Flow Measurement

for Rehabilitation Planning[1]

Report Prepared for

Cameron County Irrigation District No. 2

by

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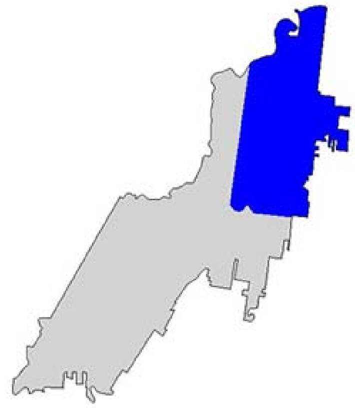


Assistance Requested

Cameron County Irrigation District No. 2 (CCID2) contracted with the Bureau of Reclamation to complete a project plan for rehabilitation of a portion of the district as shown on the right. The district plans on replacing earthen canals with pipelines in this area.

The Bureau of Reclamation requested our assistance in obtaining data and conducting measurements to support this project. This report summaries the portion of this study relating to the determination of flow rates in existing canals and at specific location of the irrigation water distribution system.

Measurement Methods

Flows were measured in four canals using a current meter and at 14 farm turnouts using propeller flow meters by Eric Leigh and Martin Barroso of Texas Cooperative Extension (TCE) and Freddie Ortega of CCID2.

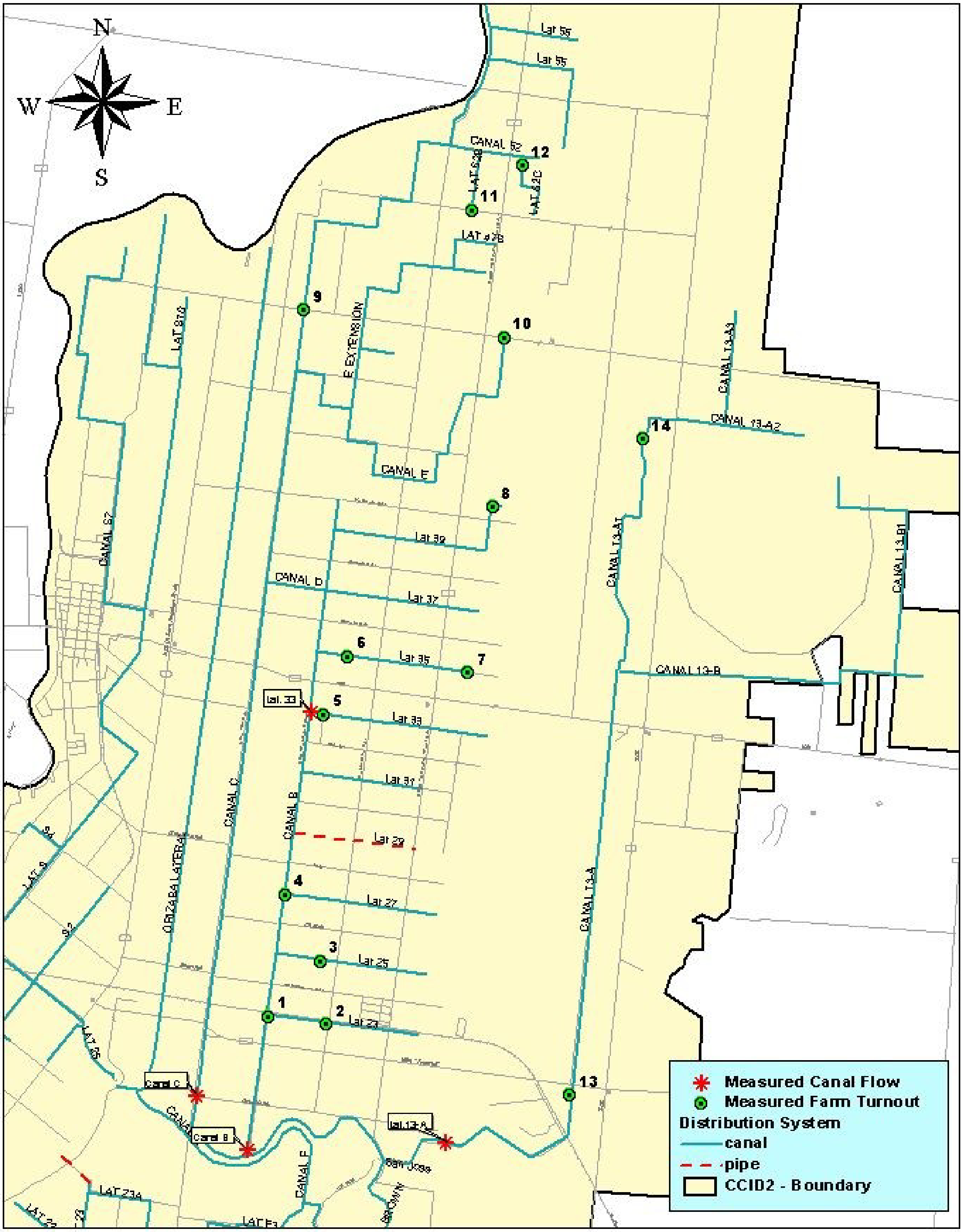
Current-meter measurements were taken at the inlets of canals B, C, 13, and lateral 33. Propeller flow meter measurements were taken of farm turnout valves in canals 23, 25, 27, 33, 35, 39, C, E, 52-B, 52-C, 13-A, and 13-A1 (see map).

