

iIMI  
G31.7.1  
G730  
BUK  
Pakistan

Open channels / flow channels / flow measurement / water delivery / measurement instruments  
weirs

Report No. R-74

**DEVELOPMENT AND USE OF RECTANGULAR CHANNELS  
WITH A SINGLE CURRENT METER MEASUREMENT  
FOR RECORDING FARM WATER DELIVERIES**

(ANNEXES)

by

**Nisar Hussain Bukhari  
Muhammad Mohsin Hafeez  
M. S. Shafique  
Gaylord V. Skogerboe**



**December 1998**

**PAKISTAN NATIONAL PROGRAM  
INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE  
LAHORE**

# 24733 C1

## TABLE OF CONTENTS

ANNEX A	COMPARISON OF CURRENT METER MEASUREMENTS WITH A V-NOTCH WEIR	33
ANNEX B	HYDRAULIC LABORATORY DATA FOR CALIBRATION OF 8-INCH RECTANGULAR CHANNEL	39
ANNEX C	HYDRAULIC LABORATORY DATA FOR CALIBRATION OF 12-INCH RECTANGULAR CHANNEL	49
ANNEX D	HYDRAULIC LABORATORY DATA FOR CALIBRATION OF 18-INCH RECTANGULAR CHANNEL	59
ANNEX E	HYDRAULIC LABORATORY DATA FOR CALIBRATION OF 24-INCH RECTANGULAR CHANNEL	69
ANNEX F	HYDRAULIC LABORATORY DATA FOR CALIBRATION OF 27-INCH RECTANGULAR CHANNEL	79

## LIST OF TABLES

Table A1	Velocity measurements by mean section method for 8-inch Rectangular Channel.	33
Table A2	Velocity measurements by mean section method for 12-inch Rectangular Channel.	34
Table A3	Velocity measurements by mean section method for 18-inch Rectangular Channel.	35
Table A4	Velocity measurements by mean section method for 24-inch Rectangular Channel.	36
Table A5	Velocity measurements by mean section method for 27-inch Rectangular Channel.	37
Table B1	Calibration of 8-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 0.59$ cfs, flow depth = 0.92 ft).	39
Table B2	Calibration of 8-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 0.71$ cfs, flow depth = 0.94 ft).	41
Table B3	Calibration of 8-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 0.43$ cfs, flow depth = 1.15 ft).	43
Table B4	Calibration of 8-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 0.59$ cfs, flow depth = 1.18 ft).	45
Table B5	Calibration of 8-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 0.66$ cfs, flow depth = 1.20 ft).	47
Table C1	Calibration of 12-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 0.604$ cfs, flow depth = 0.574 ft).	49
Table C2	Calibration of 12-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 0.72$ cfs, flow depth = 0.85 ft).	51
Table C3	Calibration of 12-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 1.15$ cfs, flow depth = 1.10 ft).	53
Table C4	Calibration of 12-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 1.18$ cfs, flow depth = 1.30 ft).	55
Table C5	Calibration of 12-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 0.75$ cfs, flow depth = 1.31 ft).	57
Table D1	Calibration of 18-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 0.89$ cfs, flow depth = 0.45 ft).	59
Table D2	Calibration of 18-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 0.89$ cfs, flow depth = 0.55 ft).	61
Table D3	Calibration of 18-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 0.71$ cfs, flow depth = 0.75 ft).	63
Table D4	Calibration of 18-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 0.74$ cfs, flow depth = 1.03 ft).	65
Table D5	Calibration of 18-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 0.89$ cfs, flow depth = 1.42 ft).	67
Table E1	Calibration of 24-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 1.21$ cfs, flow depth = 0.62 ft).	69

Table E2	Calibration of 24-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 1.63$ cfs, flow depth = 0.83 ft).	71
Table E3	Calibration of 24-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 1.51$ cfs, flow depth = 1.07 ft).	73
Table E4	Calibration of 24-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 1.61$ cfs, flow depth = 1.11 ft).	75
Table E5	Calibration of 24-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 1.76$ cfs, flow depth = 1.25 ft).	77
Table F1	Calibration of 27-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 1.23$ cfs, flow depth = 0.31 ft).	79
Table F2	Calibration of 27-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 1.60$ cfs, flow depth = 0.74 ft).	81
Table F3	Calibration of 27-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 1.52$ cfs, flow depth = 0.92 ft).	83
Table F4	Calibration of 27-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 0.92$ cfs, flow depth = 1.10 ft).	85
Table F5	Calibration of 27-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 1.73$ cfs, flow depth = 1.26 ft).	87

## LIST OF FIGURES

Figure B1	Velocity profile at mid-width in 8-inch Rectangular Channel for all four piezometer wells ( $Q = 0.59$ cfs, flow depth = 0.92 ft).	40
Figure B2	Velocity profile at mid-width in 8-inch Rectangular Channel for all four piezometer wells ( $Q = 0.71$ cfs, flow depth = 0.94 ft).	42
Figure B3	Velocity profile at mid-width in 8-inch Rectangular Channel for all four piezometer wells ( $Q = 0.43$ cfs, flow depth = 1.15 ft).	44
Figure B4	Velocity profile at mid-width in 8-inch Rectangular Channel for all four piezometer wells ( $Q = 0.59$ cfs, flow depth = 1.18 ft).	46
Figure B5	Velocity profile at mid-width in 8-inch Rectangular Channel for all four piezometer wells ( $Q = 0.66$ cfs, flow depth = 1.20 ft).	48
Figure C1	Velocity profile at mid-width in 12-inch Rectangular Channel for all four piezometer wells ( $Q = 0.604$ cfs, flow depth = 0.574 ft).	50
Figure C2	Velocity profile at mid-width in 12-inch Rectangular Channel for all four piezometer wells ( $Q = 0.72$ cfs, flow depth = 0.85 ft).	52
Figure C3	Velocity profile at mid-width in 12-inch Rectangular Channel for all four piezometer wells ( $Q = 1.15$ cfs, flow depth = 1.10 ft).	54
Figure C4	Velocity profile at mid-width in 12-inch Rectangular Channel for all four piezometer wells ( $Q = 1.18$ cfs, flow depth = 1.30 ft).	56
Figure C5	Velocity profile at mid-width in 12-inch Rectangular Channel for all four piezometer wells ( $Q = 0.75$ cfs, flow depth = 1.31 ft).	58
Figure D1	Velocity profile at mid-width in 18-inch Rectangular Channel for all four piezometer wells ( $Q = 0.89$ cfs, flow depth = 0.45 ft).	60
Figure D2	Velocity profile at mid-width in 18-inch Rectangular Channel for all four piezometer wells ( $Q = 0.89$ cfs, flow depth = 0.55 ft).	62
Figure D3	Velocity profile at mid-width in 18-inch Rectangular Channel for all four piezometer wells ( $Q = 0.71$ cfs, flow depth = 0.75 ft).	64
Figure D4	Velocity profile at mid-width in 18-inch Rectangular Channel for all four piezometer wells ( $Q = 0.74$ cfs, flow depth = 1.03 ft).	66
Figure D5	Velocity profile at mid-width in 18-inch Rectangular Channel for all four piezometer wells ( $Q = 0.89$ cfs, flow depth = 1.42 ft).	68
Figure E1	Velocity profile at mid-width in 24-inch Rectangular Channel for all four piezometer wells ( $Q = 1.21$ cfs, flow depth = 0.62 ft).	70
Figure E2	Velocity profile at mid-width in 24-inch Rectangular Channel for all four piezometer wells ( $Q = 1.63$ cfs, flow depth = 0.83 ft).	72
Figure E3	Velocity profile at mid-width in 24-inch Rectangular Channel for all four piezometer wells ( $Q = 1.51$ cfs, flow depth = 1.07 ft).	74
Figure E4	Velocity profile at mid-width in 24-inch Rectangular Channel for all four piezometer wells ( $Q = 1.61$ cfs, flow depth = 1.11 ft).	76
Figure E5	Velocity profile at mid-width in 24-inch Rectangular Channel for all four piezometer wells ( $Q = 1.76$ cfs, flow depth = 1.25 ft).	78
Figure F1	Velocity profile at mid-width in 27-inch Rectangular Channel for all four piezometer wells ( $Q = 1.23$ cfs, flow depth = 0.31 ft).	80

Figure F2	Velocity profile at mid-width in 27-inch Rectangular Channel for all four piezometer wells ( $Q = 1.60$ cfs, flow depth = 0.74 ft).	82
Figure F3	Velocity profile at mid-width in 27-inch Rectangular Channel for all four piezometer wells ( $Q = 1.52$ cfs, flow depth = 0.92 ft).	84
Figure F4	Velocity profile at mid-width in 27-inch Rectangular Channel for all four piezometer wells ( $Q = 0.92$ cfs, flow depth = 1.10 ft).	86
Figure F5	Velocity profile at mid-width in 27-inch Rectangular Channel for all four piezometer wells ( $Q = 1.73$ cfs, flow depth = 1.26 ft).	88

## ANNEXES

**ANNEX A. COMPARISON OF CURRENT METER MEASUREMENTS WITH A V-NOTCH WEIR**

Table A1. Velocity measurements by mean section method for 8-inch Rectangular Channel.

Sr. No	h weir (ft)	Q weir (cusecs)	Current meter depth (ft)	Width of flume (ft)	Depth of water in channel (ft)	Mean velocity of water (fps)	No of current meter revolutions (no.)	Time (sec)	Measurement of velocity by current meter			Cross-sectional area of section (ft <sup>2</sup> )	Average discharge of water in each section (cfs)	Total discharge (cfs)	Percentage difference (%)	
									at mid-points (fps)	at the mid-point and near walls (fps)	Average velocity (fps)					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
										0.67						
pz2	0.43	0.306	0.24	0.67	0.59	0.78	40	50.00	0.82	0.82	0.75	0.066	0.049			
							40	46.90	0.87	0.87	0.84	0.066	0.055			
											0.87	0.066	0.057			
							40	46.30	0.88	0.88	0.89	0.066	0.058	0.303	0.97	
							40	45.60	0.89	0.89	0.89	0.066	0.058			
											0.74	0.066	0.048			
							30	54.50	0.58	0.58	0.53	0.066	0.035			
										0.48						



Table A2. Velocity measurements by mean section method for 12-inch Rectangular Channel.

Sr. No	h weir (ft)	Q weir (cusecs)	Current meter depth (ft)	Width of flume *ft)	Depth of water in channel (ft)	Mean Velocity of water (fps)	No of current meter revolutions (no.)	Time (sec)	Measurement of velocity by current meter			Cross-sectional area of section (ft <sup>2</sup> )	Average discharge in each section (cfs)	Total discharge (cfs)	Percentage difference (%)
									at mid-points (fps)	at the mid-point and near walls (fps)	Average velocity (fps)				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
										0.98					
p22	0.57	0.604	0.23	1	0.57	1.05	50	43	1.17	1.17	1.07	0.048	0.051		
							50	43.1	1.16	1.16	1.17	0.048	0.056		
							50	44	1.14	1.14	1.15	0.096	0.110		
							50	44	1.14	1.14	1.14	0.096	0.109		
							50	43.8	1.15	1.15	1.14	0.096	0.109		
							50	51	0.99	0.99	1.07	0.096	0.102		
							30	56	0.56	0.56	0.78	0.048	0.037		
											0.52	0.048	0.025		
										0.47					

Table A3. Velocity measurements by mean section method for 18-inch Rectangular Channel.

Sr. No	h weir (ft)	Q weir (cusecs)	Current meter depth (ft)	Width of flume (ft)	Depth of water in channel (ft)	Mean Velocity of water (fps)	No of current meter revolutions	Time (sec)	Measurement of velocity by current meter			Cross-sectional area of section (ft <sup>2</sup> )	Average discharge of each section (cfs)	Total discharge (cfs)	Percentage difference (%)	
									at mid-points (fps)	at the mid-point and near walls (fps)	Average velocity (fps)					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
										0.53						
pz2	0.72	1.110	0.46	1.5	1.15	0.64	30	51.5	0.61	0.61	0.57	0.144	0.082			
							30	45	0.69	0.69		0.144	0.094			
							30	45.3	0.69	0.69	0.69	0.289	0.199	1.140	-2.76	
							30	45	0.69	0.69		0.289	0.199			
							30	42	0.74	0.74	0.71	0.289	0.206			
							30	49	0.64	0.64	0.69	0.289	0.198			
							30	56.5	0.56	0.56	0.60	0.144	0.087			
											0.52	0.144	0.076			
										0.49						

Table A4. Velocity measurements by mean section method for 24-inch Rectangular Channel.

Sr. No	h weir (ft)	Q weir (cusecs)	Current meter depth (ft)	Width of flume (ft)	Depth of water in channel (ft)	Mean velocity of water (fps)	No of current meter revolutions	Time (sec)	Measurement of velocity by current meter			Cross-sectional area of section (ft <sup>2</sup> )	Average discharge of each section (cfs)	Total discharge (cfs)	Percentage difference (%)
									at mid-points (fps)	at the mid-point and near walls (fps)	Average velocity (fps)				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
										0.74					
p22	0.77	1.298	0.25	1.993	0.62	1.05	50	53.5	0.95	0.95	0.85	0.103	0.087		
							50	46	1.09	1.09	1.02	0.103	0.105		
							50	46.25	1.09	1.09	1.09	0.206	0.225		
							50	46.5	1.08	1.08	1.09	0.206	0.224	1.279	1.48
							50	47.5	1.06	1.06	1.07	0.206	0.221		
							50	46.75	1.08	1.08	1.07	0.206	0.220		
							50	51.25	0.99	0.99	1.03	0.103	0.106		
											0.88	0.103	0.091		
										0.78					

Table A5. Velocity measurements by mean section method for 27-inch Rectangular Channel.

Sr. No	h weir (ft)	Q weir (cusecs)	Current meter depth (ft)	Width of flume (ft)	Depth of water in channel (ft)	Mean velocity of water (fps)	No of current meter revolutions (no.)	Time (sec)	Measurement of velocity by current meter			Cross-sectional area of section (ft <sup>2</sup> )	Average discharge of each section (cfs)	Total discharge (cfs)	Percentage difference (%)
									at mid-points (fps)	at the mid-point and near walls (fps)	Average velocity (fps)				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
										0.56					
pz2	0.74	1.171	0.26	2.25	0.66	0.79	40	57.00	0.72	0.72	0.64	0.123	0.079		
							40	50.50	0.81	0.81	0.77	0.123	0.094		
							40	49.75	0.82	0.82	0.82	0.246	0.201	1.162	0.76
							40	48.50	0.84	0.84	0.83	0.246	0.205		
							40	49.50	0.83	0.83	0.83	0.246	0.205		
							40	51.00	0.80	0.80	0.82	0.246	0.201		
							40	55.00	0.75	0.75	0.78	0.123	0.095		
										0.58	0.66	0.123	0.082		

**ANNEX B. HYDRAULIC LABORATORY DATA FOR CALIBRATION OF 8-INCH RECTANGULAR CHANNEL.**

Table B1. Calibration of 8-inch Rectangular Channel for flow measurement with a pygmy current meter (Q=0.59 cft, flow depth =0.92 ft).

Sr. No	h weir	Q weir	Width of channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(Cusecs)	(ft)	(ft)	(fps)	(ft)	(no.)	(sec)	(fps)		
1	2	3	4	5	6	7	8	9	10	11	12
pz1	0.56	0.59	0.67	0.92	0.97	0.18	40	46.5	0.88	1.10	0.16
						0.37	50	47.0	1.07	0.90	0.20
						0.46	50	46.0	1.09	0.88	0.20
						0.55	50	48.5	1.04	0.93	0.19
						0.73	50	44.5	1.13	0.86	0.21
pz2	0.56	0.59	0.67	0.92	0.97	0.18	40	52.5	0.78	1.24	0.14
						0.37	50	49.0	1.03	0.94	0.19
						0.46	50	46.3	1.09	0.89	0.20
						0.55	50	46.5	1.08	0.89	0.20
						0.73	50	46.8	1.08	0.90	0.20
pz3	0.56	0.59	0.67	0.92	0.97	0.18	40	52.0	0.79	1.22	0.14
						0.37	50	49.0	1.03	0.94	0.19
						0.46	50	46.3	1.09	0.89	0.20
						0.55	50	46.0	1.09	0.88	0.20
						0.73	50	48.0	1.05	0.92	0.19
pz4	0.56	0.59	0.67	0.92	0.97	0.18	40	53.0	0.78	1.25	0.14
						0.37	50	48.3	1.05	0.92	0.19
						0.46	50	46.8	1.08	0.90	0.20
						0.55	50	46.5	1.08	0.89	0.20
						0.73	50	49.0	1.03	0.94	0.19

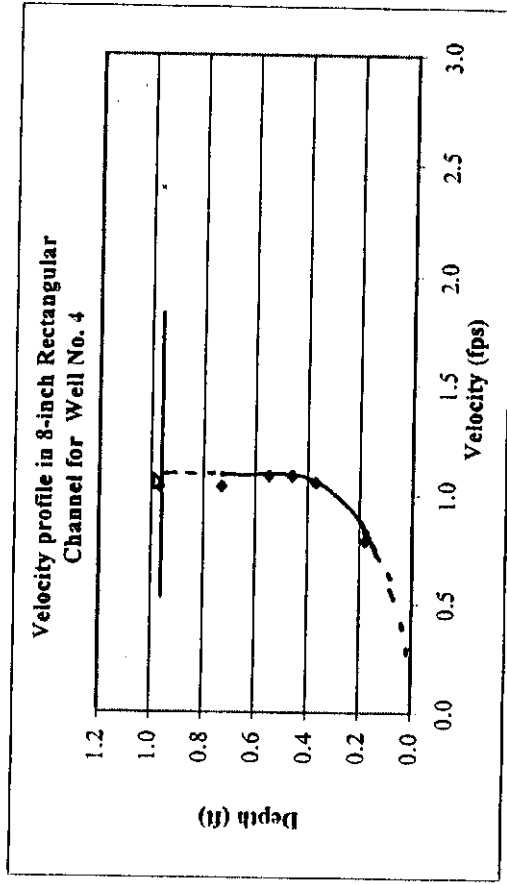
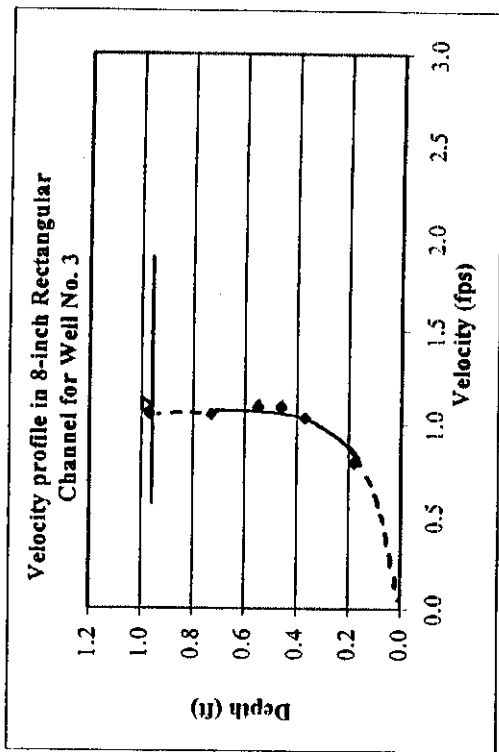
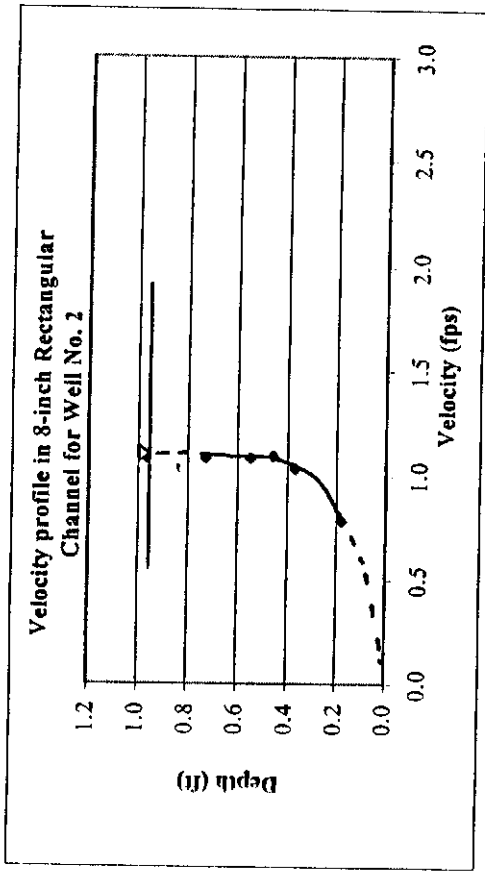
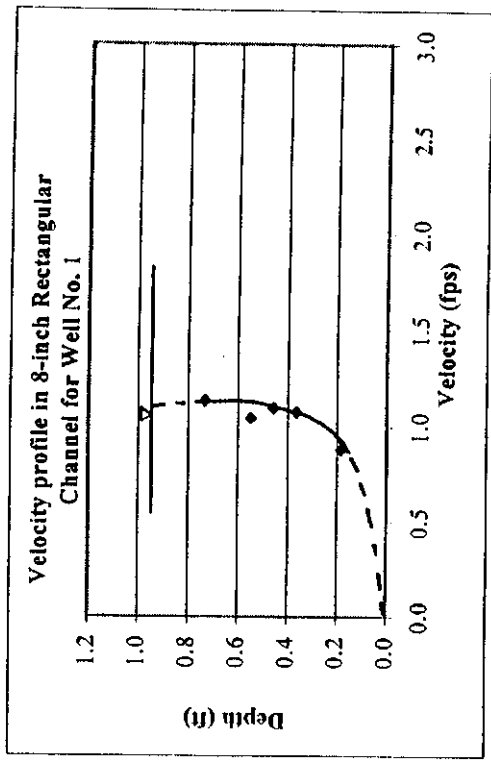


Figure B1. Velocity profile at mid-width in 8-inch Rectangular Channel for all four piezometer well ( $Q = 0.59$  cfs, flow depth = 0.92 ft).

Table B2. Calibration of 8-inch Rectangular Channel for flow measurement with a pygmy current meter (Q=0.71 cft, flow depth=0.94 ft).

