001	Right	64	12:39:17	123.861	-1.35	29.165	60.548	27.848	1.838	1.00	4.462	2.00	17.60	48.64
FFDCUS002	Left	62	12:40:55	129.552	3.19	31.728	67.334	26.816	1.823	1.00	1.851	1.00	18.15	50.25
FFDCUS003	Right	57	12:42:22	127.405	1.48	31.473	65.905	26.225	1.978	1.00	1.824	1.00	17.86	50.09
FFDCUS004	Left	60	12:44:09	124.658	-0.71	30.822	64.657	25.138	2.078	1.00	1.964	1.00	17.85	49.78
FFDCUS005	Right	56	12:45:31	124.086	-1.17	30.274	59.955	29.837	2.060	1.00	1.960	1.00	17.71	49.76
FFDCUS006	Left	54	12:46:43	124.709	0.67	32.044	61.485	27.302	2.013	1.00	1.865	1.00	17.70	49.27
FFDCUS007	Right	63	12:48:04	125.482	-0.06	30.850	65.120	25.565	2.114	1.00	1.834	1.00	17.32	48.89
Average		60		125.553	-0.00	30.682	63.675	26.698	1.952	1.00	2.545	1.25	17.75	49.49
Std Dev.		4		1.954	1.56	1.107	2.682	1.644	0.144	0.00	1.228	0.46	0.24	0.57
Std. Avg.		0.07		0.02	0.00	0.04	0.04	0.06	0.07	0.00	0.48	0.37	0.01	0.01

Turnout Flows

During the July 31, 2012 flow measurements, neither of the two small turnouts in the lining project reach were delivering water during these flow measurements (pers. commun. with Mr. Charlie McCoy, July 31, 2012).

Observed Seepage

The seepage site that was observed on May 31, 2012 (figure 6) was observed to be dry on July 31, 2012. Figure 7 is a photograph of the dry seepage area.

July 31, 2012 Seepage Loss Estimate for Reach G of the Florida Farmers Ditch

Using the same methodology used by Wright Water Engineers – a normalized seepage loss was calculated in ft³/sec (loss) per mile per ft³/sec (diversion flow), WWE, October 2010. A normalized seepage loss for Reach G was computed using a loss of 4.30 ft³/sec over the reach length of 1.52 miles for a diversion flow rate of 125.6 ± 2.0 ft³/sec. The normalized reach loss was computed to be 0.0225 ft³/sec/mile/ft³/sec. This loss is slightly less than what was measured May 31, 2012. This seepage loss is much less than what was reported by WWE in their 2010 report, 0.055 ft³/sec/mile/ft³/sec, even though the time of year and diversion flow were similar - WWE seepage measurements were made on July 14, 2009 at a diversion flow of 157 ft³/sec.



Figure 7. July 31, 2012 photograph of the same canal seepage area from May 29, 2012 (shown in figure 6) that had dried up, N37.28796° W107.79712°.

Recommendations

The two seepage loss estimates measured using a Streampro will be used as a baseline for the canal lining evaluation, because it is considered impractical to try to repeat the tracer-dilution measurements.

The close agreement between Streampro measurements and the flow measured using the 10-ft Parshall Flume (FARMERCO) creates confidence in both the flume's calibration and the Streampro's performance. For 2013 seepage measurements, the 10-ft Parshall Flume can be used to determine the Florida Farmers Ditch diversion flow.

Another set of Streampro flow measurements will be made in 2013 after the canal lining project is complete to compute the seepage loss for the post-lining condition.

The repairs to the two 6-inch Parshall Flumes measuring turnout flows near the Horse Gulch and Payne Canyon siphons recommended by WWE (2010), should be completed prior to the 2013 seepage tests.

References

Wright Water Engineers, Inc., Florida Mesa Ditch Loss Study, October 2010 (061-100.041)

Wright Water Engineers, Inc. Memorandum, Florida Farmers Ditch - Flume Measurements and Water Saving Verification, May 4, 2012