Current Meter Measurements

Current-meter (velocity) readings were taken along the cross-section of canals B, C, 13, and at the inlet structure of lateral 33. Equipment used was a *Price Type AA* current meter (model 1220) with conventional round wading rod, and a *Scientific Instruments* model CMD 9000 digimeter.

We followed USGS recommended procedures, and used both the two-point and the six-tenths-depth methods in measuring mean velocities in a vertical line. The two-point method was used in canals sections with a water depth greater than 2 feet. For canals with a water depth 2 feet or less, the six-tenths-depth method used.

Table 1 gives the average flows rates calculated with the USGS midsection method. Table 2 gives the flow rates calculated using all three USGS methods. Detailed data sets on each canal section and velocity measurements are given in Tables A1- A4.



N
W
E
S
Lat 55
Lat 55
CANAL 52
12
LAT 52B
LAT 52C
11
LAT 47B
9
10
E EXTENSION
LAT 37A
CANAL 13-A3
14
CANAL 13-A2
CANAL E
8
Lat 39
CANAL 87
CANAL D
Lat 37
CANAL 13-A1
CANAL 13-B1
6
Lat 35
7
CANAL 13-B
lat. 33
5
Lat 33
Lat 31
CANAL C
CANAL B
Lat 29
4
Lat 27
ORIZABA LATERAL
CANAL 13-A
3
Lat 25
1
2
Lat 23
LAT 25
13
Canal C
Canal B
lat.13-A
CANAL F
San Jose
BROWN
LAT 23A
LAT F3
Measured Canal Flow
Measured Farm Turnout
Distribution System
canal
pipe
CCID2 - Boundary

Table 1: Canal identifications, attributes and flow calculated using the USGS midsection method from velocity meter measurements.

Canal	Width (ft)	Avg. Depth (ft)	Area (ft^2)	Avg. Velocity (FPS)	Total Discharge		Head*	Turns on Gate**
					CFS	GPM		
B	19.08	2.380	45.38	0.3834	17.84	8008	5.947	36
C	11.00	4.921	54.13	0.5748	30.91	13,874	10.31	NA
13	7.5	1.163	9.692	1.966	20.35	9135	6.785	NA
33	2.5	2.5	6.25	0.9061	5.663	2542	1.8878	8

* corresponding head based on the relationship 1 head = 3 CFS
**corresponding "turns of the gate" based on 4 turns = 1 head.

Table 2: Canal flow rates (CFS) calculated using three USGS current-meter discharge computation methods from velocity meter measurements.

Method	Canal B	Canal C	Canal 13	Lateral 33
Simple	17.407	29.596	19.875	5.005
Midsection	17.796	30.913	20.354	5.663
Simpson's	17.385	29.076	19.852	5.199

USGS Calculation Methods

According to the U.S. Bureau of Reclamation Manual (Chapter 10, section 31-32):

> Simpson's parabolic rule method is particularly applicable to river channels and old canals that have cross sections conforming in a general way to the arc of a parabola or to a series of arcs of different parabolas. Simpson's method requires equally spaced verticals. The simple average and the midsection methods do not require equally spaced verticals. Thus, these two methods are well suited to computing discharges in canals that conform closely to their original trapezoidal rectangular shapes.

Notes, discussions and photographs

Canal B

Flow in canal B was measured 65 yards downstream of the main head gates of Canal A (Figure 1). Measurements were taken on the upstream side of a culvert (Figure 2). Before the test could begin, a CCID2 maintenance crew helped remove excessive amounts of aquatic vegetation clogging canal B's inlet. The detailed data (Table A-1) clearly shows that the aquatic vegetation drastically hinders flow in the upper portion of the canal cross-section.

Figure 1. Head gate inlet into canal B (one operational gate).