Sr. No	h weir	Q weir	Width of channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(Cusecs )	(ft)	(ft)	(fps)	(ft)	(No.)	(sec.)	(fps)		
1	2	3	4	5	6	7	8	9	10	11	12
pz1	0.61	0.71	0.67	0.94	1.14	0.19	50	49.0	1.03	1.11	0.19
						0.38	60	53.0	1.14	1.00	0.21
						0.47	60	46.3	1.30	0.88	0.24
						0.56	60	46.0	1.30	0.87	0.24
						0.75	60	47.5	1.26	0.90	0.23
pz2	0.61	0.71	0.67	0.94	1.14	0.19	50	52.5	0.97	1.18	0.17
						0.38	60	49.0	1.23	0.93	0.22
						0.47	60	46.3	1.30	0.88	0.24
						0.56	60	46.5	1.29	0.88	0.23
						0.75	60	46.8	1.28	0.89	0.23
pz3	0.61	0.71	0.67	0.94	1.14	0.19	50	52.0	0.97	1.17	0.18
						0.38	60	49.0	1.23	0.93	0.22
						0.47	60	46.3	1.30	0.88	0.24
						0.56	60	46.0	1.30	0.87	0.24
						0.75	60	48.0	1.25	0.91	0.23
pz4	0.61	0.71	0.67	0.94	1.14	0.19	50	53.0	0.96	1.19	0.17
						0.38	60	48.3	1.25	0.91	0.23
						0.47	60	46.8	1.28	0.89	0.23
						0.56	60	46.5	1.29	0.88	0.23
						0.75	60	49.0	1.23	0.93	0.22

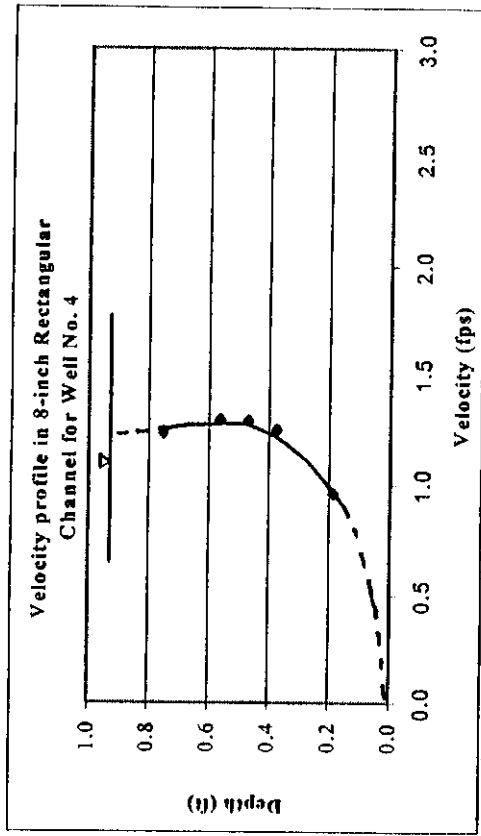
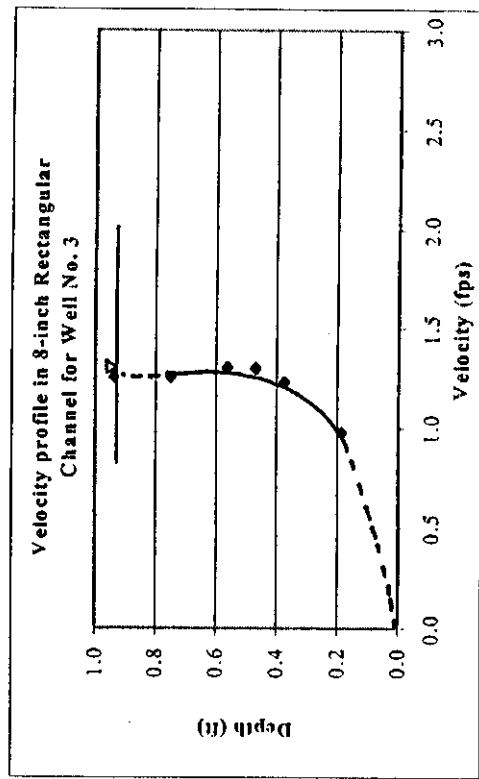
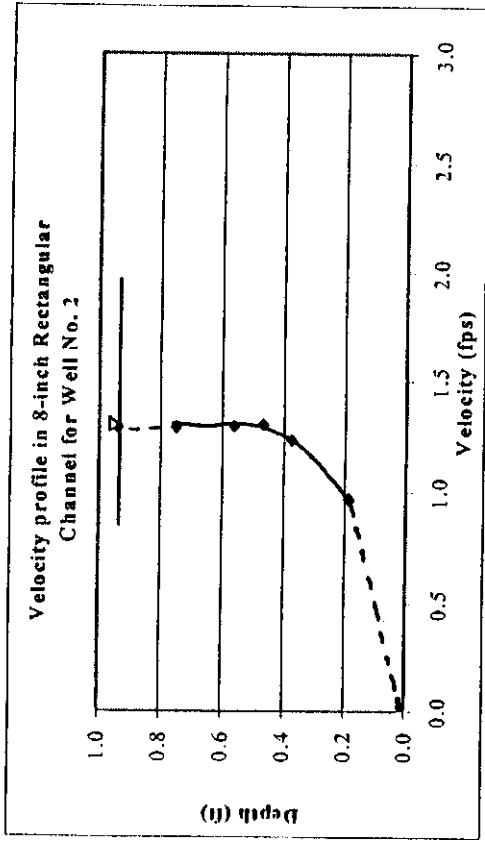
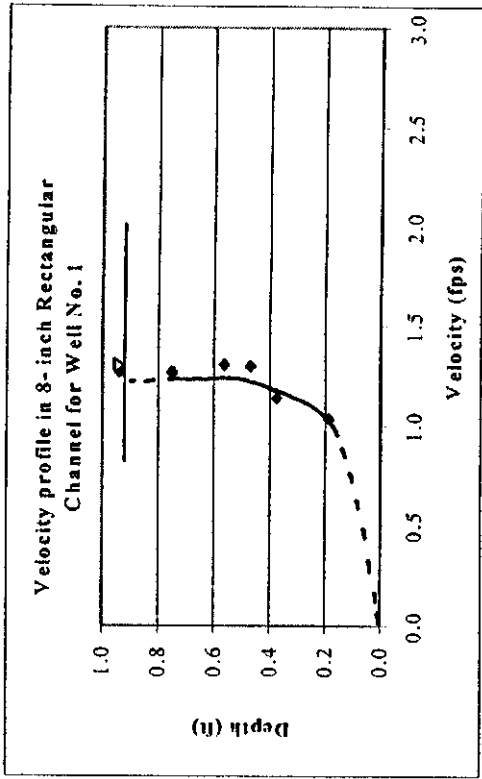


Figure B2. Velocity profile at mid-width in 8-inch Rectangular Channel for all four piezometer wells ( $Q = 0.71$  cfts, flow rate = 0.94 ft).



Table B3. Calibration of 8-inch Rectangular Channel for flow measurement with a pygmy current meter (Q = 0.43 cft, flow depth = 1.15 ft).

Sr. No	h weir	Q weir	Width of channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(Cusecs)	(ft)	(ft)	(fps)	(ft)	(no.)	(sec)	(fps)		
1	2	3	4	5	6	7	8	9	10	11	12
pz1	0.50	0.43	0.67	1.15	0.57	0.23	30	56.7	0.56	1.02	0.09
						0.46	40	65.1	0.64	0.89	0.11
						0.57	40	63.5	0.66	0.87	0.11
						0.69	40	65.9	0.63	0.90	0.10
						0.92	40	64.4	0.65	0.88	0.11
pz2	0.50	0.43	0.67	1.15	0.57	0.23	30	56.2	0.56	1.01	0.09
						0.46	40	65.9	0.63	0.90	0.10
						0.57	40	64.5	0.65	0.88	0.11
						0.69	40	66.5	0.63	0.91	0.10
						0.92	40	65.5	0.64	0.89	0.10
pz3	0.50	0.43	0.67	1.15	0.57	0.23	30	59.0	0.54	1.06	0.09
						0.46	40	64.9	0.64	0.89	0.11
						0.57	40	64.8	0.64	0.89	0.11
						0.69	40	64.6	0.65	0.88	0.11
						0.92	40	65.8	0.63	0.90	0.10
pz4	0.50	0.43	0.67	1.15	0.57	0.23	30	58.1	0.55	1.04	0.09
						0.46	40	65.1	0.64	0.89	0.11
						0.57	40	65.2	0.64	0.89	0.10
						0.69	40	66.0	0.63	0.90	0.10
						0.92	40	66.3	0.63	0.90	0.10

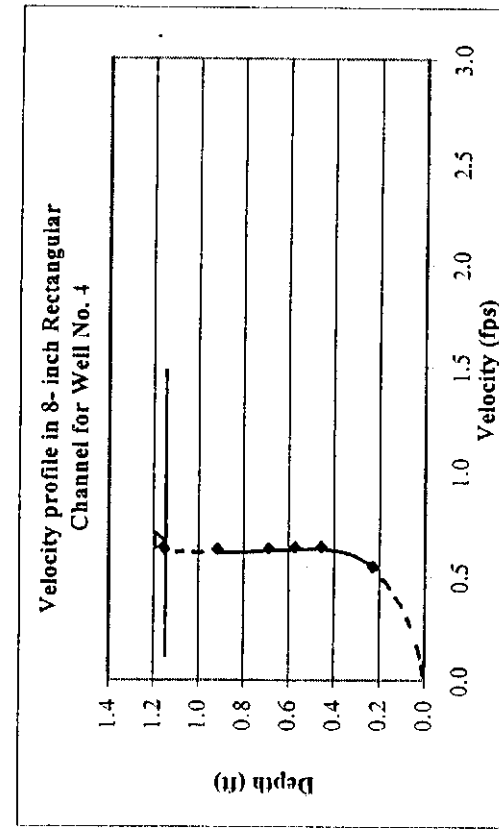
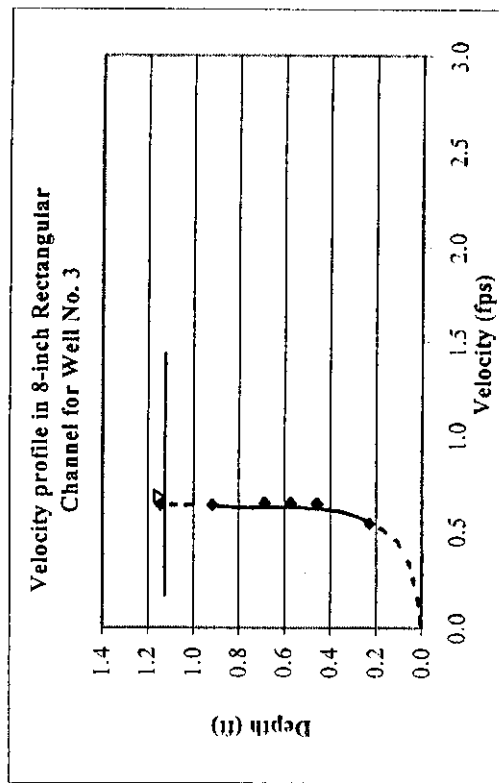
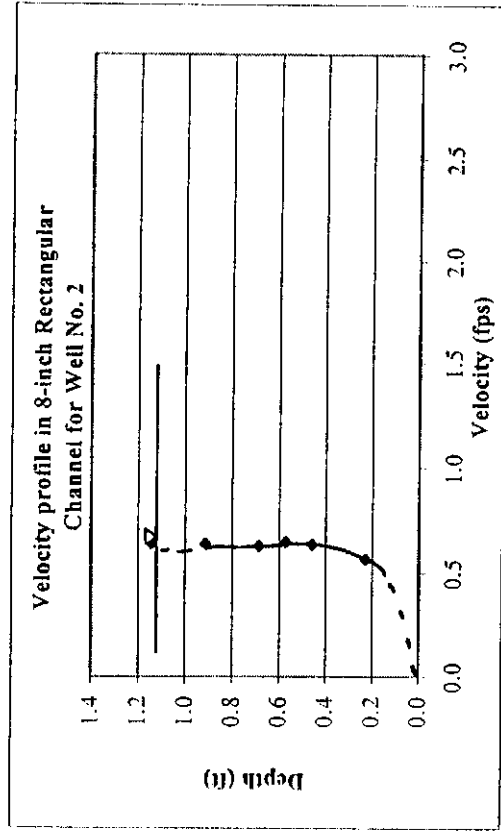
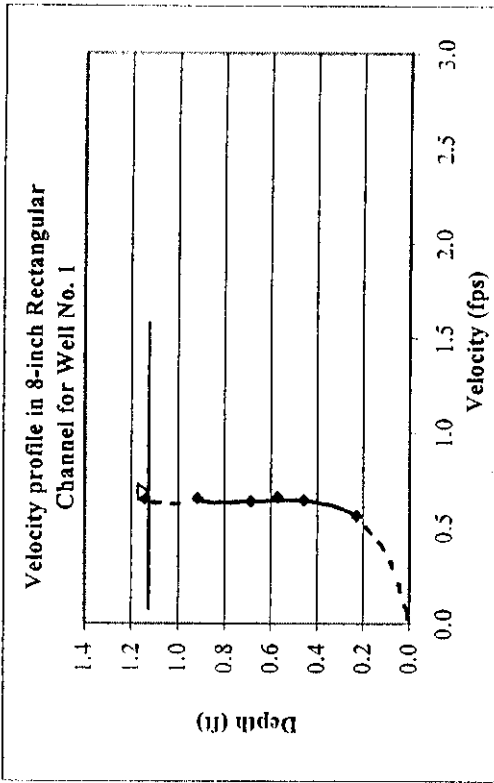


Figure B3. Velocity profile at mid-width in 8-inch Rectangular Channel for all four piezometer wells ( $Q = 0.43$  cfs, depth of flow = 1.15 ft).

Table B4. Calibration of 8-inch Rectangular Channel for flow measurement with a pygmy current meter (Q = 0.59 cft, flow depth = 0.92 ft).

Sr. No	h weir	Q weir	Width of channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(Cusecs)	(ft)	(ft)	(fps)	(ft)	(no.)	(sec)	(fps)		
1	2	3	4	5	6	7	8	9	10	11	12
pz1	0.56	0.59	0.67	1.18	0.75	0.24	40	55.8	0.74	1.02	0.12
						0.47	50	61.3	0.83	0.90	0.14
						0.59	50	61.0	0.84	0.90	0.14
						0.71	50	61.0	0.84	0.90	0.14
						0.94	50	62.0	0.83	0.91	0.13
pz2	0.56	0.59	0.67	1.18	0.75	0.24	40	55.5	0.74	1.01	0.12
						0.47	50	61.3	0.83	0.90	0.13
						0.59	50	60.8	0.84	0.89	0.14
						0.71	50	62.5	0.82	0.92	0.13
						0.94	50	62.7	0.82	0.92	0.13
pz3	0.56	0.59	0.67	1.18	0.75	0.24	40	56.3	0.73	1.02	0.12
						0.47	50	60.8	0.84	0.89	0.14
						0.59	50	59.8	0.85	0.88	0.14
						0.71	50	61.5	0.83	0.90	0.13
						0.94	50	61.8	0.83	0.91	0.13
pz4	0.56	0.59	0.67	1.18	0.75	0.24	40	56.8	0.73	1.03	0.12
						0.47	50	61.8	0.83	0.91	0.13
						0.59	50	60.0	0.85	0.88	0.14
						0.71	50	62.2	0.82	0.91	0.13
						0.94	50	63.1	0.81	0.93	0.13

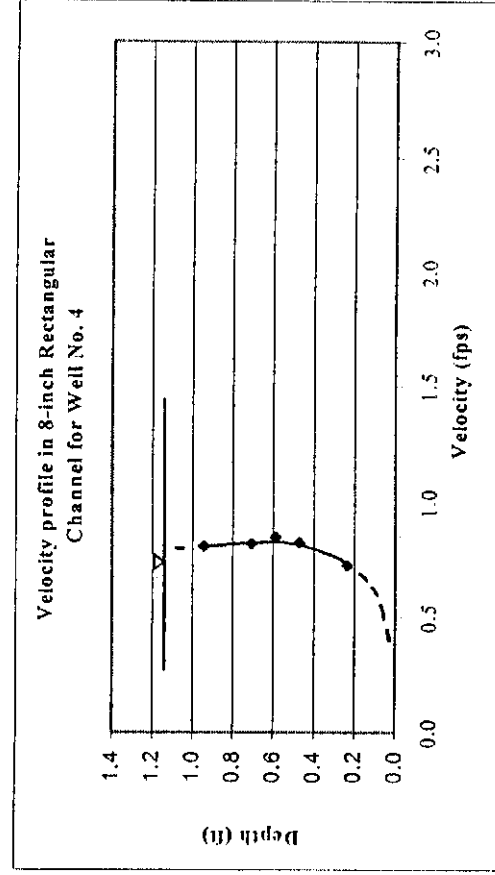
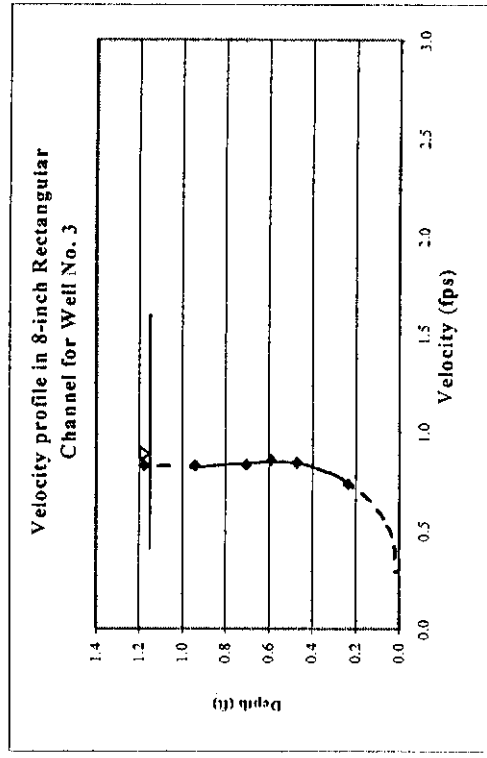
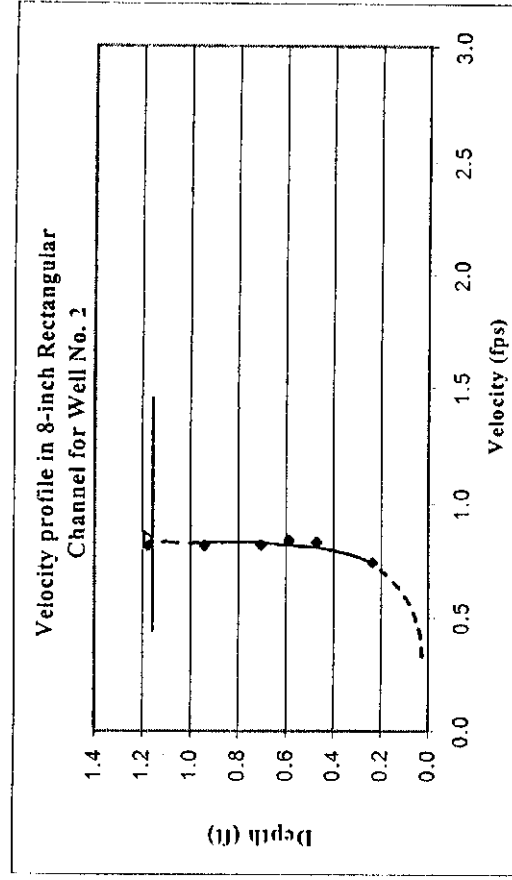
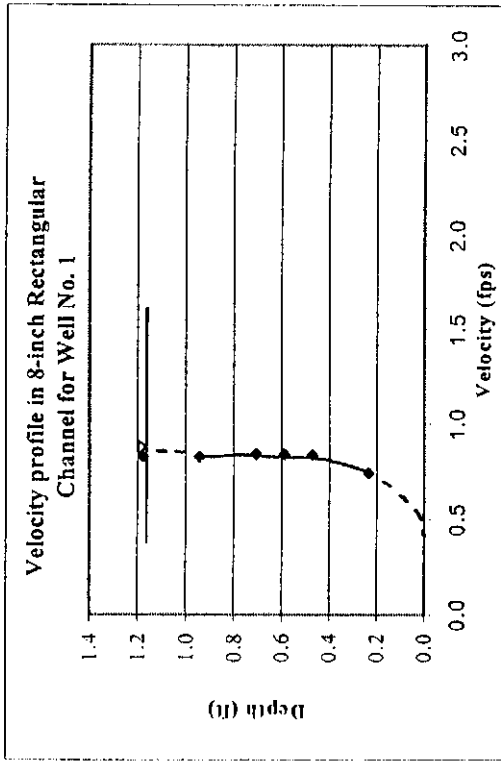


Figure B4. Velocity profile at mid width in 8-inch Rectangular Channel of all four piezometers ( $Q = 0.59$  cfs, depth of flow = 1.18)

Table B5. Calibration of 8-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 0.66$  cfs, flow depth = 1.20 ft).

Sr. No	h weir	Q weir	Width of channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(Cusecs)	(ft)	(ft)	(fps)	(ft)	(no.)	(sec)	(fps)		
1	2	3	4	5	6	7	8	9	10	11	12
pz1	0.59	0.66	0.67	1.20	0.83	0.24	40	55.0	0.75	1.10	0.12
						0.48	50	56.0	0.91	0.91	0.15
						0.60	50	54.0	0.94	0.88	0.15
						0.72	50	56.0	0.91	0.91	0.15
						0.96	50	56.4	0.90	0.92	0.14
pz2	0.59	0.66	0.67	1.20	0.83	0.24	40	56.0	0.74	1.12	0.12
						0.48	50	57.0	0.89	0.93	0.14
						0.60	50	55.0	0.92	0.90	0.15
						0.72	50	56.5	0.90	0.92	0.14
						0.96	50	57.1	0.89	0.93	0.14
pz3	0.59	0.66	0.67	1.20	0.83	0.24	40	55.5	0.74	1.11	0.12
						0.48	50	56.5	0.90	0.92	0.14
						0.60	50	55.1	0.92	0.90	0.15
						0.72	50	55.8	0.91	0.91	0.15
						0.96	50	56.8	0.90	0.92	0.14
pz4	0.59	0.66	0.67	1.20	0.83	0.24	40	57.0	0.72	1.14	0.12
						0.48	50	57.2	0.89	0.93	0.14
						0.60	50	55.2	0.92	0.90	0.15
						0.72	50	56.8	0.90	0.92	0.14
						0.96	50	57.2	0.89	0.93	0.14

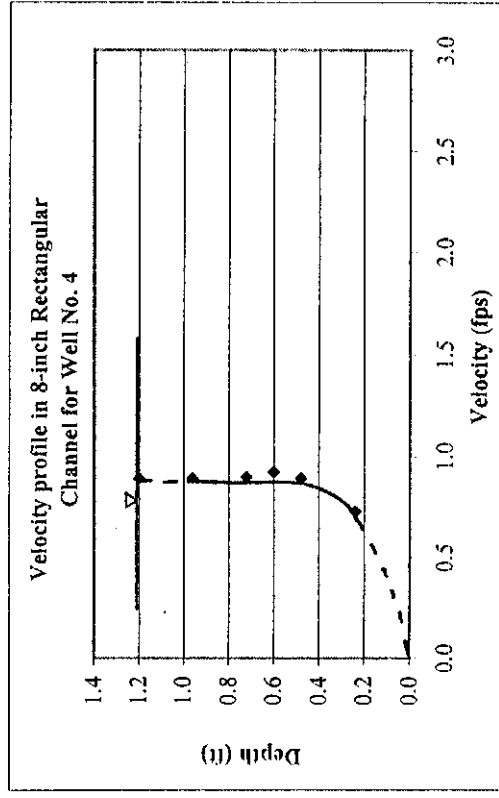
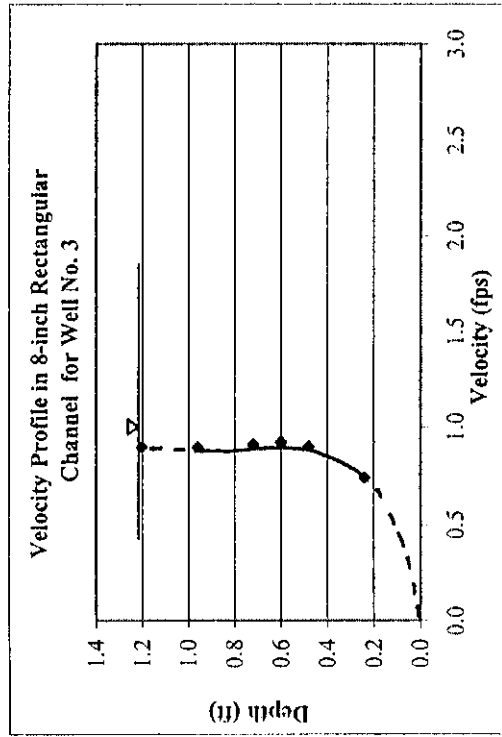
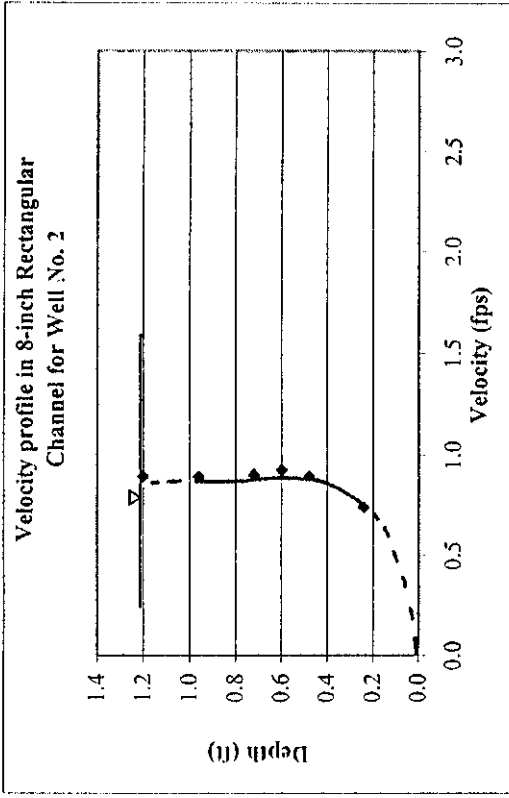
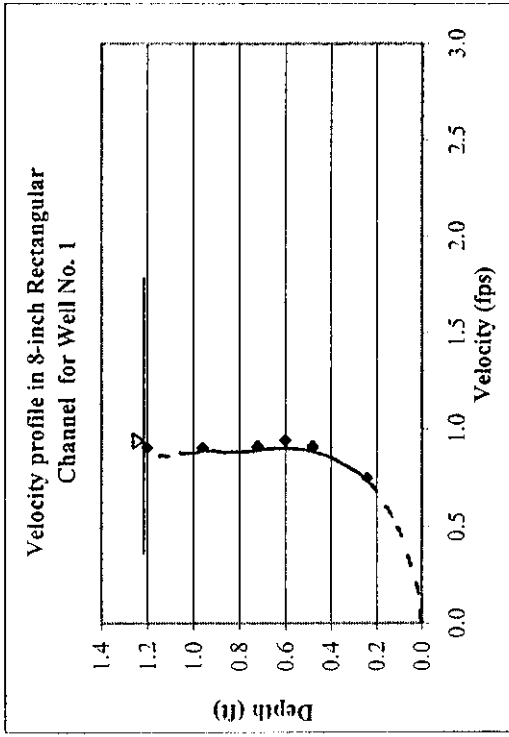


Figure B5. Velocity profile at mid-width in 8-inch Rectangular Channel for all four piezometer wells ( $Q = 0.66$  cfs, flow depth = 1.20 ft).

**ANNEX C. HYDRAULIC LABORATORY DATA FOR CALIBRATING 12- INCH  
RECTANGULAR CHANNEL.**

Table C1. Calibration of 12-inch Rectangular Channel for flow measurement with a pygmy current meter (Q=0.604 cft, flow depth =0.574 ft).

Sr. No	h weir	Q weir	Width of channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(cusecs)	(ft)	(ft)	(fps)	(ft)	(no.)	(sec)	(fps)		
1	2	3	4	5	6	7	8	9	10	11	12
pz1	0.57	0.60	1.02	0.57	1.04	0.11	50	52.0	0.97	1.06	0.23
						0.23	50	42.0	1.19	0.87	0.28
						0.29	50	42.2	1.19	0.87	0.28
						0.34	50	42.1	1.19	0.87	0.28
						0.46	50	43.0	1.17	0.89	0.27
pz2	0.57	0.60	1.02	0.57	1.04	0.11	50	53.0	0.96	1.08	0.22
						0.23	50	42.8	1.17	0.88	0.27
						0.29	50	42.0	1.19	0.87	0.28
						0.34	50	42.6	1.18	0.88	0.27
						0.46	50	42.8	1.17	0.88	0.27
pz3	0.57	0.60	1.02	0.57	1.04	0.11	50	54.1	0.94	1.10	0.22
						0.23	50	43.5	1.15	0.90	0.27
						0.29	50	42.8	1.17	0.88	0.27
						0.34	50	42.8	1.17	0.88	0.27
						0.46	50	42.0	1.19	0.87	0.28
pz4	0.57	0.60	1.02	0.57	1.04	0.11	50	56.0	0.91	1.14	0.21
						0.23	50	44.2	1.14	0.91	0.26
						0.29	50	43.1	1.16	0.89	0.27
						0.34	50	43.0	1.17	0.89	0.27
						0.46	50	42.8	1.17	0.88	0.27

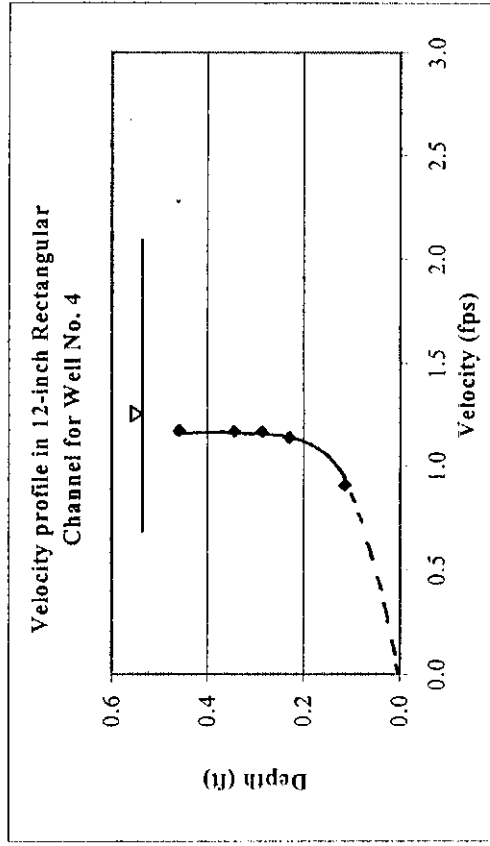
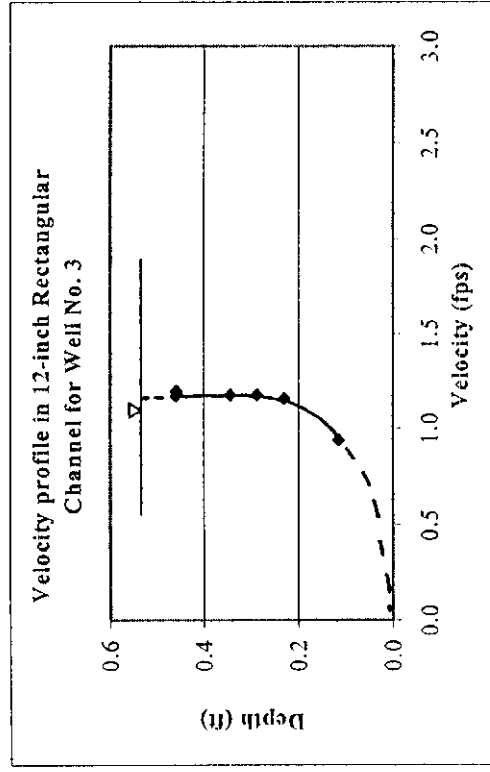
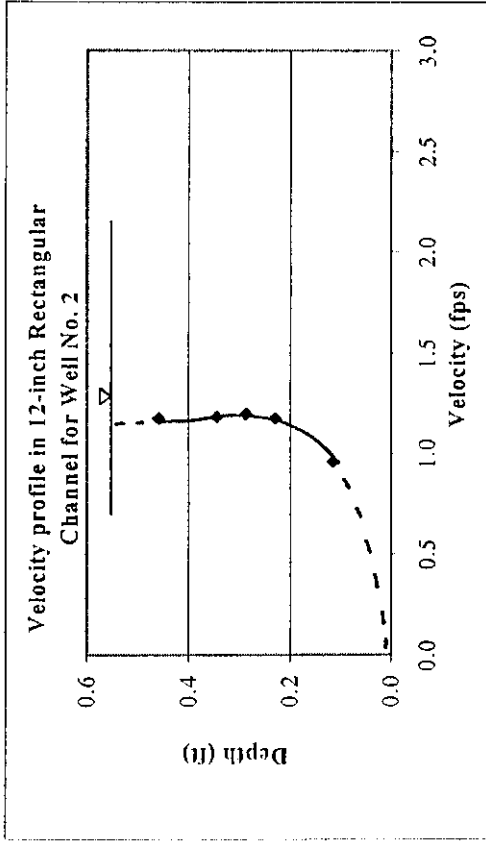
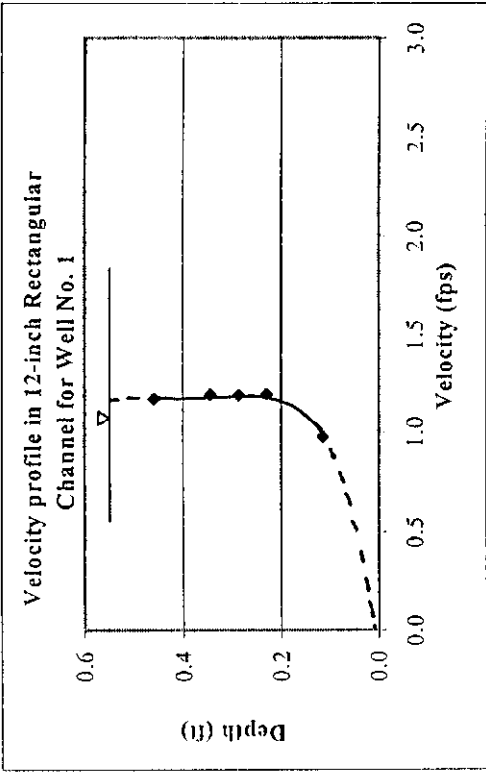


Figure C1. Velocity profile at mid-width in 12-inch Rectangular Channel for all four piezometer wells ( $Q = 0.604$  cfs, flow depth = 0.574 ft).



Table C2. Calibration of 12-inch Rectangular Channel for flow measurement with a pygmy current meter (Q=0.72 cft, flow depth=0.85 ft).

Sr. No	h weir	Q weir	Width of channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(cusecs)	(ft)	(ft)	(fps)	(ft)	(No.)	(sec.)	(fps)		
1	2	3	4	5	6	7	8	9	10	11	12
pz1	0.60	0.72	1.02	0.85	0.83	0.17	50	59.5	0.86	0.97	0.16
						0.34	50	52.5	0.97	0.87	0.18
						0.43	50	52.7	0.96	0.87	0.18
						0.51	50	52.1	0.97	0.86	0.19
						0.68	50	52.0	0.97	0.86	0.19
pz2	0.60	0.72	1.02	0.85	0.83	0.17	50	60.5	0.84	0.99	0.16
						0.34	50	53.5	0.95	0.88	0.18
						0.43	50	53.6	0.95	0.89	0.18
						0.51	50	53.0	0.96	0.88	0.18
						0.68	50	52.9	0.96	0.88	0.18
pz3	0.60	0.72	1.02	0.85	0.83	0.17	50	61.0	0.84	1.00	0.16
						0.34	50	53.4	0.95	0.89	0.18
						0.43	50	53.8	0.94	0.89	0.18
						0.51	50	53.8	0.94	0.89	0.18
						0.68	50	53.0	0.96	0.88	0.18
pz4	0.60	0.72	1.02	0.85	0.83	0.17	50	61.5	0.83	1.01	0.16
						0.34	50	53.0	0.96	0.88	0.18
						0.43	50	53.3	0.95	0.88	0.18
						0.51	50	53.0	0.96	0.88	0.18
						0.68	50	53.3	0.95	0.88	0.18

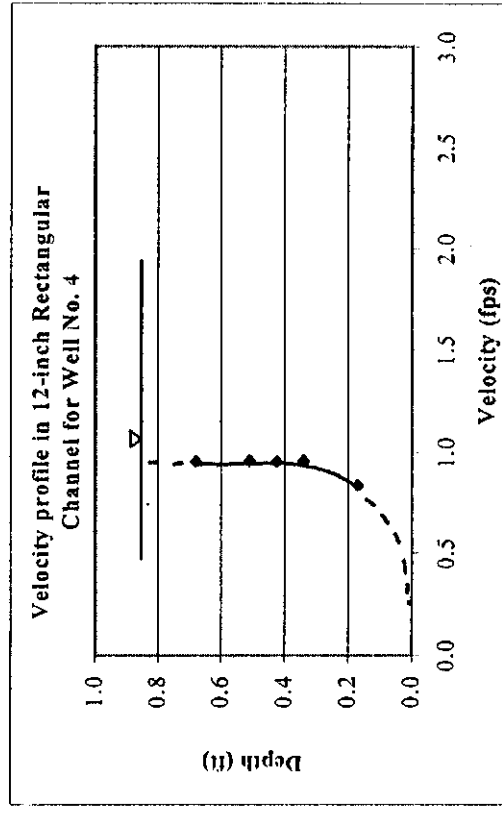
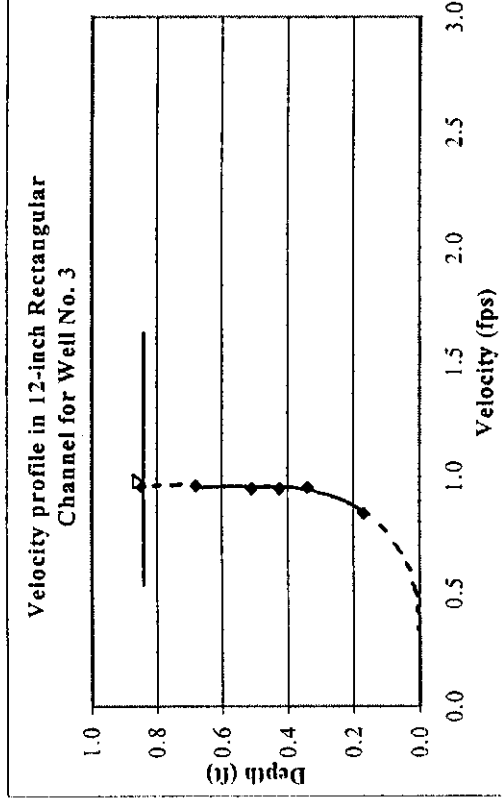
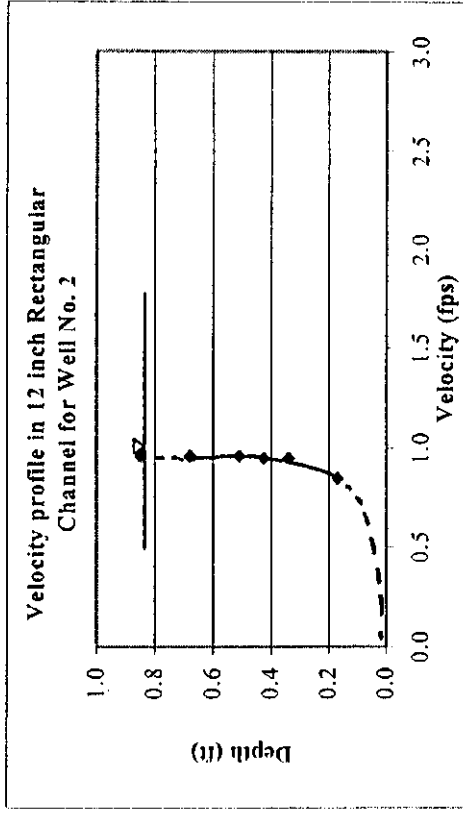
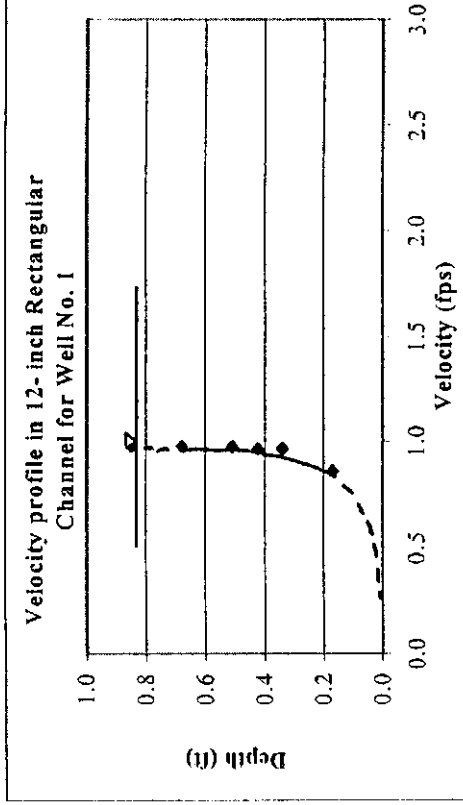


Figure C2. Velocity profile at mid-width in 12-inch Rectangular Channel for all four piezometer wells ( $Q = 0.72$  cfs, flow rate =  $0.85$  ft).

Table C3. Calibration of 12-inch Rectangular Channel for flow measurement with a pygmy current meter (Q = 1.15 cft, flow depth = 1.10 ft).

Sr. No	h weir	Q weir	Width of channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(cusecs)	(ft)	(ft)	(fps)	ft	no.	sec	fps		
1	2	3	4	5	6	7	8	9	10	11	12
pz1	0.73	1.15	1.02	1.10	1.03	0.22	50	47.0	1.07	0.96	0.18
						0.44	60	52.5	1.15	0.90	0.19
						0.55	60	51.0	1.18	0.87	0.20
						0.66	60	52.0	1.16	0.89	0.19
						0.88	60	52.3	1.15	0.89	0.19
pz2	0.73	1.15	1.02	1.10	1.03	0.22	50	49.0	1.03	1.00	0.17
						0.44	60	53.0	1.14	0.90	0.19
						0.55	60	51.5	1.17	0.88	0.20
						0.66	60	52.0	1.16	0.89	0.19
						0.88	60	53.9	1.12	0.92	0.19
pz3	0.73	1.15	1.02	1.10	1.03	0.22	50	53.0	0.96	1.08	0.16
						0.44	60	53.0	1.14	0.90	0.19
						0.55	60	51.5	1.17	0.88	0.20
						0.66	60	53.0	1.14	0.90	0.19
						0.88	60	54.5	1.11	0.93	0.19
pz4	0.73	1.15	1.02	1.10	1.03	0.22	50	53.0	0.96	1.08	0.16
						0.44	60	54.0	1.12	0.92	0.19
						0.55	60	52.4	1.15	0.89	0.19
						0.66	60	54.0	1.12	0.92	0.19
						0.88	60	55.0	1.10	0.94	0.18

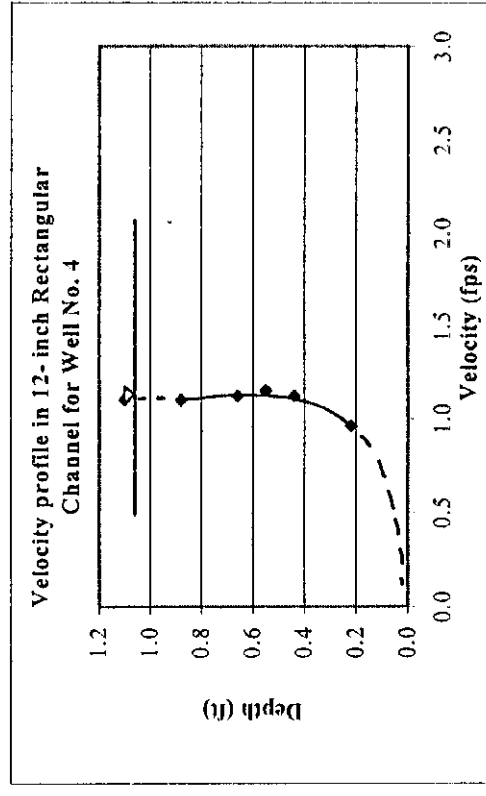
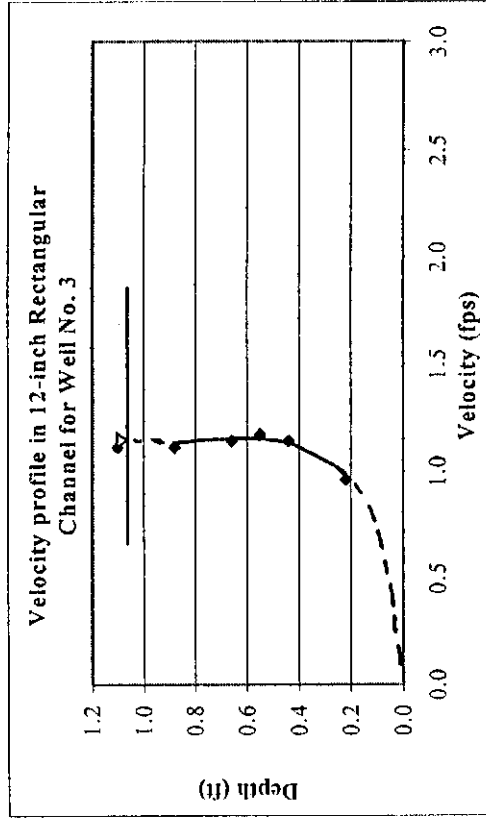
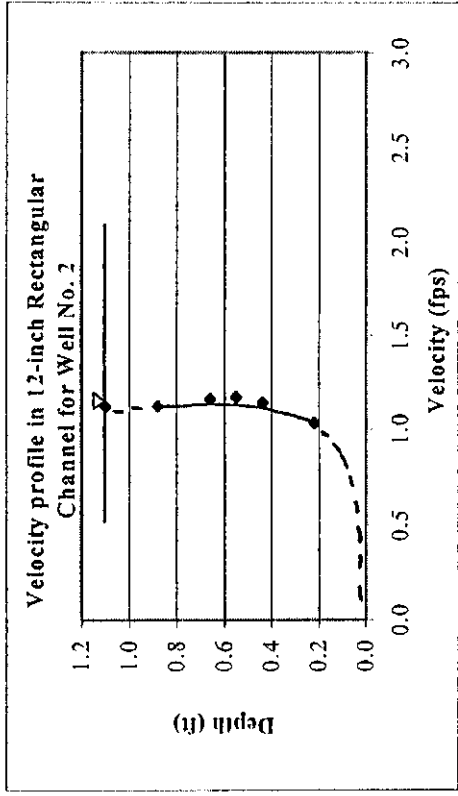
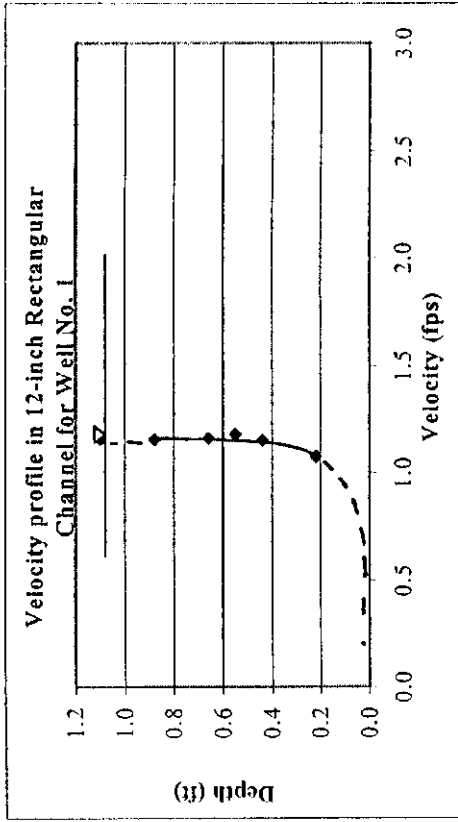


Figure C3. Velocity profile at mid-width in 12- inch Rectangular Channel for all four piezometer wells ( $Q = 1.15$  cfs, flow depth = 1.10 ft).

Table C4. Calibration of 12-inch Rectangular Channel for flow measurement with a pygmy current meter (Q = 1.18 cft, flow depth = 1.30 ft).