Figure 2. Culvert clogged by aquatic vegetation (Water Hyacinth)

Canal C

Figure 3 shows the culvert downstream of the head gates of canal C, located at Nelson Road and Line 20, at which flow measurements were taken.

Figure 3. Canal C's flow measurement location.

Canal 13

While measuring flow in canal 13, the canal rider informed us that he was unable to produce a water level equal to normal or maximum operating conditions in the canal due to low water use downstream.   As a result, flow measurements were taken with a water level of 1.5 ft. This represents 37% of canal's capacity based on the high water level marking of 4 ft.

Figure 4. Canal 13's flow measurement location.

Flow Measurement Problems

We attempted to measure velocities with the current meter in the following canals and laterals: 23, 25, 27, 31, 35, 37, 39, 52, 52-B, 52-C, 55, 56, and E. However, this method of flow measurement proved to be very difficult due to inconsistent (unstable) flows, dead-end flows (with no irrigation occurring), and the lack of control structures. For example, Figure 5 shows the inlet to canal E. This inlet has no control gates to regulate downstream flow.   Head levels of canal E are maintained and controlled by the inflows to canal C and through other withdraws in system.

Figure 5. Inlet to Canal E from Canal C.

Propeller Meter Measurements

As discussed above, it was difficult to impossible to obtain current meter readings in the remaining canals of interest. As an alternative, we measured the flows at selected farm turnout valves using propeller flow meters. A vertical propeller flow meter calibrated for 14-inch pipes was obtained from San Benito Irrigation District and was used along with an in-line saddle flow meter. Table 3 summarizes the farm turnout flow data. The map shows the locations where these measurements were obtained. A standard survey transit was used to obtain elevations.

Figure 6. Typical 14-inch *Fresnos* alfalfa valve used in the district.

Figure 6. Vertical flow meter ready to measure farm outlet.

Figure 7. A typical 15-inch steel pipe feeding a black poly-riser, usually fitted with a 12-inch pipe outlet feeding into poly-pipe.

Figure 8. Recording flows with in-line saddle propeller meter.

Figure 9. A box head gate situation that typical occurs at the beginning of a canal or after a road crossing. This controls downstream, levels and supplies usually two farm turnouts.

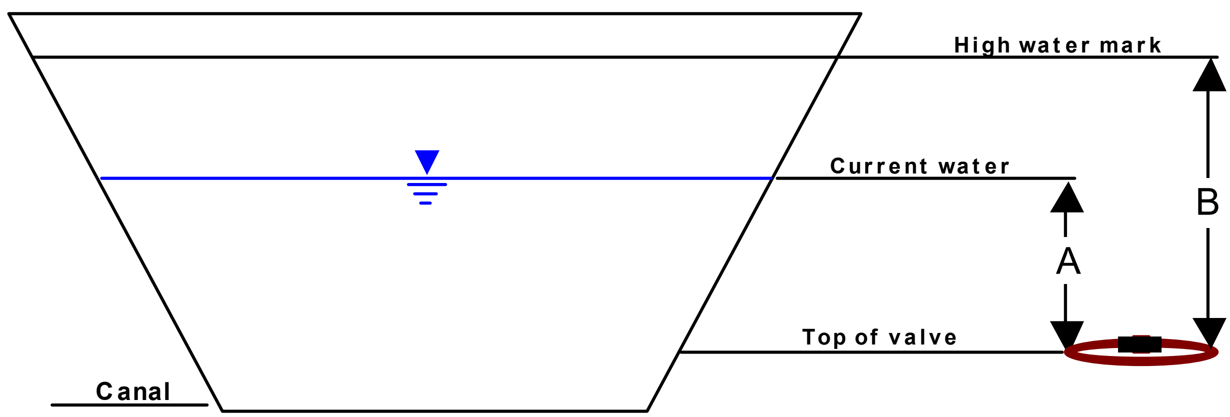
Figure 10. Root-gate usually made of wood.

Figure 11. Farm turnout valve at canal 27 and B.

Table 3: Measured Farm Turnouts (valves are 14 inch in diameter).