Sr. No	h weir	Q weir	Width of channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(cusecs)	(ft)	(ft)	(fps)	(ft)	(no.)	(sec)	(fps)		
1	2	3	4	5	6	7	8	9	10	11	12
pz1	0.74	1.18	1.02	1.30	0.89	0.26	40	46.0	0.89	1.01	0.14
						0.52	50	49.0	1.03	0.87	0.16
						0.65	50	48.4	1.04	0.86	0.16
						0.78	50	48.5	1.04	0.86	0.16
						1.04	50	53.0	0.96	0.94	0.15
pz2	0.74	1.18	1.02	1.30	0.89	0.26	40	45.0	0.90	0.99	0.14
						0.52	50	51.0	0.99	0.90	0.15
						0.65	50	48.5	1.04	0.86	0.16
						0.78	50	49.3	1.02	0.87	0.16
						1.04	50	52.0	0.97	0.92	0.15
pz3	0.74	1.18	1.02	1.30	0.89	0.26	40	48.5	0.84	1.06	0.13
						0.52	50	52.0	0.97	0.92	0.15
						0.65	50	49.0	1.03	0.87	0.16
						0.78	50	49.3	1.03	0.87	0.16
						1.04	50	51.0	0.99	0.90	0.15
pz4	0.74	1.18	1.02	1.30	0.89	0.26	40	50.0	0.82	1.09	0.13
						0.52	50	53.0	0.96	0.94	0.15
						0.65	50	50.0	1.01	0.89	0.16
						0.78	50	51.0	0.99	0.90	0.15
						1.04	50	54.0	0.94	0.95	0.14

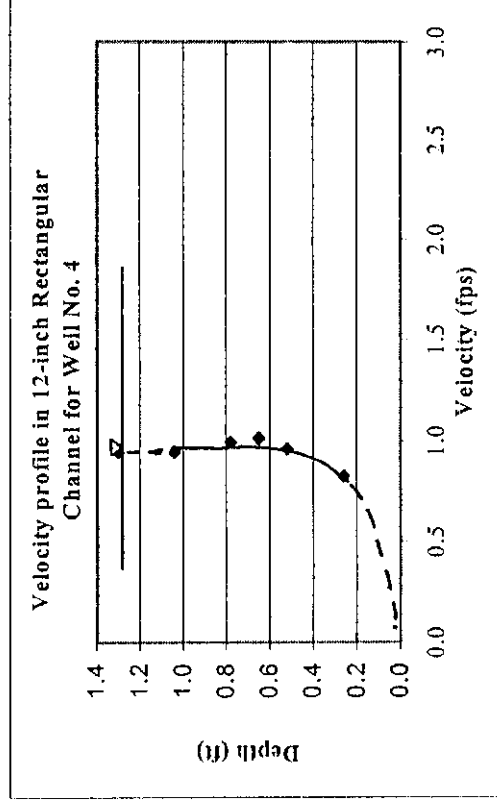
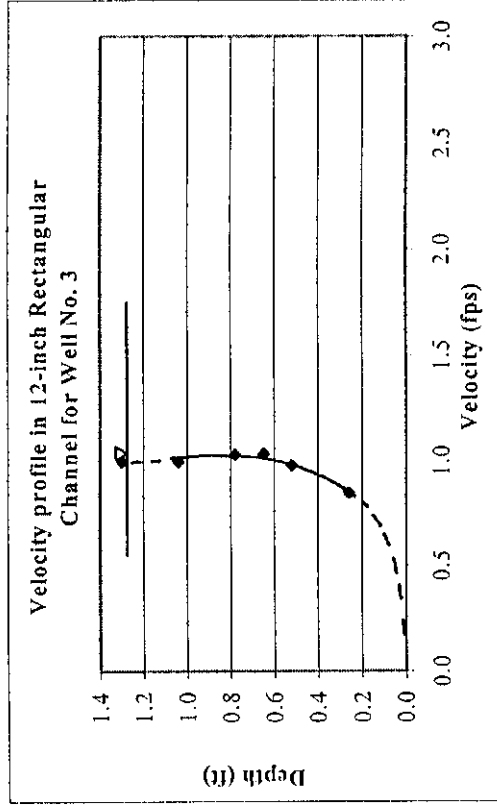
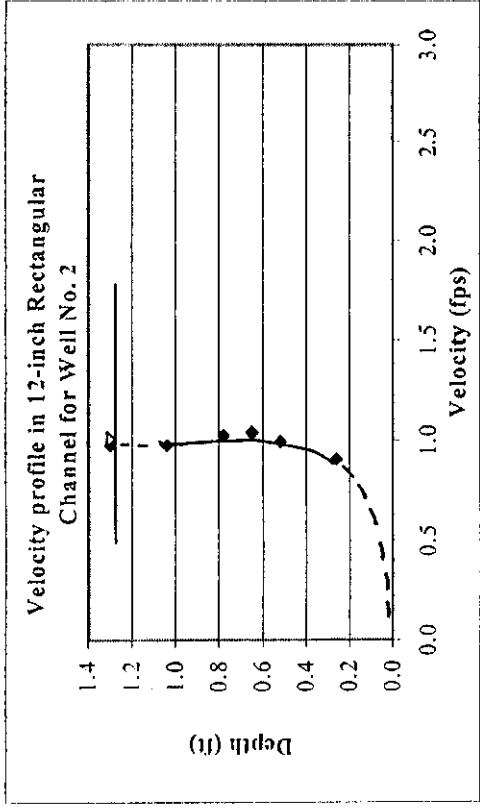
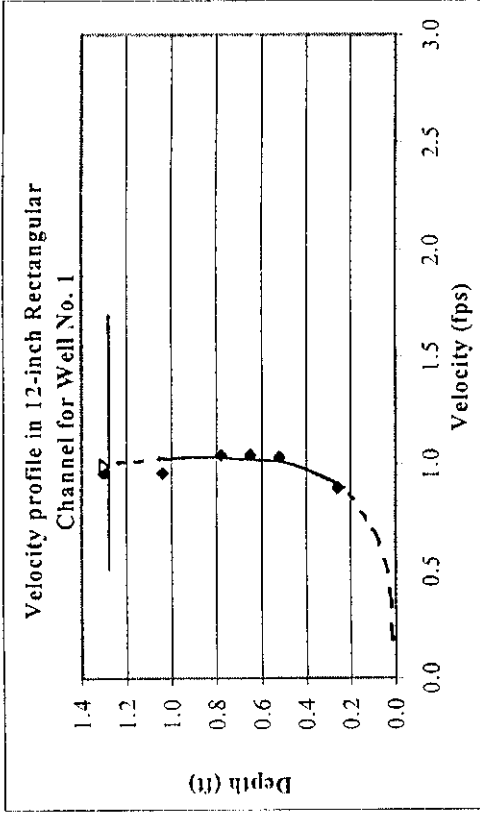


Figure C4. Velocity profile at mid-width in 12-inch Rectangular Channel for all four piezometer wells ( $Q = 1.18$  cfs, depth of flow = 1.30).

Table C5. Calibration of 8-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 0.75$  cfs, flow depth = 1.31 ft).

Sr. No	h weir	Q weir	Width of channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(cusecs)	(ft)	(ft)	(fps)	(ft)	(no.)	(sec)	(fps)		
1	2	3	4	5	6	7	8	9	10	11	12
pz1	0.62	0.75	1.02	1.31	0.56	0.26	30	55.0	0.57	0.98	0.09
						0.52	30	50.2	0.62	0.90	0.10
						0.66	30	49.5	0.63	0.89	0.10
						0.79	30	49.0	0.64	0.88	0.10
						1.05	30	50.0	0.63	0.90	0.10
pz2	0.62	0.75	1.02	1.31	0.56	0.26	30	54.6	0.58	0.98	0.09
						0.52	30	50.0	0.63	0.90	0.10
						0.66	30	49.0	0.64	0.88	0.10
						0.79	30	49.0	0.64	0.88	0.10
						1.05	30	51.0	0.62	0.92	0.09
pz3	0.62	0.75	1.02	1.31	0.56	0.26	30	54.4	0.58	0.97	0.09
						0.52	30	50.0	0.63	0.90	0.10
						0.66	30	49.5	0.63	0.89	0.10
						0.79	30	49.5	0.63	0.89	0.10
						1.05	30	52.0	0.60	0.93	0.09
pz4	0.62	0.75	1.02	1.31	0.56	0.26	30	54.8	0.58	0.98	0.09
						0.52	30	49.8	0.63	0.90	0.10
						0.66	30	49.5	0.63	0.89	0.10
						0.79	30	50.0	0.63	0.90	0.10
						1.05	30	50.5	0.62	0.91	0.10

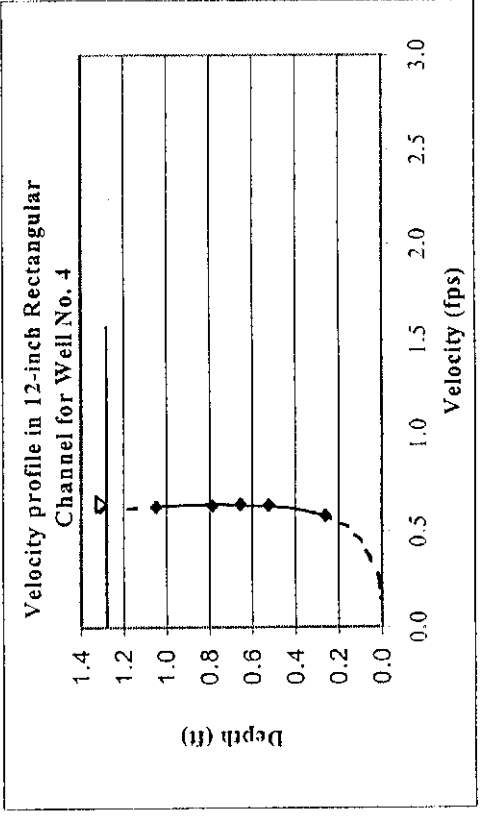
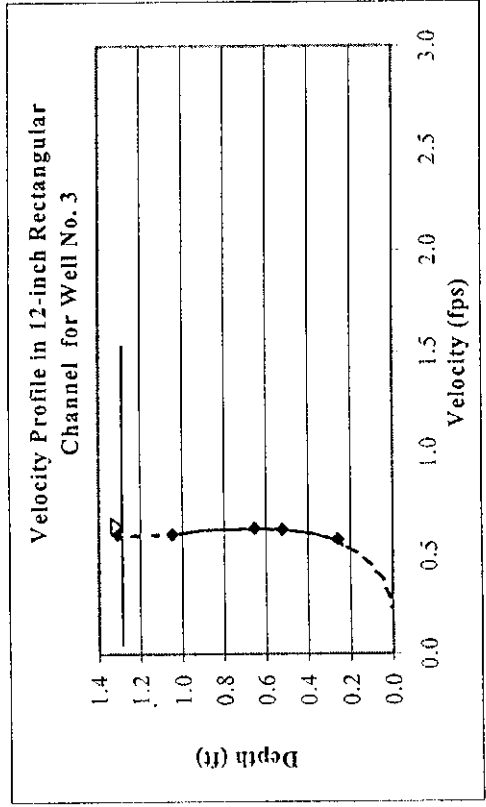
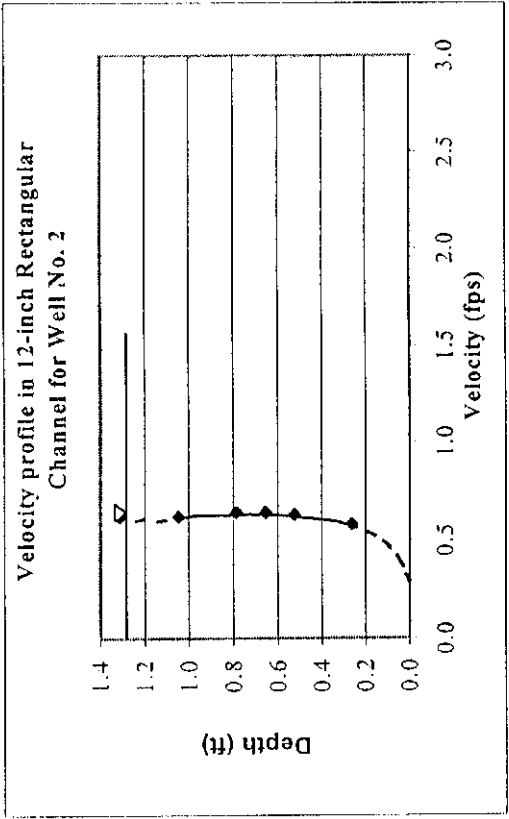
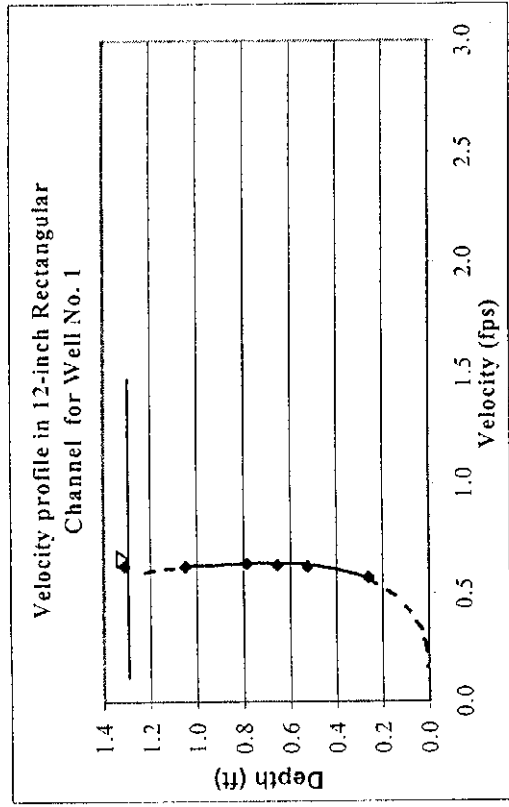


Figure C5. Velocity profile at mid-width in 12-inch Rectangular Channel for all four piezometer wells ( $Q = 1.31$  cfs, flow depth = 1.31 ft).



**ANNEX D. HYDRAULIC LABORATORY DATA FOR CALIBRATION OF 18-INCH RECTANGULAR CHANNEL.**

Table D1. Calibration of 18-inch Rectangular Channel for flow measurement with a pygmy current meter (Q = 0.89 cfs, flow depth = 0.45 ft) .

Sr. No	h weir	Q weir	Width of channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(cusecs)	(ft)	(ft)	(fps)	(ft)	(no.)	(sec)	(fps)		
1	2	3	4	5	6	7	8	9	10	11	12
pz1	0.66	0.89	1.5	0.45	1.32	0.09	60	47	1.28	1.03	0.33
						0.18	80	54	1.47	0.90	0.39
						0.22	80	53.5	1.49	0.89	0.39
						0.27	80	53	1.50	0.88	0.39
						0.36	80	53.5	1.49	0.89	0.39
pz2	0.66	0.89	1.5	0.45	1.32	0.09	60	47	1.28	1.03	0.33
						0.18	80	56	1.42	0.93	0.37
						0.22	80	53	1.50	0.88	0.39
						0.27	80	54	1.47	0.90	0.39
						0.36	80	58.5	1.36	0.97	0.36
pz3	0.66	0.89	1.5	0.45	1.32	0.09	60	46	1.30	1.01	0.34
						0.18	80	55	1.45	0.91	0.38
						0.22	80	53	1.50	0.88	0.39
						0.27	80	53	1.50	0.88	0.39
						0.36	80	55	1.45	0.91	0.38
pz4	0.66	0.89	1.5	0.45	1.32	0.09	60	45	1.33	0.99	0.35
						0.18	80	55	1.45	0.91	0.38
						0.22	80	52.5	1.51	0.87	0.40
						0.27	80	52.5	1.51	0.87	0.40
						0.36	80	55.5	1.44	0.92	0.38

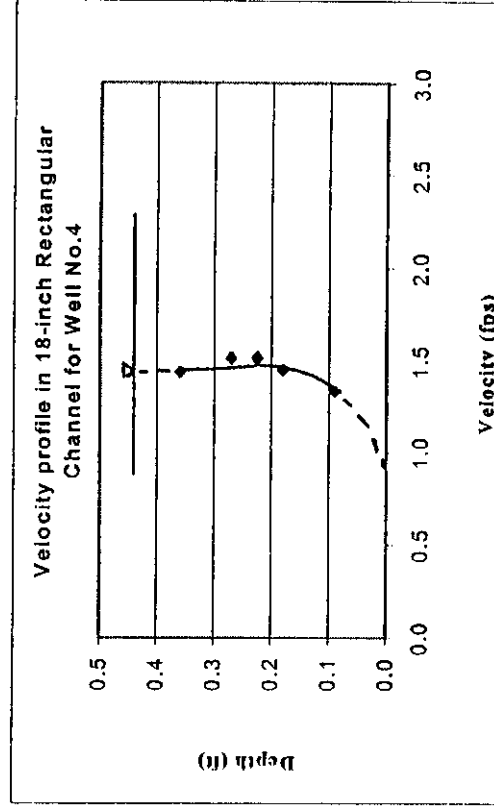
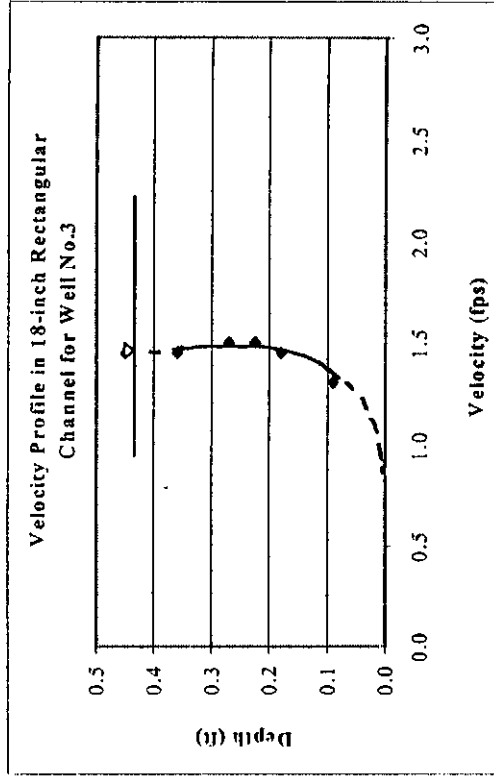
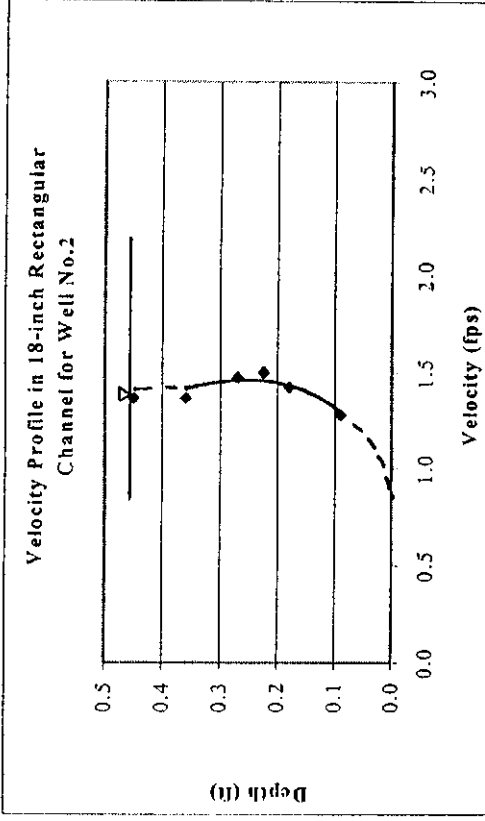
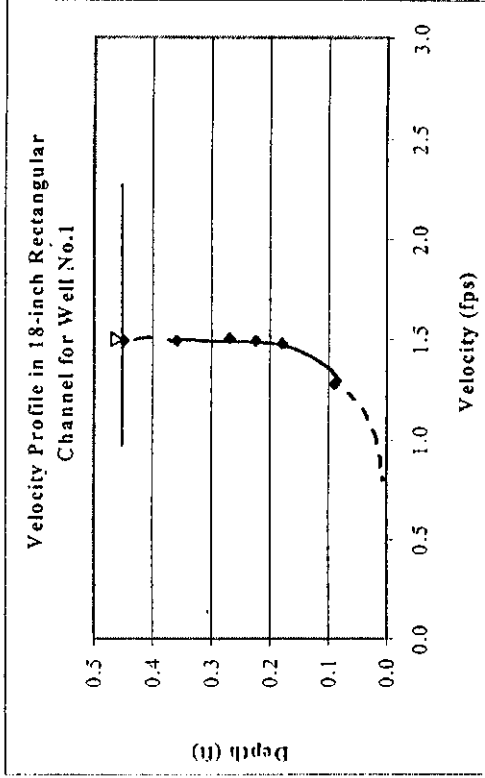


Figure D1. Velocity profile at mid-width in 18-inch Rectangular Channel for all four piezometer wells ( $Q = 0.89$  cfs, flow depth = 0.45 ft).

Table D2. Calibration of 18-inch Rectangular Channel for flow measurement with a pygmy current meter (Q = 0.89 cfs, flow depth = 0.55 ft).

Sr. No	h weir	Q weir	Width of channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(cusecs)	(ft)	(ft)	(fps)	(ft)	(no.)	(sec)	(fps)		
1	2	3	4	5	6	7	8	9	10	11	12
pz1	0.6603	0.89	1.5	0.55	1.07	0.11	50	50	1.01	1.06	0.24
						0.22	60	50	1.20	0.89	0.28
						0.28	60	48	1.25	0.86	0.30
						0.33	60	48	1.25	0.86	0.30
						0.44	60	50	1.20	0.89	0.28
pz2	0.66	0.89	1.5	0.55	1.07	0.11	50	48	1.05	1.02	0.25
						0.22	60	50	1.20	0.89	0.28
						0.28	60	49	1.23	0.87	0.29
						0.33	60	48	1.25	0.86	0.30
						0.44	60	49.5	1.21	0.88	0.29
pz3	0.66	0.89	1.5	0.55	1.07	0.11	50	48	1.05	1.02	0.25
						0.22	60	50	1.20	0.89	0.28
						0.28	60	49	1.23	0.87	0.29
						0.33	60	48	1.25	0.86	0.30
						0.44	60	50.5	1.19	0.90	0.28
pz4	0.66	0.89	1.5	0.55	1.07	0.11	50	49	1.03	1.04	0.24
						0.22	60	49.5	1.21	0.88	0.29
						0.28	60	49.5	1.21	0.88	0.29
						0.33	60	47.5	1.26	0.85	0.30
						0.44	60	49.5	1.21	0.88	0.29

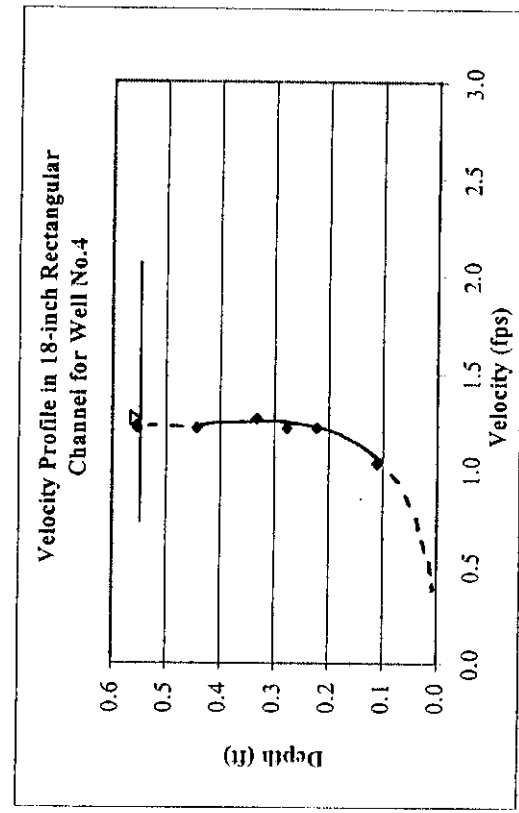
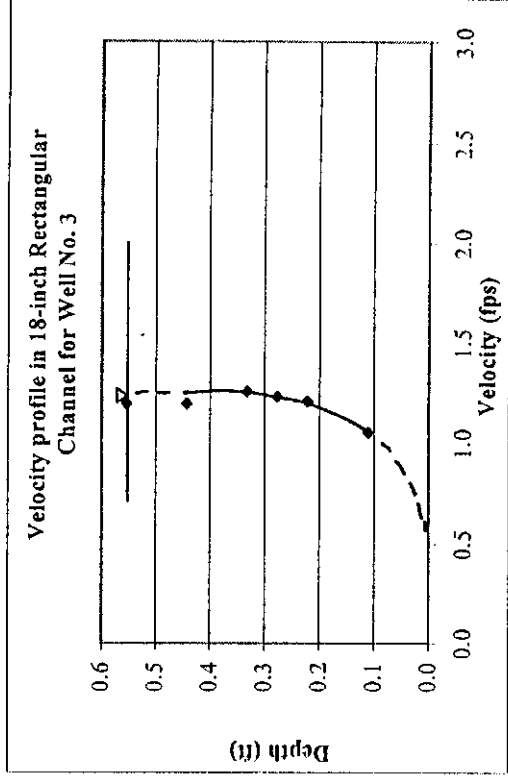
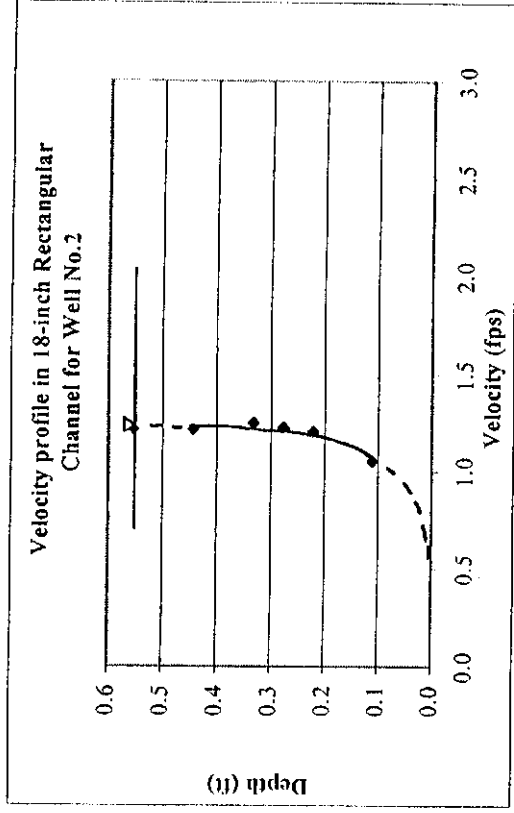
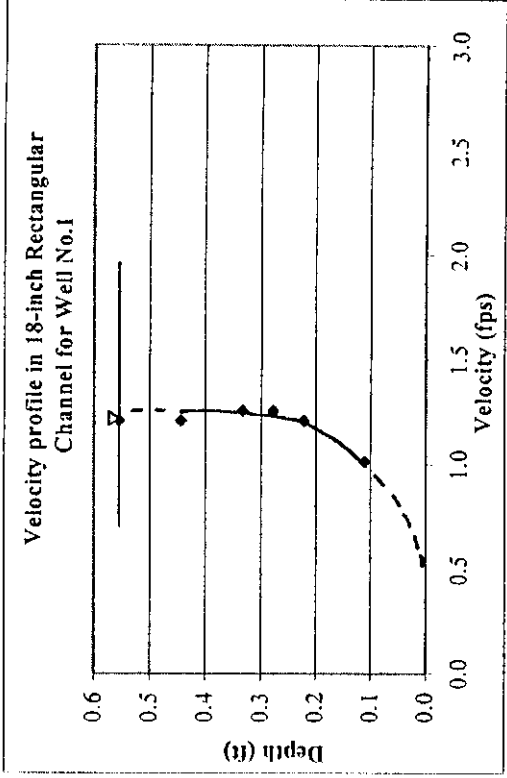


Figure D2. Velocity profile at mid-width in 18-inch Rectangular Channel for all four piezometer wells ( $Q = 0.89$  cfs, flow depth = 0.55 ft).

Table D3. Calibration of 18-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 0.71$  cfs, flow depth = 0.75 ft).

Sr. No	h weir	Q weir	Width of Channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(cusecs)	(ft)	(ft)	(fps)	(ft)	(no.)	(sec)	(fps)		
1	2	3	4	5	6	7	8	9	9	10	12
pz1	0.60	0.71	1.5	0.75	0.62	0.15	25	51.25	0.52	1.20	0.10
						0.30	40	62	0.67	0.93	0.14
						0.38	40	59.1	0.70	0.89	0.14
						0.45	40	59	0.70	0.89	0.14
						0.60	40	58.4	0.71	0.88	0.14
pz2	0.60	0.71	1.5	0.75	0.62	0.15	25	51.25	0.52	1.20	0.10
						0.30	40	63	0.66	0.94	0.13
						0.38	40	59.4	0.70	0.89	0.14
						0.45	40	60	0.69	0.90	0.14
						0.60	40	60	0.69	0.90	0.14
pz3	0.60	0.71	1.5	0.75	0.62	0.15	25	51	0.52	1.20	0.11
						0.30	40	63	0.66	0.94	0.13
						0.38	40	59.5	0.70	0.90	0.14
						0.45	40	58.5	0.71	0.88	0.14
						0.60	40	61	0.68	0.92	0.14
pz4	0.60	0.71	1.5	0.75	0.62	0.15	25	52	0.51	1.22	0.10
						0.30	40	61.5	0.68	0.92	0.14
						0.38	40	59.8	0.69	0.90	0.14
						0.45	40	58	0.71	0.87	0.14
						0.60	40	60	0.69	0.90	0.14

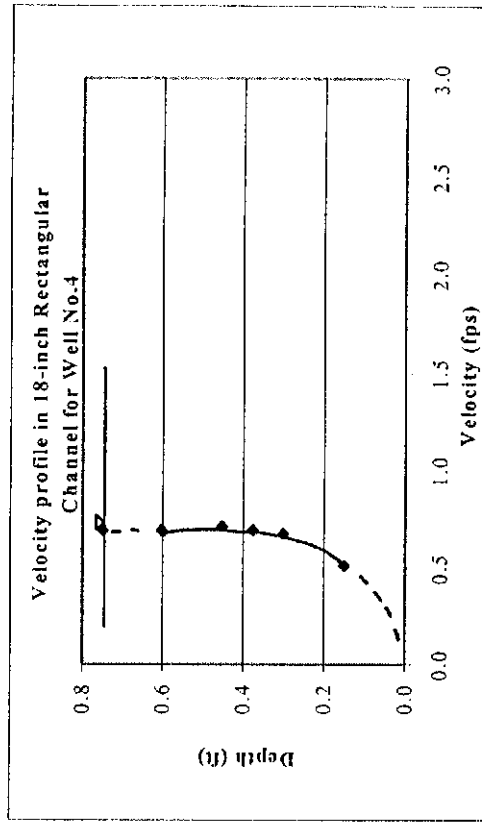
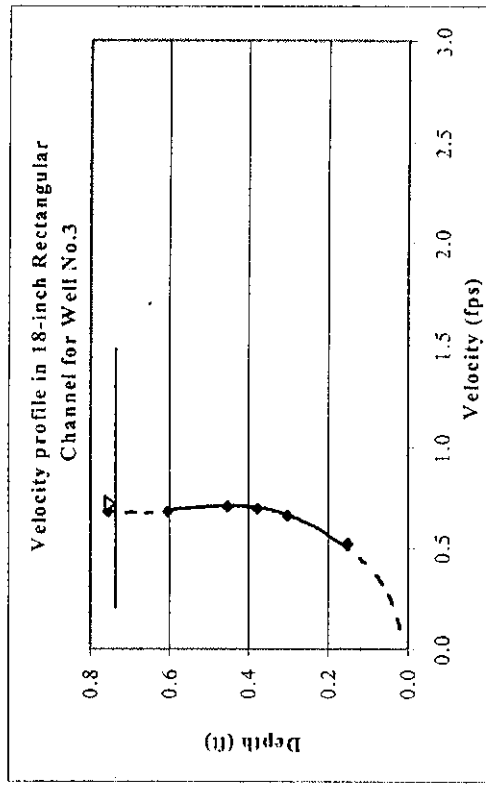
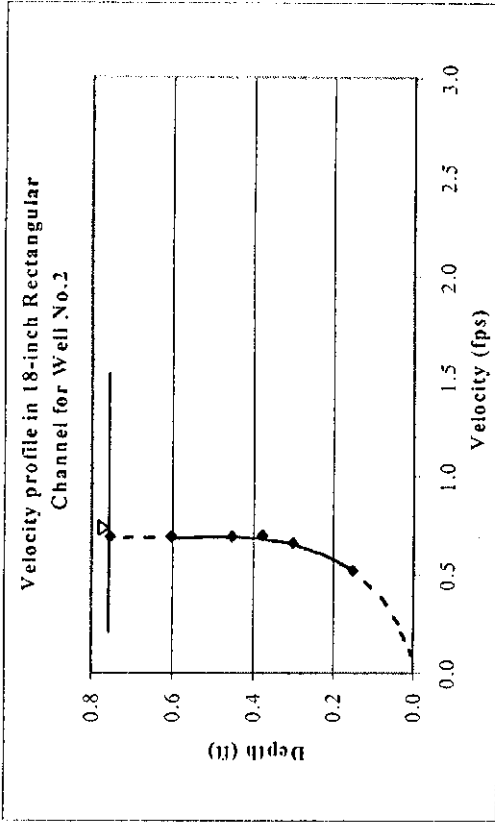
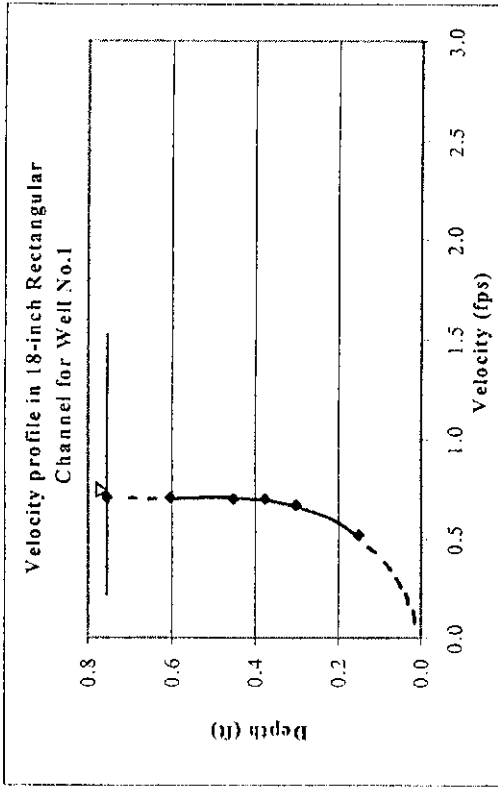


Figure D3. Velocity profile at mid-width in 18-inch Rectangular Channel for all four piezometer wells ( $Q = 0.71$  cfs, flow depth = 0.75 ft).

Table D4. Calibration of 18-inch Rectangular Channel for flow measurement with a pygmy current meter (Q = 0.74 cfs, flow depth = 1.03 ft).

Sr. No	h weir	Q weir	Width of channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(cusecs)	(ft)	(ft)	(fps)	(ft)	(no.)	(sec)	(fps)		
1	2	3	4	5	6	7	8	9	10	11	12
pz1	0.61	0.74	1.5	1.03	0.48	0.21	25	62.5	0.43	1.10	0.08
						0.41	30	59.7	0.53	0.90	0.09
						0.51	30	59	0.54	0.89	0.09
						0.62	30	58	0.55	0.87	0.09
						0.82	30	59.5	0.53	0.89	0.09
pz2	0.61	0.74	1.5	1.03	0.48	0.21	25	59.5	0.45	1.05	0.08
						0.41	30	59.5	0.53	0.89	0.09
						0.51	30	59	0.54	0.89	0.09
						0.62	30	59	0.54	0.89	0.09
						0.82	30	59.3	0.54	0.89	0.09
pz3	0.61	0.74	1.5	1.03	0.48	0.21	25	59.3	0.46	1.05	0.08
						0.41	30	60	0.53	0.90	0.09
						0.51	30	58.5	0.54	0.88	0.09
						0.62	30	59	0.54	0.89	0.09
						0.82	30	58.8	0.54	0.88	0.09
pz4	0.61	0.74	1.5	1.03	0.48	0.21	25	61	0.44	1.08	0.08
						0.41	30	59	0.54	0.89	0.09
						0.51	30	58.5	0.54	0.88	0.09
						0.62	30	58.8	0.54	0.88	0.09
						0.82	30	59.2	0.54	0.89	0.09

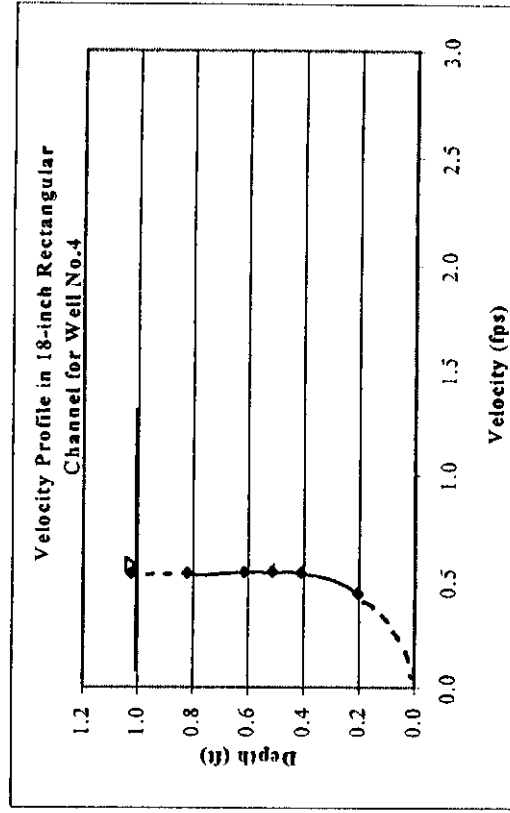
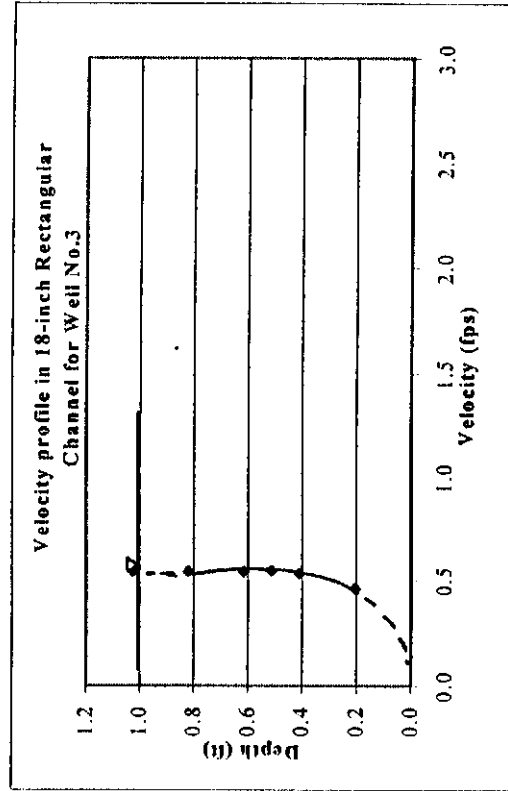
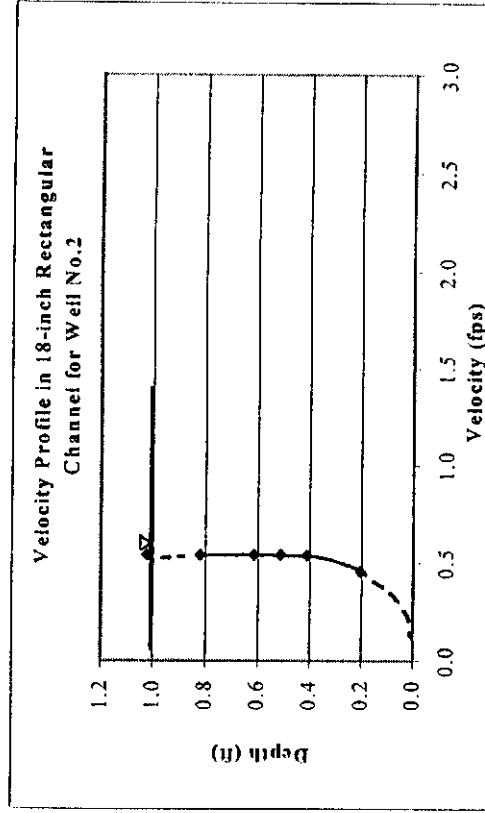
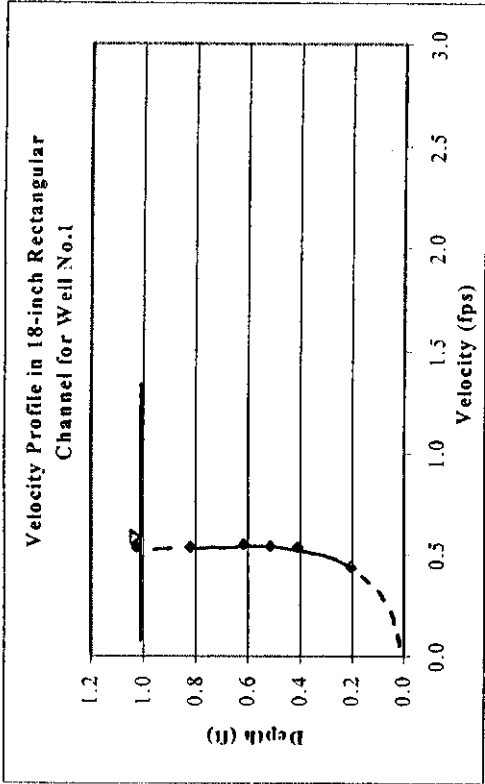


Figure D4. Velocity profile at mid-width in 18-inch Rectangular Channel for all four piezometer wells ( $Q = 0.74$  cfs, flow depth = 0.55 ft).



Table D5. Calibration of 18-inch Rectangular Channel for flow measurement with a pygmy current meter ( $Q = 0.89$  cfs, flow depth = 1.42 ft).

Sr. No	h weir	Q weir	Width of channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(cusecs)	(ft)	(ft)	(fps)	(ft)	(no.)	(sec)	(fps)		
1	2	3	4	5	6	7	8	9	10	11	12
pz1	0.66	0.89	1.5	1.42	0.42	0.28	20	51	0.43	0.98	0.06
						0.57	20	45	0.48	0.87	0.07
						0.71	20	45.5	0.47	0.88	0.07
						0.85	20	45	0.48	0.87	0.07
						1.14	20	45.5	0.47	0.88	0.07
pz2	0.66	0.89	1.5	1.42	0.42	0.28	20	52	0.42	0.99	0.06
						0.57	20	45	0.48	0.87	0.07
						0.71	20	45.5	0.47	0.88	0.07
						0.85	20	46	0.47	0.89	0.07
						1.14	20	45	0.48	0.87	0.07
pz3	0.66	0.89	1.5	1.42	0.42	0.28	20	52	0.42	0.99	0.06
						0.57	20	45.5	0.47	0.88	0.07
						0.71	20	45	0.48	0.87	0.07
						0.85	20	45	0.48	0.87	0.07
						1.14	20	45	0.48	0.87	0.07
pz4	0.66	0.89	1.5	1.42	0.42	0.28	20	52	0.42	0.99	0.06
						0.57	20	45.5	0.47	0.88	0.07
						0.71	20	46	0.47	0.89	0.07
						0.85	20	46.5	0.46	0.90	0.07
						1.14	20	47	0.46	0.91	0.07

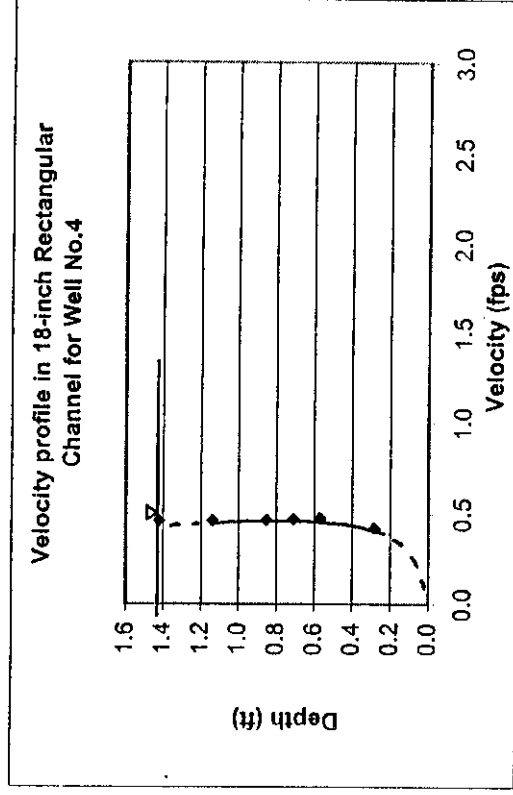
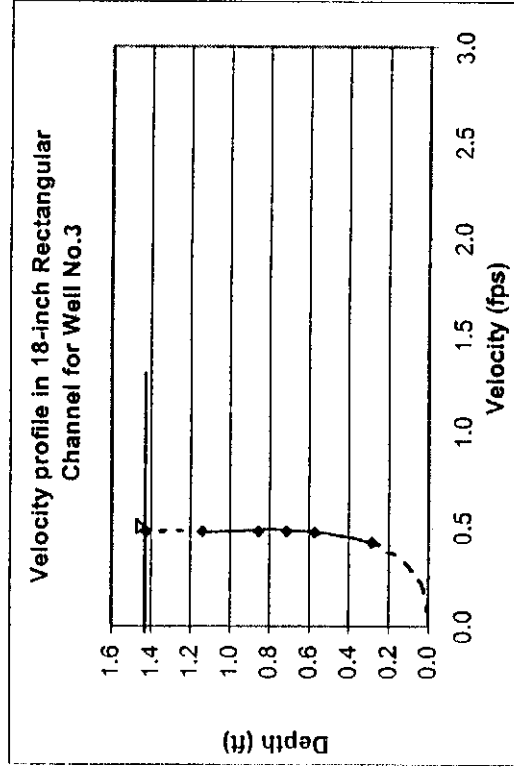
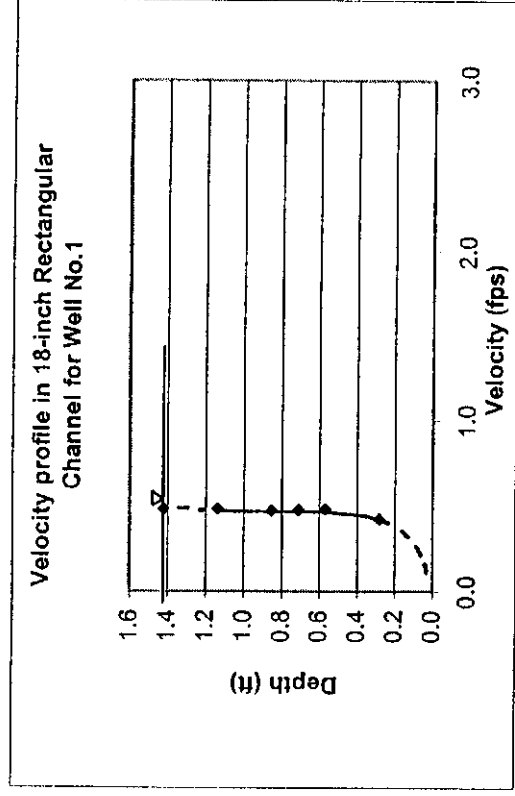
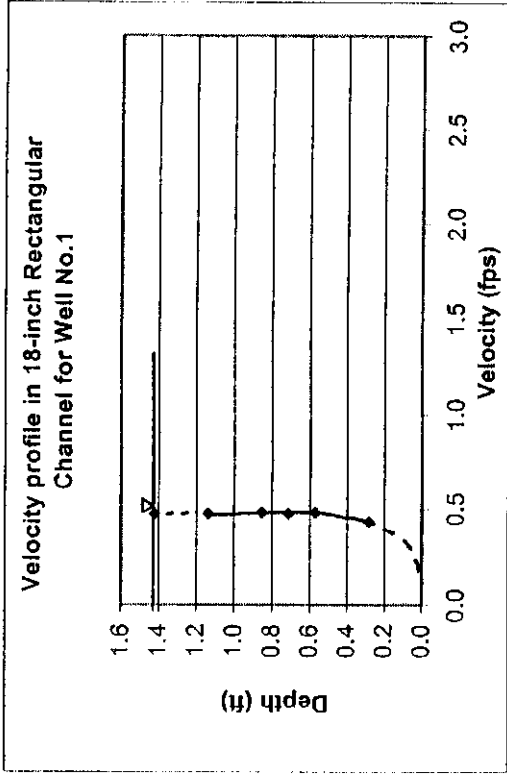


Figure D5. Velocity profile at mid-width in 18-inch Rectangular Channel for all four piezometer wells ( $Q = 0.89$  cfs, flow depth = 1.42 ft).

**ANNEX E. HYDRAULIC LABORATORY DATA FOR CALIBRATING 24-INCH RECTANGULAR CHANNEL.**

Table E1. Calibration of 24-inch Rectangular Channel for flow measurement with a pygmy current meter (Q = 1.21 cfs, flow depth = 0.62 ft).