No #	Canal	A	B	GPM	CFS	Meter Type	Meter Size (in)
1	23	2.15	2.49	675	1.504	Vertical	14
2	23	2.065	2.545	900	2.005	Horizontal	10
3	25	2.08	2.32	800	1.783	Horizontal	15
4	B/27	3.81	4.42	1650	3.676	Vertical	14
5	33	1.93	3.33	800	1.783	Horizontal	10
6	35	NA	NA	1300	2.897	Vertical	14
7	35	0.385	1.945	1000	2.228	Horizontal	15
8	39	2.19	2.39	800	1.783	Vertical	14
9	C	2.97	2.97	1200	2.674	Horizontal	10
10	E	0.015	0.885	3300	7.353	Horizontal	15
11	52-B	2.86	2.8	1900	4.234	Vertical	14
12	52-C	3.88	4.1	1450	3.231	Horizontal	10
13	13-A	1.05	2.53	1500	3.342	Horizontal	10
14	13-A1	4.87	5.62	1800	4.011	Horizontal	10

A) Water level elevation above valve
B) High-water mark elevation above valve



Appendix

Table A-1. Canal B - Current-meter field notes and computations using the midsection method.

Section	Dist. from initial point (in)	Width (ft)	Measuring Point (in)	Depth (ft)	Observation %	Observation Depth (ft)	Rev-olu-tions	Time in sec-onds	VELOCITY (FPS) At Point	VELOCITY (FPS) Mean Avg	Area (ft²)	Discharge (cfs)
1	12	1	6	1.7	.6	1.020	5	43.6	0.271	0.271	1.700	0.461
2	24	1	18	1.82	.6	1.092	3	48	0.156	0.156	1.820	0.283
3	36	1	30	2.08	.2	0.416	5	53.2	0.225	0.315	2.080	0.655
					.8	1.664	8	45.5	0.405			
4	48	1	42	2.3	.2	0.416	0	0	0	0	2.300	0
					.8	1.664	0	0	0			
5	60	1	54	2.5	.2	0.500	5	41.4	0.284	0.601	2.500	1.501
					.8	2.000	17	41.7	0.917			
6	72	1	66	2.42	.2	0.484	8	45.7	0.404	0.631	2.420	1.527
					.8	1.936	16	42	0.858			
7	84	1	78	1.95	.6	1.170	5	45	0.262	0.262	1.950	0.511
8	96	1	90	2.025	.2	0.405	0	0	0	0.408	2.025	0.825
					.8	1.620	15	41.5	0.815			
9	108	1	102	2.275	.2	0.455	3	51	0.147	0.480	2.275	1.092
					.8	1.820	15	41.5	0.813			
10	120	1	112	2.225	.2	0.445	4	48	0.202	0.479	2.225	1.066
					.8	1.780	14	41.7	0.756			
11	132	1	126	2.600	.2	0.520	0	0	0	0.448	2.600	1.165
					.8	2.080	16	41.1	0.896			
12	144	1	138	2.875	.2	0.575	0	0	0	0.410	2.875	1.179
					.8	2.300	15	41.2	0.820			
13	156	1	150	2.875	.2	0.575	4	52.5	0.186	0.482	2.875	1.386
					.8	2.300	14	40.6	0.778			
14	168	1	162	2.875	.2	0.575	3	47.5	0.157	0.377	2.875	1.084
					.8	2.300	11	41.9	0.597			
15	170	1	164	2.8	.2	0.560	3	44	0.168	0.404	2.800	1.130
					.8	2.240	12	42.6	0.639			
16	182	1	176	2.775	.2	0.555	4	54.1	0.181	0.415	2.775	1.150
					.8	2.220	12	42	0.648			
17	194	1	188	2.750	.2	0.550	4	48.6	0.199	0.402	2.750	1.106
					.8	2.200	11	41.2	0.605			
18	206	1	200	2.475	.2	0.495	5	45.4	0.261	0.452	2.475	1.119
					.8	1.980	12	42.3	0.643			
19	218	1	212	1.9	.6	1.140	6	48	0.293	0.293	2.058	0.603
								Avg. Velocity		0.383		
										Total Area	45.378	
											Total Discharge	17.842
										GPM	× 448.8	8007.695
										HEAD	÷ 3	5.947

Table A-2. Canal C - Current-meter field notes and computations using the midsection method.