Sr. No	h weir	Q weir	Width of channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(cusecs)	(ft)	(ft)	(fps)	(ft)	(no.)	(sec)	(fps)		
1	2	3	4	5	6	7	8	9	10	11	12
pz1	0.75	1.21	1.993	0.62	0.98	0.12	50	55	0.92	1.06	0.21
						0.25	50	48.5	1.04	0.94	0.23
						0.31	50	45.5	1.11	0.89	0.25
						0.37	50	45	1.12	0.88	0.25
						0.50	50	45.5	1.11	0.89	0.25
pz2	0.75	1.21	1.993	0.62	0.98	0.12	50	55	0.92	1.06	0.21
						0.25	50	48	1.05	0.93	0.23
						0.31	50	45.5	1.11	0.89	0.25
						0.37	50	45.5	1.11	0.89	0.25
						0.50	50	44.5	1.13	0.87	0.25
pz3	0.75	1.21	1.993	0.62	0.98	0.12	50	55	0.92	1.06	0.21
						0.25	50	47.5	1.06	0.92	0.24
						0.31	50	46	1.09	0.90	0.24
						0.37	50	45	1.12	0.88	0.25
						0.50	50	44.75	1.12	0.87	0.25
pz4	0.75	1.21	1.993	0.62	0.98	0.12	50	55	0.92	1.06	0.21
						0.25	50	47.5	1.06	0.92	0.24
						0.31	50	45.5	1.11	0.89	0.25
						0.37	50	44.5	1.13	0.87	0.25
						0.50	50	44	1.14	0.86	0.25

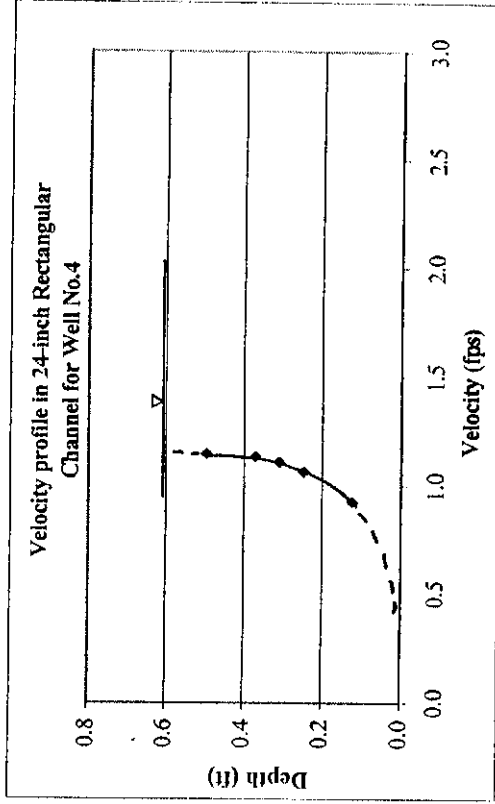
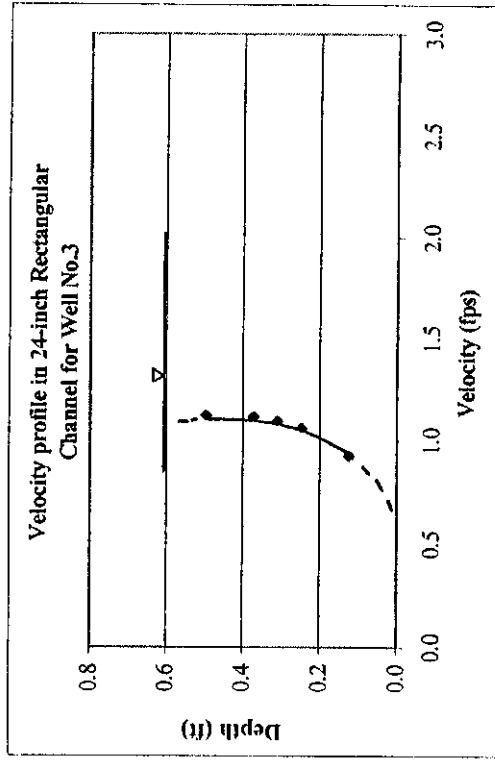
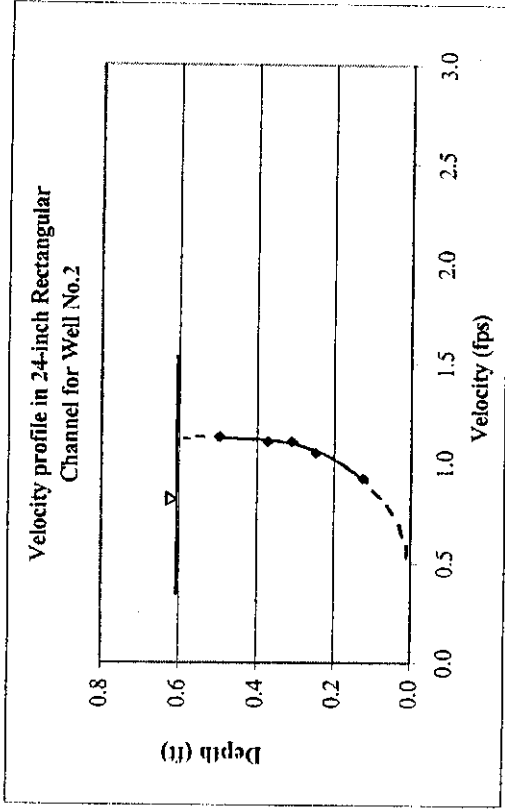
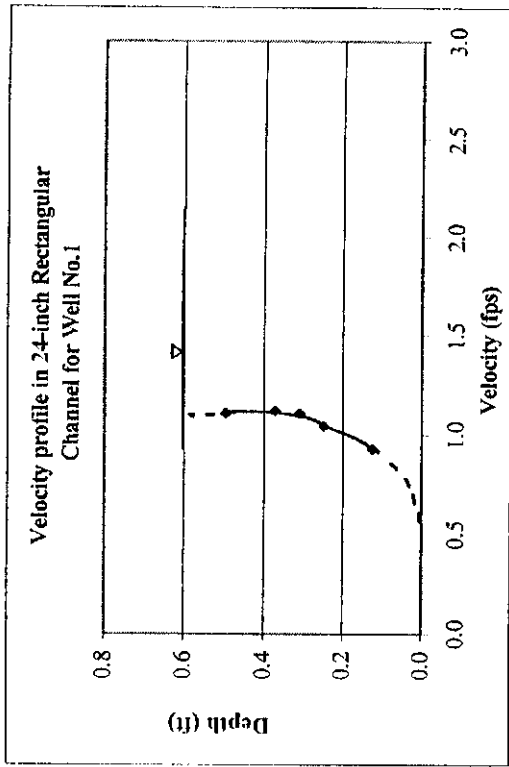


Figure E1. Velocity profile at mid-width in 24-inch Rectangular Channel for all four piezometer wells ( $Q = 1.21$  cfs, flow depth = 0.62 ft).

Table E2. Calibration of 24-inch Rectangular Channel for flow measurement with a pygmy current meter (Q = 1.63 cfs, flow depth = 0.83 ft).

Sr. No	h weir	Q weir	Width of channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(cusecs)	(ft)	(ft)	(fps)	(ft)	(no.)	(sec)	(fps)		
1	2	3	4	5	6	7	8	9	10	11	12
pz1	0.84	1.63	1.993	0.83	0.98	0.17	50	51.75	0.98	1.01	0.19
						0.33	50	47	1.07	0.92	0.21
						0.42	50	46.25	1.09	0.90	0.21
						0.50	50	46	1.09	0.90	0.21
						0.66	50	46	1.09	0.90	0.21
pz2	0.84	1.63	1.993	0.83	0.98	0.17	50	52	0.97	1.01	0.19
						0.33	50	46.5	1.08	0.91	0.21
						0.42	50	46.25	1.09	0.90	0.21
						0.50	50	45.5	1.11	0.89	0.21
						0.66	50	46	1.09	0.90	0.21
pz3	0.84	1.63	1.993	0.83	0.98	0.17	50	52	0.97	1.01	0.19
						0.33	50	47	1.07	0.92	0.21
						0.42	50	46.75	1.08	0.91	0.21
						0.50	50	45.5	1.11	0.89	0.21
						0.66	50	45.5	1.11	0.89	0.21
pz4	0.84	1.63	1.993	0.83	0.98	0.17	50	52	0.97	1.01	0.19
						0.33	50	47	1.07	0.92	0.21
						0.42	50	46	1.09	0.90	0.21
						0.50	50	45.5	1.11	0.89	0.21
						0.66	50	45.75	1.10	0.89	0.21

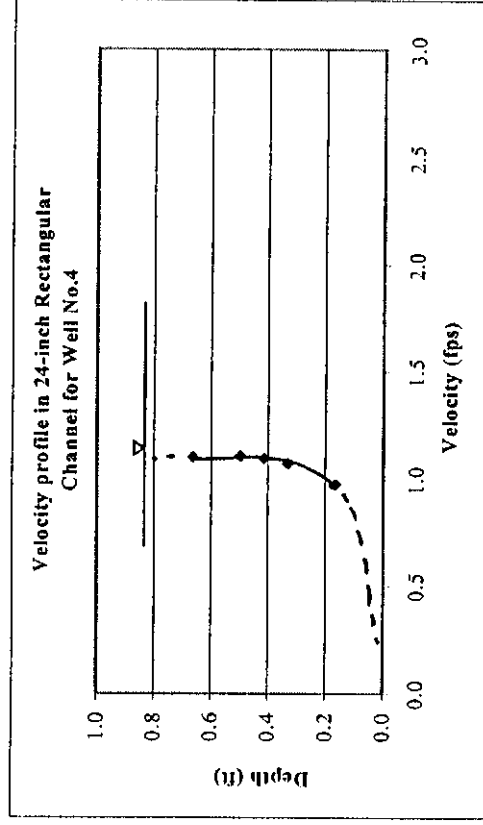
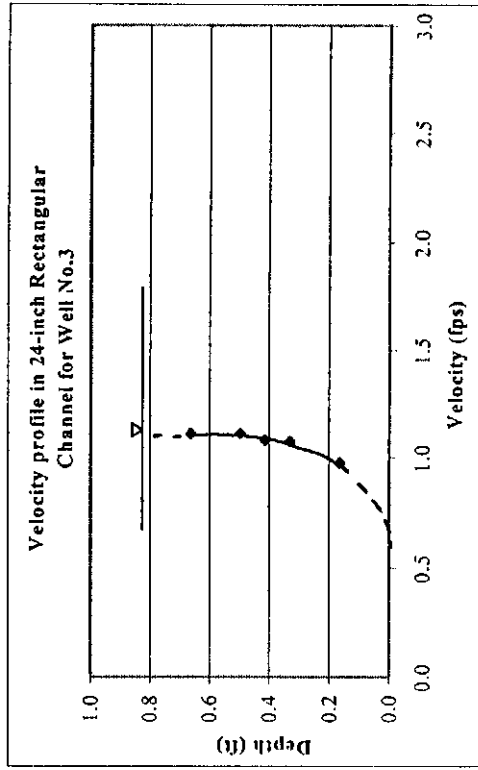
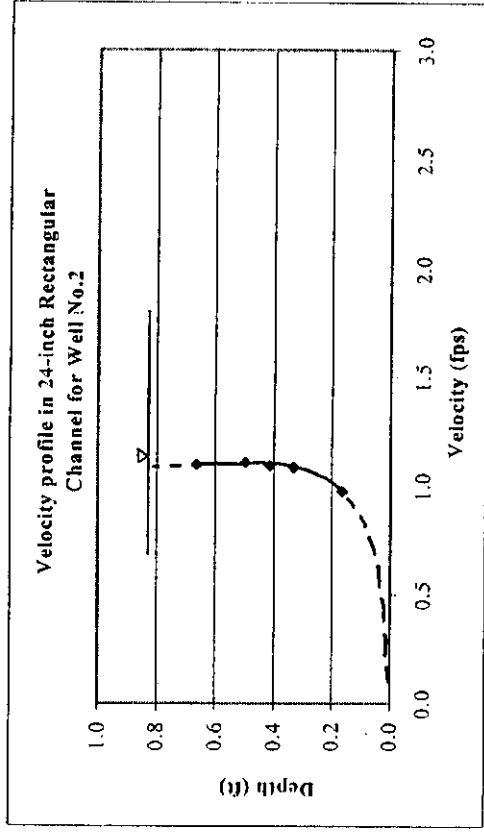
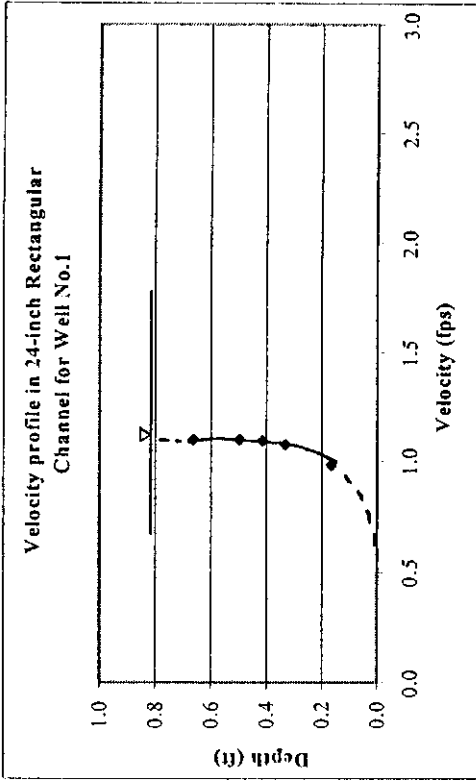


Figure E2. Velocity profile at mid-width in 24-inch Rectangular Channel for all four piezometer wells ( $Q = 1.63$  cfs, flow depth = 0.83 ft).

Table E3. Calibration of 24-inch Rectangular Channel for flow measurement with a pygmy current meter (Q = 1.51 cfs, flow depth = 1.07 ft).

Sr. No	h weir	Q weir	Width of channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(cusecs)	(ft)	(ft)	(fps)	(ft)	(no.)	(sec)	(fps)		
1	2	3	4	5	6	7	8	9	10	11	12
pz1	0.82	1.51	1.993	1.07	0.70	0.21	40	57.2	0.72	0.98	0.12
						0.43	40	52.5	0.78	0.90	0.13
						0.54	40	52.25	0.79	0.90	0.13
						0.64	40	54	0.76	0.92	0.13
						0.86	40	54.9	0.75	0.94	0.13
pz2	0.82	1.51	1.993	1.07	0.70	0.21	40	58.8	0.70	1.00	0.12
						0.43	40	52.3	0.78	0.90	0.13
						0.54	40	53.5	0.77	0.92	0.13
						0.64	40	53.6	0.77	0.92	0.13
						0.86	40	53.8	0.76	0.92	0.13
pz3	0.82	1.51	1.993	1.07	0.70	0.21	40	57.75	0.72	0.98	0.12
						0.43	40	52.1	0.79	0.89	0.13
						0.54	40	52	0.79	0.89	0.13
						0.64	40	53	0.78	0.91	0.13
						0.86	40	53.6	0.77	0.92	0.13
pz4	0.82	1.51	1.993	1.07	0.70	0.21	40	58	0.71	0.99	0.12
						0.43	40	53.2	0.77	0.91	0.13
						0.54	40	52	0.79	0.89	0.13
						0.64	40	54	0.76	0.92	0.13
						0.86	40	54	0.76	0.92	0.13

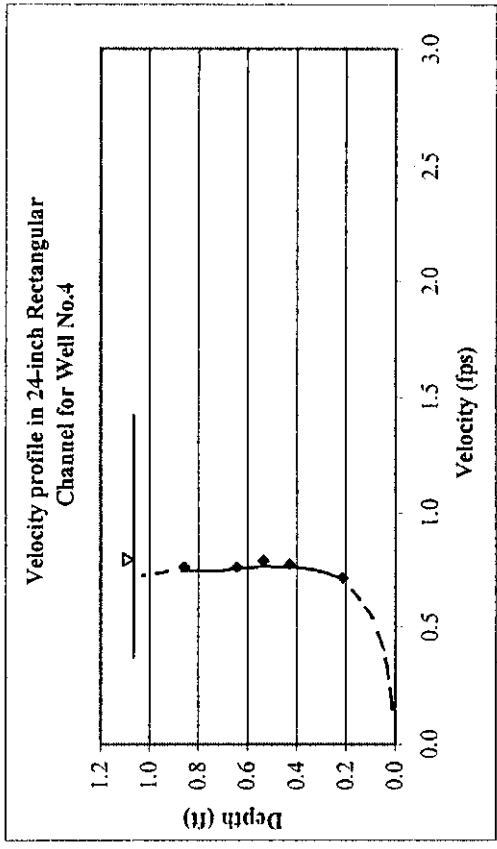
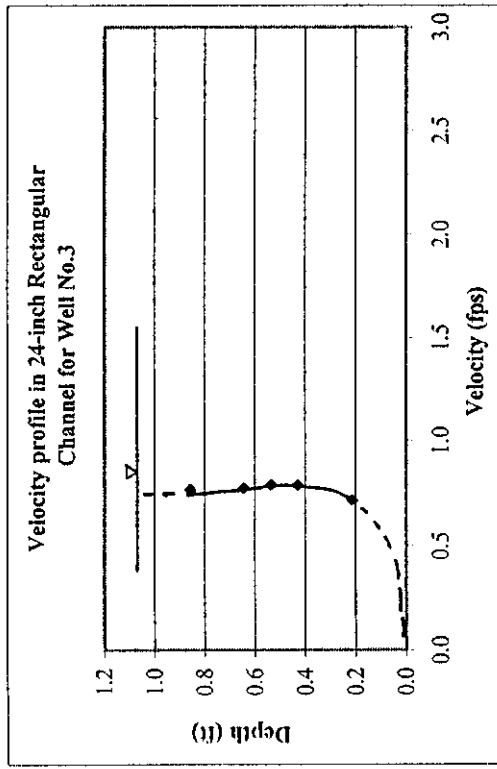
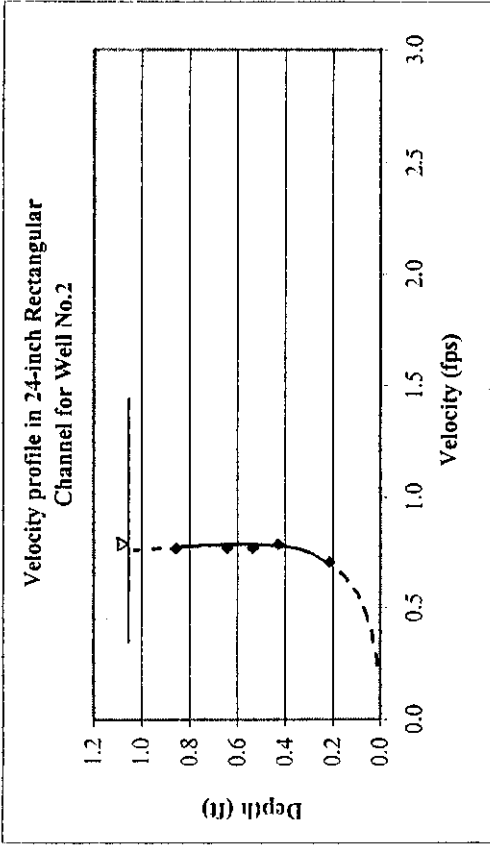
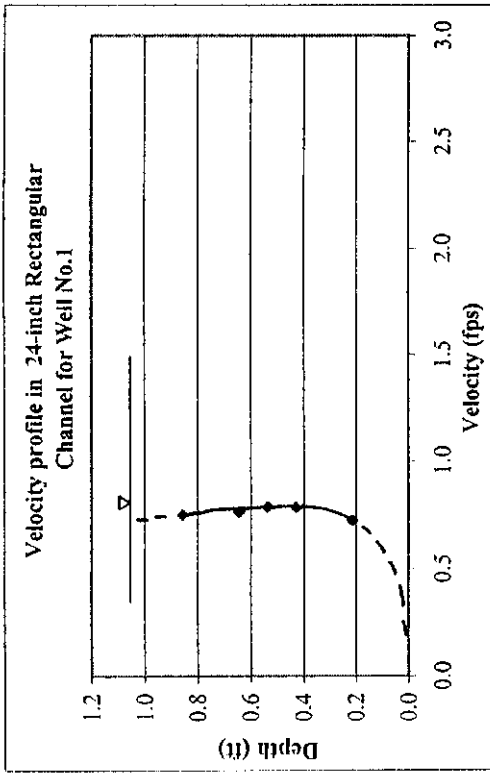


Figure E3. Velocity profile at mid-width in 24-inch Rectangular Channel for all four piezometer wells ( $Q = 1.51$  cfs, flow depth = 1.07 ft).



Table E4. Calibration of 24-inch Rectangular Channel for flow measurement with a pygmy current meter (Q = 1.61 cfs, flow depth = 1.11 ft).

Sr. No	h weir	Q weir	Width of channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(cusecs)	(ft)	(ft)	(fps)	(ft)	(no.)	(sec)	(fps)		
1	2	3	4	5	6	7	8	9	10	11	12
pz1	0.84	1.61	1.993	1.11	0.73	0.22	40	57.9	0.71	1.02	0.12
						0.44	40	51.3	0.80	0.91	0.13
						0.55	40	50.95	0.80	0.91	0.13
						0.66	40	51.55	0.80	0.92	0.13
						0.89	40	50.5	0.81	0.90	0.14
pz2	0.84	1.61	1.993	1.11	0.73	0.22	40	57.8	0.72	1.02	0.12
						0.44	40	51.3	0.80	0.91	0.13
						0.55	40	50.95	0.80	0.91	0.13
						0.66	40	51.3	0.80	0.91	0.13
						0.89	40	51.2	0.80	0.91	0.13
pz3	0.84	1.61	1.993	1.11	0.73	0.22	40	57.5	0.72	1.01	0.12
						0.44	40	51.2	0.80	0.91	0.13
						0.55	40	50.5	0.81	0.90	0.14
						0.66	40	50.95	0.80	0.91	0.13
						0.89	40	51	0.80	0.91	0.13
pz4	0.84	1.61	1.993	1.11	0.73	0.22	40	57.9	0.71	1.02	0.12
						0.44	40	50.75	0.81	0.90	0.13
						0.55	40	50.6	0.81	0.90	0.14
						0.66	40	50.5	0.81	0.90	0.14
						0.89	40	51.5	0.80	0.92	0.13

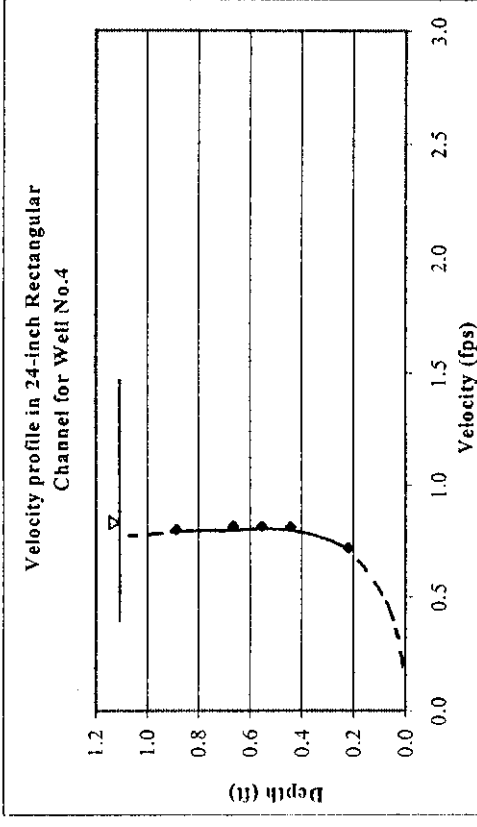
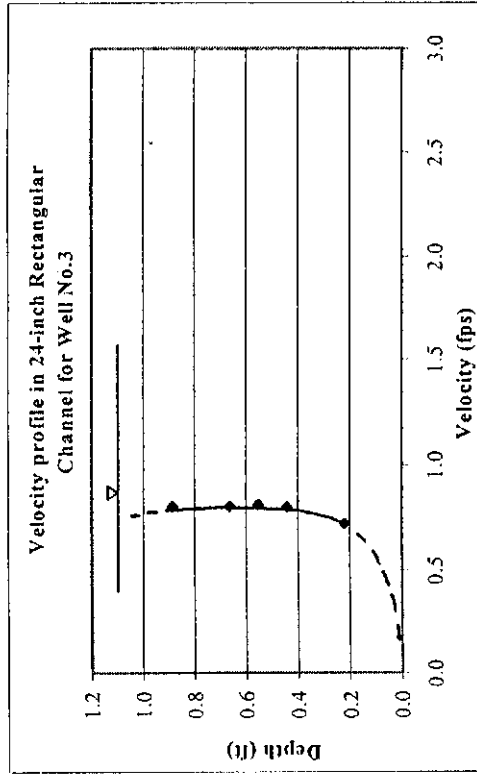
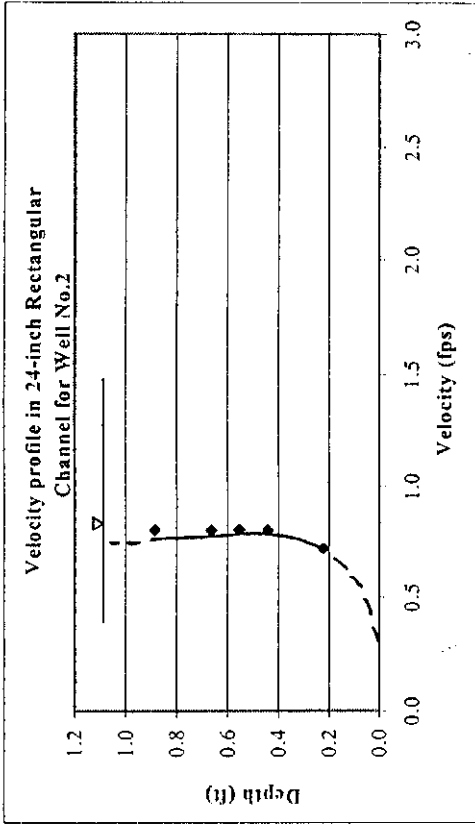
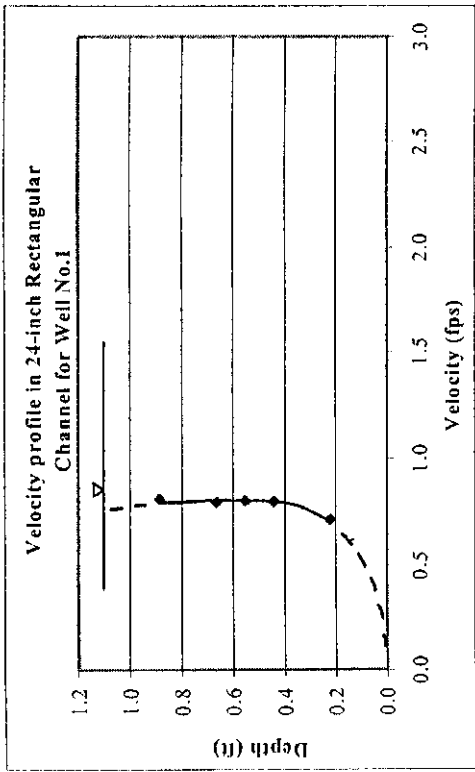


Figure E4. Velocity profile at mid-width in 24-inch Rectangular Channel for all four piezometer wells ( $Q = 1.61$  cfs, flow depth = 1.11 ft).

Table E5. Calibration of 24-inch Rectangular Channel for flow measurement with a pygmy current meter (Q = 1.76 cfs, flow depth = 1.25 ft).

Sr. No	h weir	Q weir	Width of channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(cusecs)	(ft)	(ft)	(fps)	(ft)	(no.)	(sec)	(fps)		
1	2	3	4	5	6	7	8	9	10	11	12
pz1	0.87	1.76	1.993	1.25	0.71	0.25	40	58	0.71	1.00	0.11
						0.50	40	53	0.78	0.92	0.12
						0.62	40	52	0.79	0.90	0.12
						0.75	40	52.8	0.78	0.91	0.12
						1.00	40	52.5	0.78	0.91	0.12
pz2	0.87	1.76	1.993	1.25	0.71	0.25	40	57.8	0.72	0.99	0.11
						0.50	40	53.2	0.77	0.92	0.12
						0.62	40	52	0.79	0.90	0.12
						0.75	40	52.5	0.78	0.91	0.12
						1.00	40	52.6	0.78	0.91	0.12
pz3	0.87	1.76	1.993	1.25	0.71	0.25	40	57.6	0.72	0.99	0.11
						0.50	40	53.3	0.77	0.92	0.12
						0.62	40	53	0.78	0.92	0.12
						0.75	40	52.5	0.78	0.91	0.12
						1.00	40	52.8	0.78	0.91	0.12
pz4	0.87	1.76	1.993	1.25	0.71	0.25	40	57	0.72	0.98	0.11
						0.50	40	53.5	0.77	0.92	0.12
						0.62	40	52.1	0.79	0.90	0.12
						0.75	40	52.6	0.78	0.91	0.12
						1.00	40	52.2	0.79	0.90	0.12

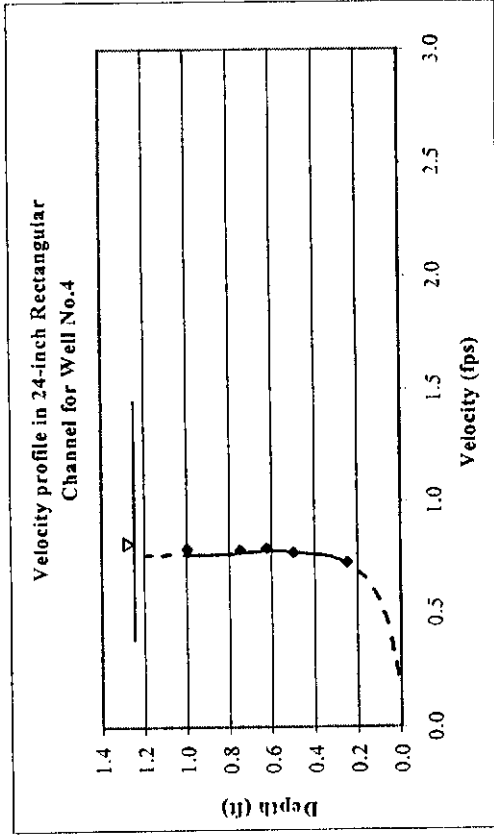
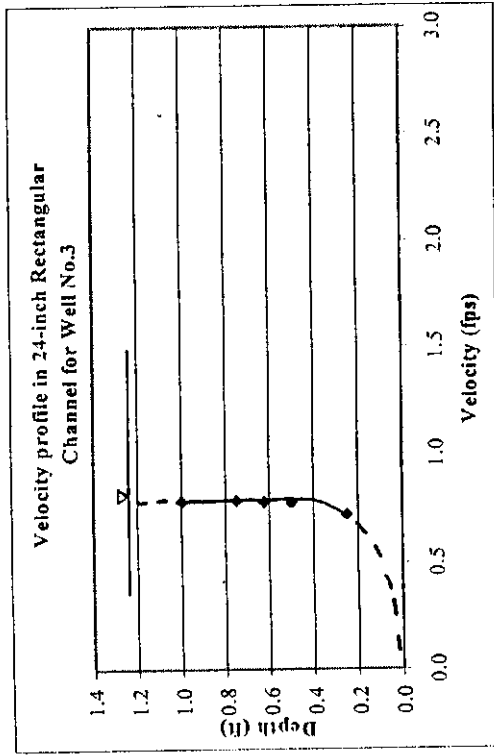
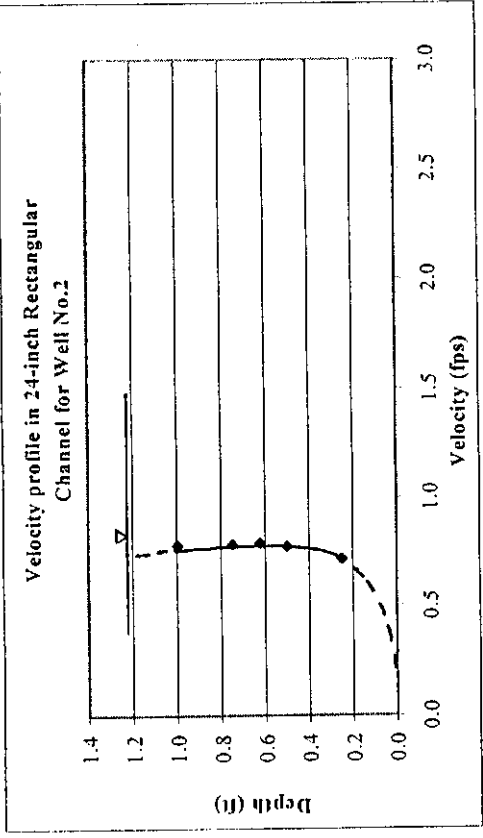
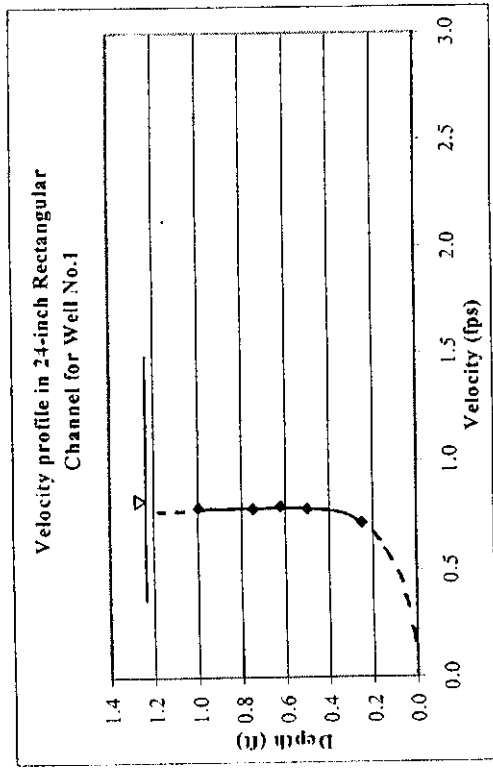


Figure E5. Velocity profile at mid-width in 24-inch Rectangular Channel for all four piezometer wells ( $Q = 1.76$  cfs, flow depth = 1.25 ft).

**ANNEX F. HYDRAULIC LABORATORY DATA FOR CALIBRATING 27-INCH  
RECTANGULAR CHANNEL.**

Table F1. Calibration of 27 inch Rectangular Channel for flow measurement with a pygmy current meter (Q= 1.23 cfs, flow depth = 0.31 ft).

Sr. No	h weir	Q weir	Width of channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of Revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(cusecs)	(ft)	(ft)	(fps)	(ft)	(no.)	(sec)	(fps)		
1	2	3	4	5	6	7	8	9	10	11	12
pz1	0.75	1.23	2.25	0.31	1.76	0.06	80	44	1.80	0.98	0.57
						0.12	100	51	1.93	0.91	0.61
						0.16	100	52	1.90	0.93	0.60
						0.19	100	52.5	1.88	0.94	0.59
						0.25	100	58	1.71	1.03	0.54
pz2	0.75	1.23	2.25	0.31	1.76	0.06	80	44	1.80	0.98	0.57
						0.12	100	52	1.90	0.93	0.60
						0.16	100	51	1.93	0.91	0.61
						0.19	100	52	1.90	0.93	0.60
						0.25	100	57	1.74	1.01	0.55
pz3	0.75	1.23	2.25	0.31	1.76	0.06	80	44	1.80	0.98	0.57
						0.12	100	49	2.01	0.87	0.63
						0.16	100	51	1.93	0.91	0.61
						0.19	100	52	1.90	0.93	0.60
						0.25	100	59	1.68	1.05	0.53
pz4	0.75	1.23	2.25	0.31	1.76	0.06	80	43	1.84	0.96	0.58
						0.12	100	52	1.90	0.93	0.60
						0.16	100	51	1.93	0.91	0.61
						0.19	100	52	1.90	0.93	0.60
						0.25	100	58	1.71	1.03	0.54

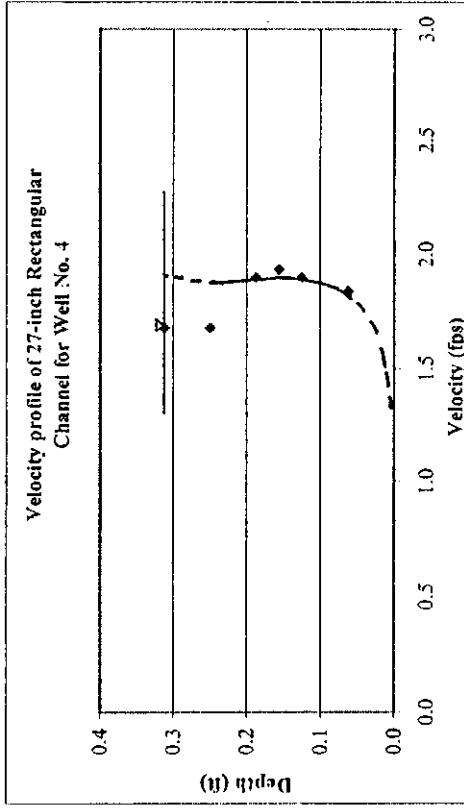
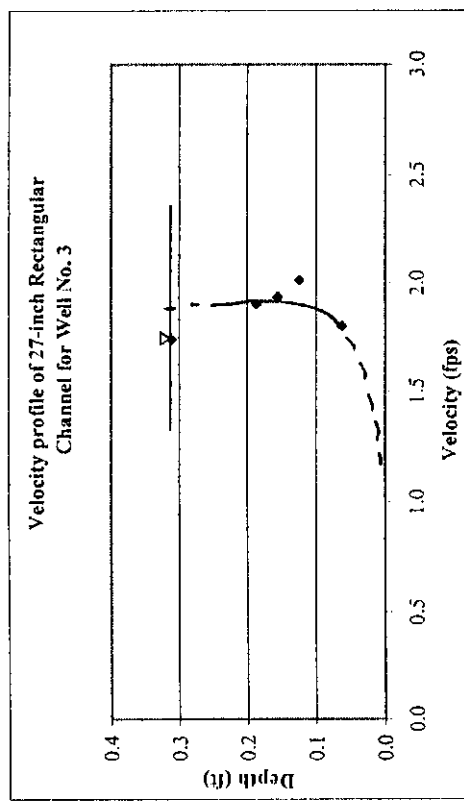
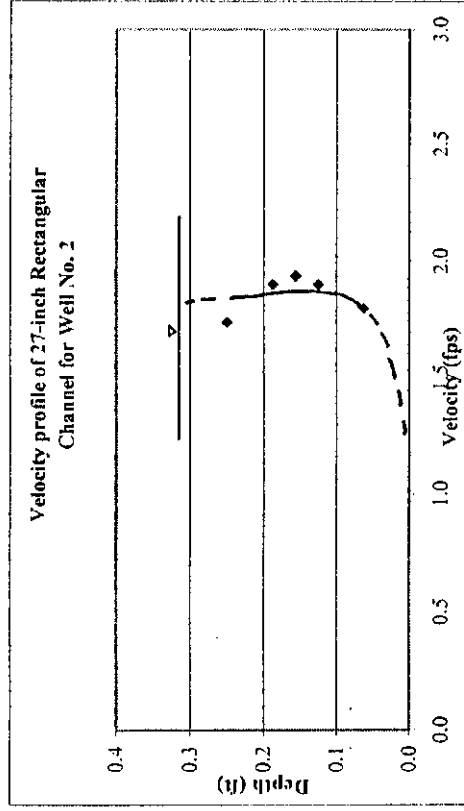
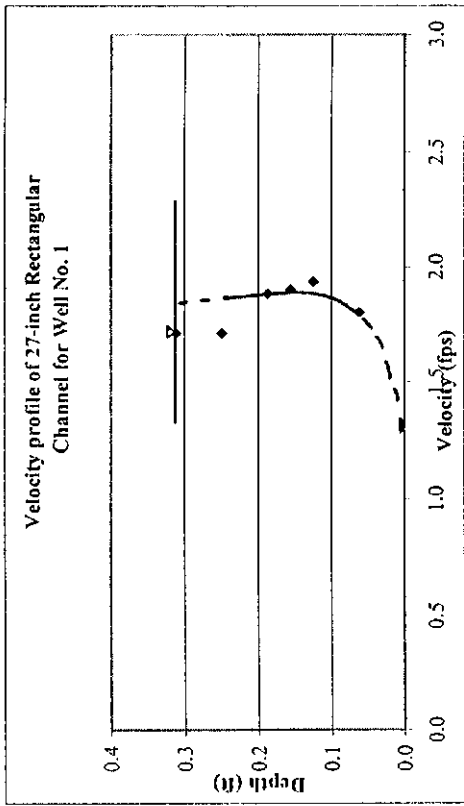


Figure F1. Velocity profile at mid-width in 27-inch Rectangular Channel for all four Piezometer wells ( $Q = 1.23$  cfs, flow depth = 0.31 ft).

Table F2. Calibration of 27 inch Rectangular Channel for flow measurement with a pygmy current meter (Q= 1.60 cfs, flow depth = 0.74 ft).

Sr. No	h weir	Q weir	Width of channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(cusecs)	(ft)	(ft)	(fps)	(ft)	(no.)	(sec)	(fps)		
1	2	3	4	5	6	7	8	9	10	11	12
pz1	0.84	1.60	2.25	0.74	0.97	0.15	50	54	0.94	1.03	0.19
						0.30	50	50	1.01	0.95	0.21
						0.37	50	47	1.07	0.90	0.22
						0.44	50	51	0.99	0.97	0.20
						0.59	50	51	0.99	0.97	0.20
pz2	0.84	1.60	2.25	0.74	0.97	0.15	50	53	0.96	1.01	0.20
						0.30	50	51	0.99	0.97	0.20
						0.37	50	48.5	1.04	0.93	0.21
						0.44	50	52	0.97	0.99	0.20
						0.59	50	51.5	0.98	0.98	0.20
pz3	0.84	1.60	2.25	0.74	0.97	0.15	50	53	0.96	1.01	0.20
						0.30	50	50	1.01	0.95	0.21
						0.37	50	47.5	1.06	0.91	0.22
						0.44	50	51.5	0.98	0.98	0.20
						0.59	50	51.25	0.99	0.98	0.20
pz4	0.84	1.60	2.25	0.74	0.97	0.15	50	55	0.92	1.05	0.19
						0.30	50	51.5	0.98	0.98	0.20
						0.37	50	47.5	1.06	0.91	0.22
						0.44	50	51.5	0.98	0.98	0.20
						0.59	50	52	0.97	0.99	0.20

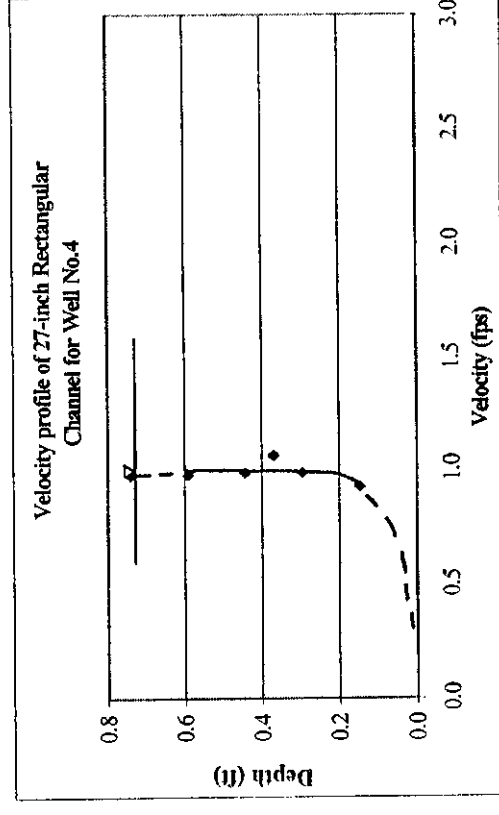
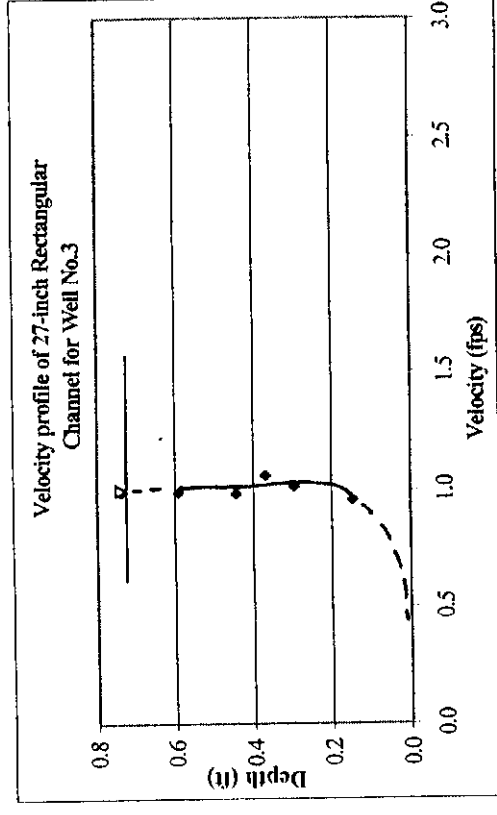
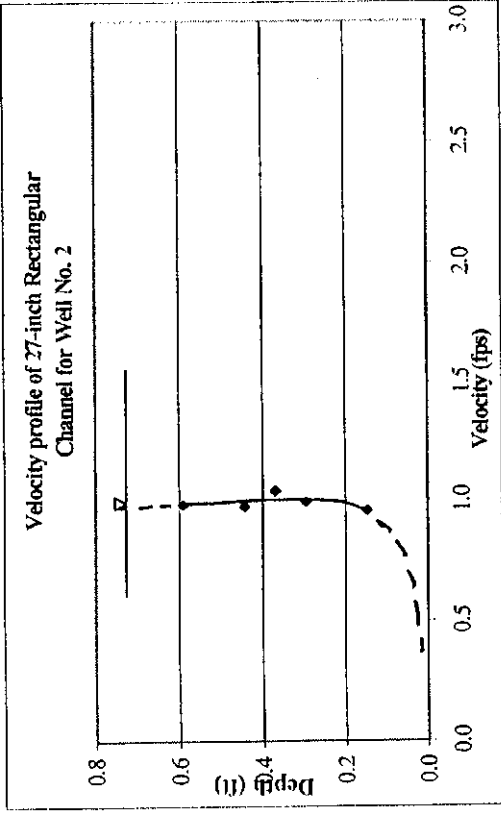
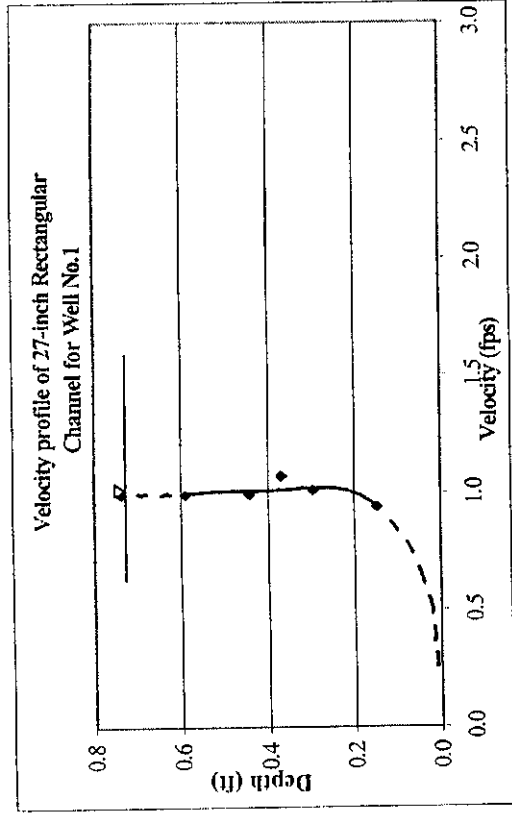


Figure F2. Velocity profile at mid- width in 27-inch Rectangular Channel for all four Piezometer wells ( $Q = 1.60$  cfs, flow depth = 0.74 ft).



Table F3. Calibration of 27 inch Rectangular Channel for flow measurement with a pygmy current meter (Q= 1.52 cfs, flow depth = 0.92 ft).