Section	Dist. from initial point (in)	Width (ft)	Measuring Point (in)	Depth (ft)	Observation %	Observation Depth (ft)	Rev-olu-tions	Time in sec-onds	VELOCITY (FPS) At Point	VELOCITY (FPS) Mean Avg	Area (ft²)	Discharge (cfs)
1	11	.9167	5.5	4.85	.2	0.970	15	41.0	0.817	0.758	4.446	3.370
					.8	3.880	13	42.0	0.699			
2	22	.9167	16.5	4.95	.2	0.990	11	43.0	0.582	0.614	4.537	2.786
					.8	3.960	12	42.5	0.646			
3	33	.9167	27.5	3.95	.2	0.790	12	42	0.652	0.684	3.621	2.476
					.8	3.160	13	40.7	0.722			
4	44	.9167	38.5	5.05	.2	1.010	12	41.7	0.652	0.667	4.629	3.085
					.8	4.040	13	43.2	0.681			
5	55	.9167	49.5	5.00	.2	1.000	10	42.5	0.537	0.592	4.583	2.711
					.8	4.000	12	42.1	0.646			
6	66	.9167	60.5	5.05	.2	1.010	0	0	0	0.290	4.629	1.340
					.8	4.040	11	43.2	0.579			
7	77	.9167	71.5	5.05	.2	1.010	11	43.5	0.575	0.577	4.629	2.669
					.8	4.040	11	43.3	0.578			
8	88	.9167	82.5	5.00	.2	1.000	9	40.4	0.509	0.534	4.583	2.445
					.8	4.000	10	40.7	0.558			
9	99	.9167	93.5	5.00	.2	1.000	8	39.9	0.46	0.524	4.583	2.402
					.8	4.000	11	42.5	0.588			
10	110	.9167	104.5	5.05	.2	1.010	9	41.2	0.499	0.549	4.629	2.539
					.8	4.040	11	41.8	0.598			
11	121	.9167	115.5	5.05	.2	1.010	10	40.7	0.358	0.490	4.629	2.266
					.8	4.040	11	40.2	0.621			
12	132	.9167	126.5	5.05	.2	1.010	13	40.9	0.719	0.610	4.629	2.824
					.8	4.040	9	41.1	0.501			
									Avg. Velocity	0.574		
										Total Area	54.129	
											Total Discharge	30.914
										GPM	× 448.8	13874
										HEAD	÷ 3	10.305

Table A-3. Canal 13 - Current-meter field notes and computations using the midsection method.

Section	Dist. from initial point (in)	Width (ft)	Measuring Point (in)	Depth (ft)	Observation %	Observation Depth (ft)	Rev-olu-tions	Time in sec-onds	VELOCITY (FPS) At Point	VELOCITY (FPS) Mean Avg	Area (ft²)	Discharge (cfs)
1	10	0.8334	14.75	0.3	.6	0.180	22	40	1.23	1.23	0.250	0.308
2	20	0.8333	15.583	1.1	.6	0.660	33	40.2	1.82	1.82	0.917	1.668
3	30	0.8333	16.417	1.5	.6	0.900	40	40.1	2.22	2.22	1.250	2.775
4	40	0.8333	17.25	1.5	.6	0.900	41	41	2.22	2.22	1.250	2.775
5	50	0.8333	18.083	1.5	.6	0.900	40	40.2	2.21	2.21	1.250	2.762
6	60	0.8333	18.917	1.5	.6	0.900	41	40.3	2.26	2.26	1.250	2.825
7	70	0.8333	19.75	1.5	.6	0.900	39	40.1	2.16	2.16	1.250	2.700
8	80	0.8333	20.583	1.5	.6	0.900	39	40.1	2.16	2.16	1.250	2.700
9	90	0.8333	21.417	1	.6	0.600	34	40.7	1.86	1.86	0.833	1.550
10	100	0.8334	22.25	0.23	.6	0.138	28	40.7	1.52	1.52	0.192	0.291
									Avg. Velocity	1.966		
	Top Width		12.75ft							Total Area	19.054	
	Total Depth		4.5 ft								Total Discharge	20.355
	High Water Mark		4.0 ft							GPM	× 448.8	9135.1
										HEAD	÷ 3	6.785

Table A-4. Canal 33 – Current-meter field notes and computations using the midsection method.

Section	Dist. from initial point (in)	Width (ft)	Measuring Point (in)	Depth (ft)	Observation		Rev-olu-tions	Time in sec-onds	VELOCITY (FPS)		Area (ft²)	Discharge (cfs)
					%	Depth (ft)			At Point	Mean Avg		
1	7.5	0.625	3.75	2.5	.2	0.5	18	42	0.963	0.9385	1.5625	1.4664
					.8	2.0	17	41.7	0.914			
2	15	1.25	11.25	2.5	.2	0.5	18	41.5	0.974	0.897	1.5625	1.4016
					.8	2.0	15	41.2	0.820			
3	22.5	1.875	18.75	2.5	.2	0.5	18	41.7	0.969	0.947	1.5625	1.4797
					.8	2.0	17	41.2	0.925			
4	30	2.5	26.25	2.5	.2	0.5	16	41.7	0.862	0.842	1.5625	1.3156
					.8	2.0	15	41.0	0.822			
								Avg. Velocity	0.9061			
										Total Area	6.25	
											Total Discharge	5.6633
										GPM	× 448.8	2542
										HEAD	÷ 3	1.8878