Sr. No	h weir	Q weir	Width of channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(cusecs)	(ft)	(ft)	(fps)	(ft)	(no.)	(sec)	(fps)		
1	2	3	4	5	6	7	8	9	10	11	12
pz1	0.82	1.52	2.25	0.92	0.738	0.18	40	56.5	0.73	1.01	0.13
						0.37	40	53	0.78	0.95	0.14
						0.46	40	52.5	0.78	0.94	0.14
						0.55	40	52	0.79	0.93	0.14
						0.73	40	52.5	0.78	0.94	0.14
pz2	0.82	1.52	2.25	0.92	0.74	0.18	40	55.5	0.74	0.99	0.14
						0.37	40	53	0.78	0.95	0.14
						0.46	40	52	0.79	0.93	0.14
						0.55	40	52.25	0.79	0.94	0.14
						0.73	40	51.75	0.79	0.93	0.15
pz3	0.82	1.52	2.25	0.92	0.74	0.18	40	56	0.74	1.00	0.14
						0.37	40	53.5	0.77	0.96	0.14
						0.46	40	52	0.79	0.93	0.14
						0.55	40	52	0.79	0.93	0.14
						0.73	40	52	0.79	0.93	0.14
pz4	0.82	1.52	2.25	0.92	0.74	0.18	40	55.5	0.74	0.99	0.14
						0.37	40	52.5	0.78	0.94	0.14
						0.46	40	52	0.79	0.93	0.14
						0.55	40	52	0.79	0.93	0.14
						0.73	40	52	0.79	0.93	0.14

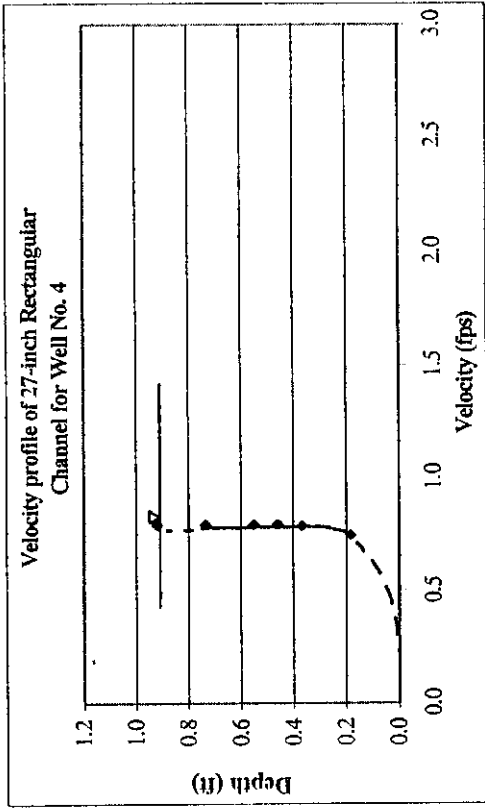
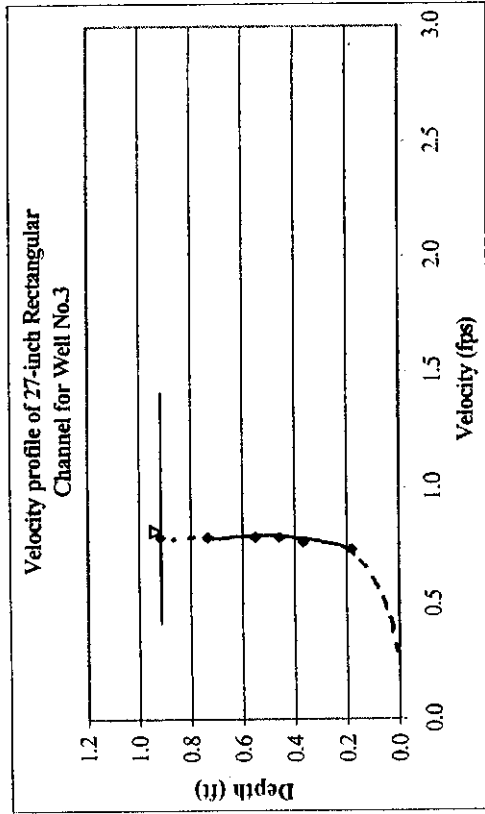
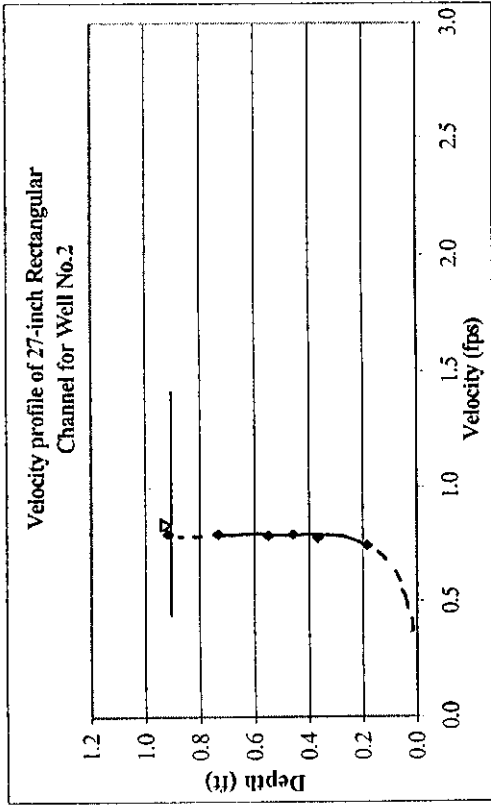
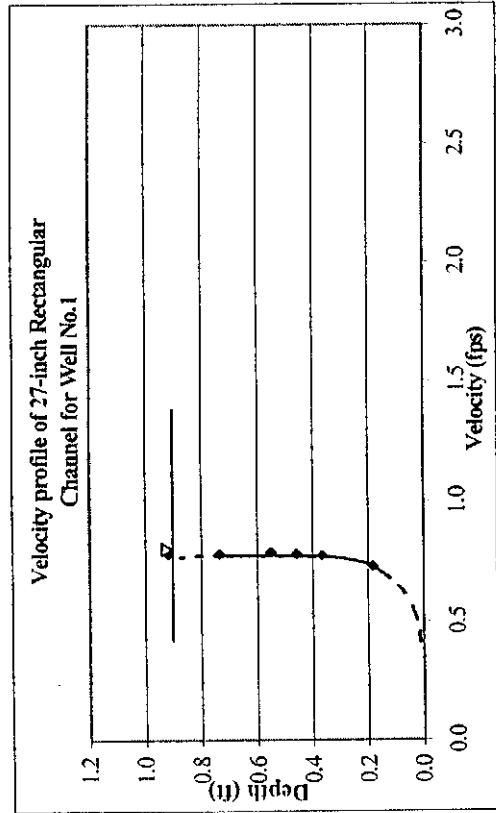


Figure F3. Velocity profile at mid-width in 27-inch Rectangular Channel for all four Piezometer wells ( $Q=1.52$  cfs, flow depth = 0.92 ft).

Table F4. Calibration of 27 inch Rectangular Channel for flow measurement with a pygmy current meter (Q = 0.92 cfs, flow depth = 1.10 ft).

Sr. No	h weir	Q weir	Width of channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(cusecs)	(ft)	(ft)	(fps)	(ft)	(no.)	(sec)	(fps)		
1	2	3	4	5	6	7	8	9	10	11	12
pz1	0.67	0.92	2.25	1.10	0.37	0.22	20	60	0.37	1.00	0.06
						0.44	20	55	0.40	0.93	0.07
						0.55	20	53	0.41	0.90	0.07
						0.66	20	53	0.41	0.90	0.07
						0.88	20	53.5	0.41	0.91	0.07
pz2	0.67	0.92	2.25	1.10	0.37	0.22	20	58	0.38	0.97	0.06
						0.44	20	54	0.41	0.91	0.07
						0.55	20	52.5	0.42	0.89	0.07
						0.66	20	54	0.41	0.91	0.07
						0.88	20	53.5	0.41	0.91	0.07
pz3	0.67	0.92	2.25	1.10	0.37	0.22	20	59	0.38	0.99	0.06
						0.44	20	55.5	0.40	0.93	0.07
						0.55	20	52.5	0.42	0.89	0.07
						0.66	20	53	0.41	0.90	0.07
						0.88	20	53.5	0.41	0.91	0.07
pz4	0.67	0.92	2.25	1.10	0.37	0.22	20	58	0.38	0.97	0.06
						0.44	20	55	0.40	0.93	0.07
						0.55	20	53	0.41	0.90	0.07
						0.66	20	53	0.41	0.90	0.07
						0.88	20	53	0.41	0.90	0.07

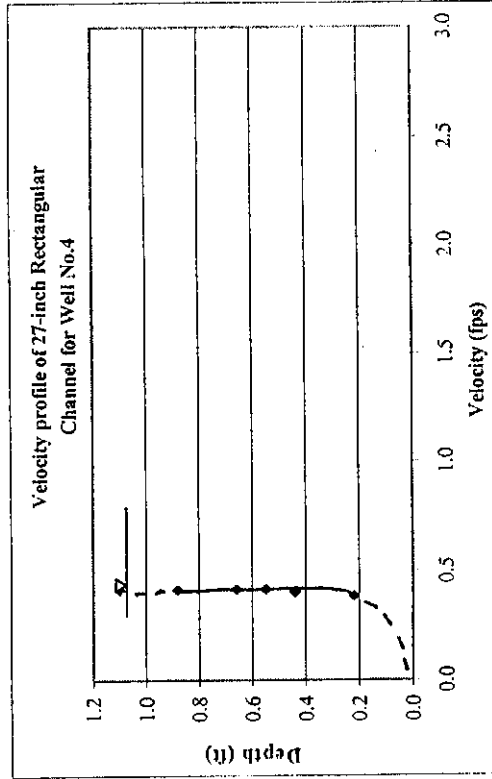
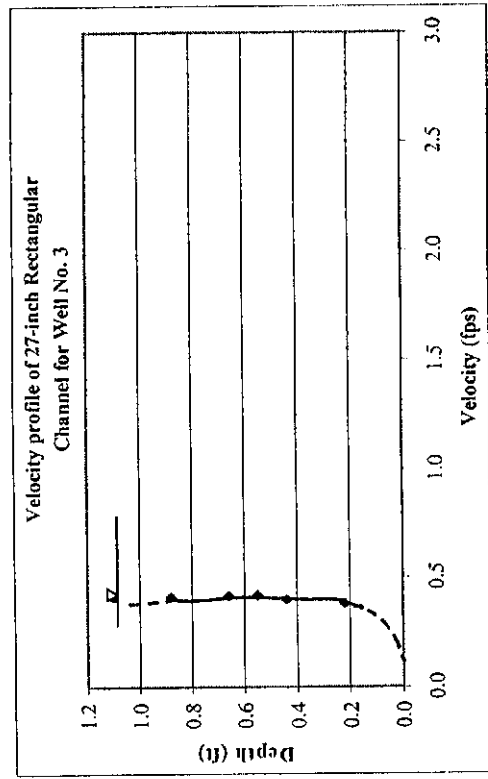
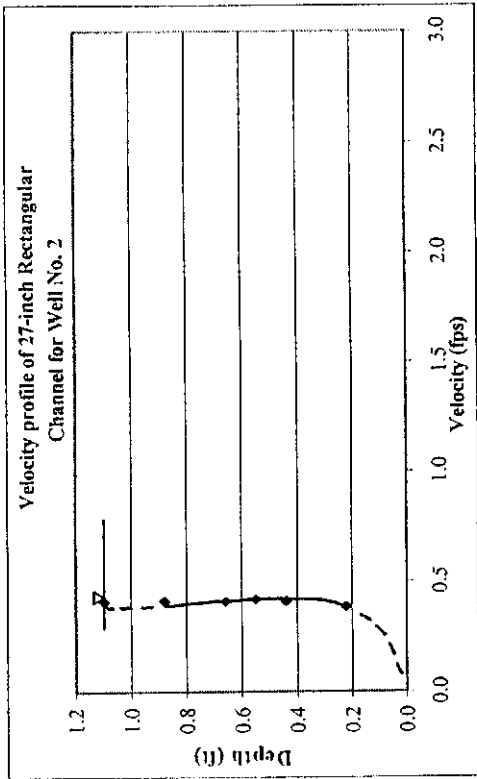
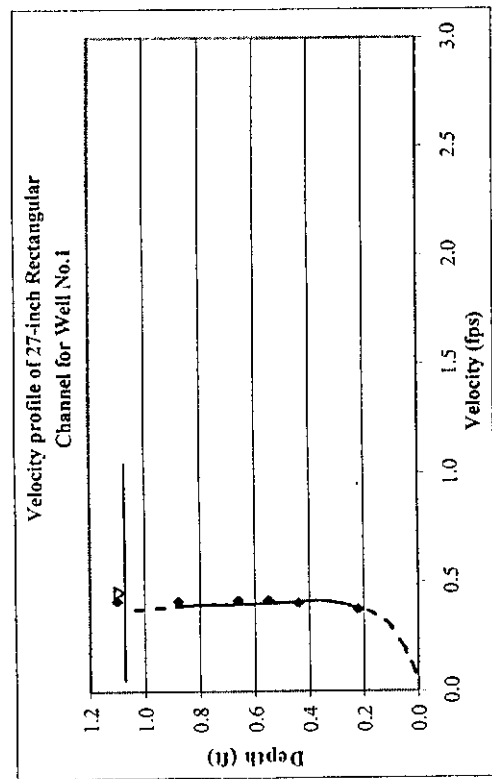


Figure F4. Velocity profile at mid-width in 27-inch Rectangular Channel for all four Piezometer wells ( $Q = 0.92$  cfs, flow depth = 1.10 ft).

Table F5. Calibration of 27 inch Rectangular Channel for flow measurement with a pygmy current meter (Q= 1.73 cfs, flow depth = 1.26 ft).

Sr. No	h weir	Q weir	Width of channel	Depth of water in channel	Mean velocity of water	Current meter depth	No of revolutions	Time	Velocity by current meter	Multiplying factor	Froude number
	(ft)	(cusecs)	(ft)	(ft)	(fps)	(ft)	(no.)	(sec)	(fps)		
1	2	3	4	5	6	7	8	9	10	11	12
pz1	0.86	1.73	2.25	1.26	0.61	0.25	40	64.5	0.65	0.95	0.10
						0.50	40	62	0.67	0.91	0.11
						0.63	40	60.2	0.69	0.89	0.11
						0.75	40	61	0.68	0.90	0.11
						1.01	40	61.4	0.68	0.91	0.11
pz2	0.86	1.73	2.25	1.26	0.61	0.25	40	66.2	0.63	0.97	0.10
						0.50	40	62.25	0.67	0.92	0.10
						0.63	40	60.8	0.68	0.90	0.11
						0.75	40	62	0.67	0.91	0.11
						1.01	40	60.75	0.68	0.90	0.11
pz3	0.86	1.73	2.25	1.26	0.61	0.25	40	65.4	0.64	0.96	0.10
						0.50	40	62.7	0.66	0.92	0.10
						0.63	40	60.6	0.68	0.89	0.11
						0.75	40	61.9	0.67	0.91	0.11
						1.01	40	60.7	0.68	0.90	0.11
pz4	0.86	1.73	2.25	1.26	0.61	0.25	40	65.8	0.63	0.96	0.10
						0.50	40	62.4	0.67	0.92	0.10
						0.63	40	61.9	0.67	0.91	0.11
						0.75	40	60.8	0.68	0.90	0.11
						1.01	40	61	0.68	0.90	0.11

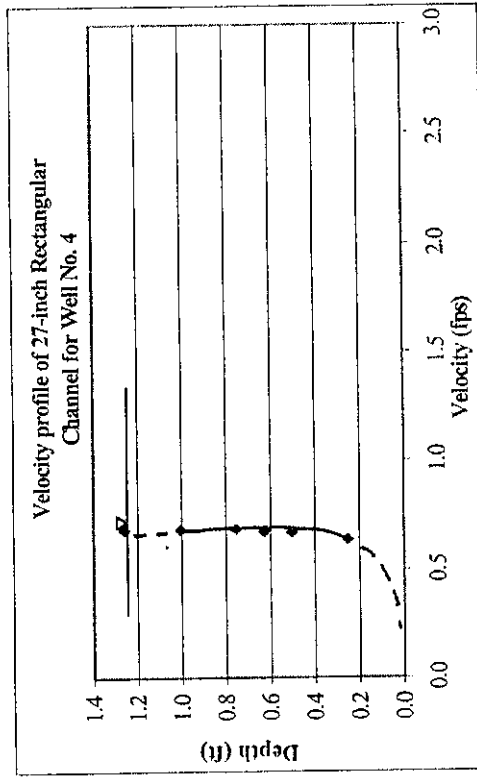
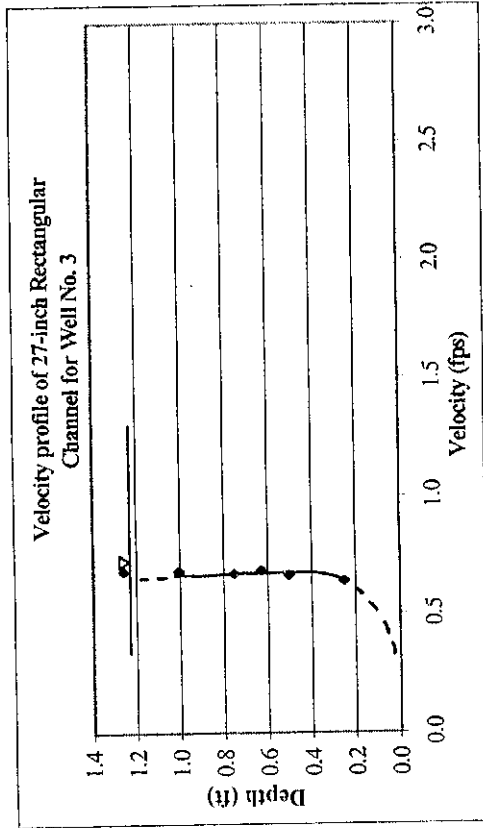
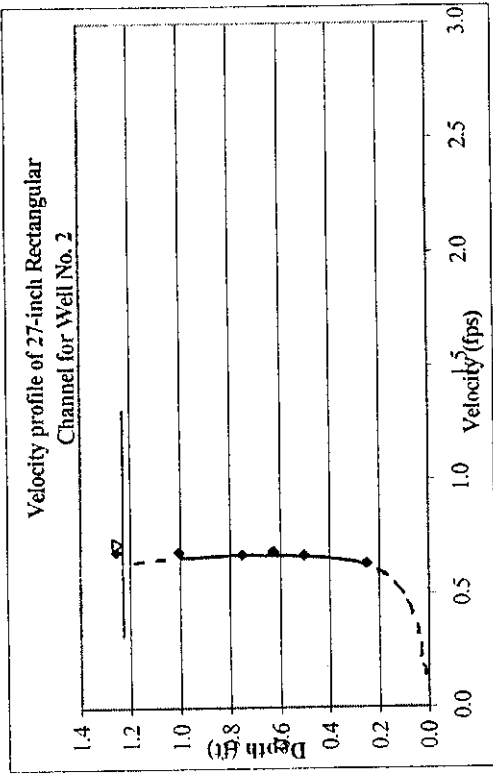
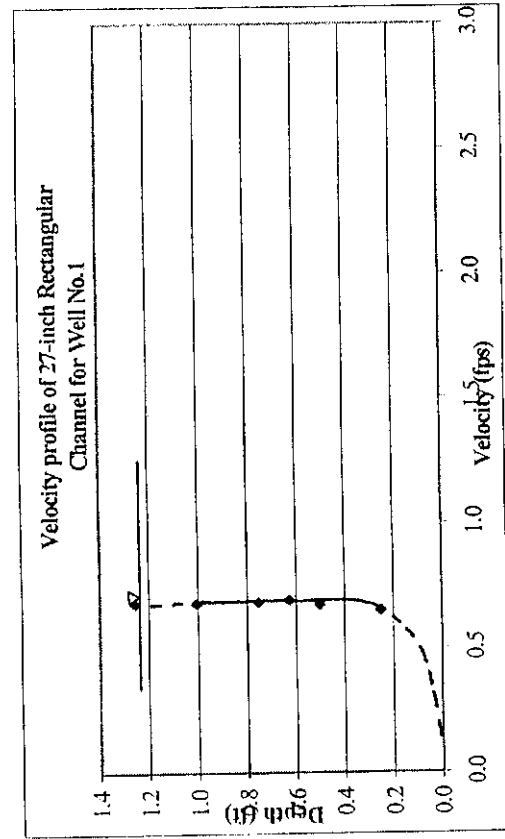


Figure F5. Velocity profile at mid-width in 27-inch Rectangular Channel for all four Piezometer wells (Q=1.73 cfs, flow depth = 1.26 ft).

# IIMI-PAKISTAN PUBLICATIONS

## RESEARCH REPORTS

Report No.	Title	Author	Year
R-1	<b>Crop-Based Irrigation Operations Study in the North West Frontier Province of Pakistan</b> Volume I: Synthesis of Findings and Recommendations	Carlos Garcés-R D.J. Bandaragoda Pierre Strosser	June 1994
	Volume II: Research Approach and Interpretation	Carlos Garcés-R Ms. Zaigham Habib Pierre Strosser Tissa Bandaragoda Rana M. Afaq Saeed ur Rehman Abdul Hakim Khan	June 1994
	Volume III: Data Collection Procedures and Data Sets	Rana M. Afaq Pierre Strosser Saeed ur Rehman Abdul Hakim Khan Carlos Garcés-R	June 1994
R-2	Salinity and Sodicity Research in Pakistan - Proceedings of a one-day Workshop	J.W. Kijne Marcel Kuper Muhammad Aslam	Mar 1995
R-3	Farmers' Perceptions on Salinity and Sodicity: A case study into farmers' knowledge of salinity and sodicity, and their strategies and practices to deal with salinity and sodicity in their farming systems	Neeltje Kielen	May 1996
R-4	Modelling the Effects of Irrigation Management on Soil Salinity and Crop Transpiration at the Field Level (M.Sc Thesis - published as Research Report)	S.M.P. Smets	June 1996
R-5	Water Distribution at the Secondary Level in the Chishtian Sub-division	M. Amin K. Tareen Khajid Mahmood Anwar Iqbal Mushtaq Khan Marcel Kuper	July 1996
R-6	Farmers Ability to Copè with Salinity and Sodicity: Farmers' perceptions, strategies and practices for dealing with salinity and sodicity in their farming systems	Neeltje Kielen	Aug 1996
R-7	Salinity and Sodicity Effects on Soils and Crops in the Chishtian Sub-Division: Documentation of a Restitution Process	Neeltje Kielen Muhammad Aslam Rafique Khan Marcel Kuper	Sept 1996
R-8	Tertiary Sub-System Management: (Workshop proceedings)	Khalid Riaz Robina Wahaj	Sept 1996
R-9	Mobilizing Social Organization Volunteers: An Initial Methodological Step Towards Establishing Effective Water Users Organization	Mehmoodul Hassan Zafar Iqbal Mirza D.J. Bandaragoda	Oct 1996
R-10	Canal Water Distribution at the Secondary Level in the Punjab, Pakistan (M.Sc Thesis published as Research Report)	Steven Visser	Oct 1996
R-11	Development of Sediment Transport Technology in Pakistan: An Annotated Bibliography	M. Hasnain Khan	Oct 1996
R-12	Modeling of Sediment Transport in Irrigation Canals of Pakistan: Examples of Application (M.Sc Thesis published as Research Report)	Gilles Belaud	Oct 1996
R-13	Methodologies for Design, Operation and Maintenance of Irrigation Canals subject to Sediment Problems: Application to Pakistan (M.Sc Thesis published as Research Report)	Alexandre Vabre	Oct 1996

Report No.	Title	Author	Year
R-14	Government Interventions in Social Organization for Water Resource Management: Experience of a Command Water Management Project in the Punjab, Pakistan	Waheed uz Zaman D.J.Bandaragoda	Oct 1996
R-15	Applying Rapid Appraisal of Agricultural Knowledge Systems (RAAKS) for Building Inter-Agency Collaboration	Derk Kuiper Mushtaq A. Khan Jos van Oostrum M. Rafique Khan Nathalie Roovers Mehmood ul Hassan	Nov 1996
R-16	Hydraulic Characteristics of Chishtian Sub-division, Fordwah Canal Division	Anwar Iqbal	Nov 1996
R-17	Hydraulic Characteristics of Irrigation Channels in the Malik Sub-Division, Sadiqia Division, Fordwah Eastern Sadiqia Irrigation and Drainage Project	Khalid Mahmood	Nov 1996
R-18	<b>Proceedings of National Conference on Managing Irrigation for Environmentally Sustainable Agriculture in Pakistan</b>	M. Badruddin Gaylord V. Skogerboe M.S. Shafique (Editors for all volumes)	Nov 1996
R-18.1	Volume-I: Inauguration and Deliberations		
R-18.2	Volume-II: Papers on the Theme: Managing Canal Operations		
R-18.3	Volume-III: Papers on the Theme: Water Management Below the Mogha		
R-18.4	Volume-IV: Papers on the Theme: Environmental Management of Irrigated Lands		
R-18.5	Volume-V: Papers on the Theme: Institutional Development		
R-19	Detailed Soil Survey of Eight Sample Watercourse Command Areas in Chishtian and Hasilpur Tehsils	Soil Survey of Pakistan IIMI-Pakistan	Nov 1996
R-20	Unsteady Flow Simulation of the Designed Pehur High-Level Canal and Proposed Remodeling of Machai and Miara Branch Canals, North West Frontier Province, Pakistan	Zaigham Habib Kobkiat Pongput Gaylord V. Skogerboe	Dec 1996
R-21	<b>Salinity Management Alternatives for the Rechna Doab, Punjab, Pakistan</b>	Gauhar Rehman Waqar A. Jehangir Abdul Rehman Muhammad Aslam Gaylord V. Skogerboe	May 1997
R-21.1	Volume One: Principal Findings and Implications for Sustainable Irrigated Agriculture		
R-21.2	Volume Two: History of Irrigated Agriculture: A Select Appraisal	Gauhar Rehman Hassan Zia Munawwar Asghar Hussain	Jan 1997
R-21.3	Volume Three: Development of Procedural and Analytical Liniks	Gauhar Rehman Muhammad Aslam Waqar A. Jehangir Abdul Rehman Asghar Hussain Nazim Ali Hassan Zia Munawwar	Jan 1997
R-21.4	Volume Four: Field Data Collection and Processing	Gauhar Rehman Muhammad Aslam Waqar A. Jehangir Mobin Ud Din Ahmed Hassan Zia Munawwar Asghar Hussain Nazim Ali	Jan 1997
R-21.5	Volume Five: Predicting Future Tubewell Salinity Discharges	Muhammad Aslam	Jan 1997



Report No.	Title	Author	Year
R-21.6	Volume Six: Resource Use and Productivity Potential in the Irrigated Agriculture	Waqar A. Jehangir Nazim Ali	Feb 1997
R-21.7	Volume Seven: Initiative for Upscaling: Irrigation Subdivision as the Building Block	Gauhar Rehman Asghar Hussain Hassan Zia Munawwar	Apr 1997
R-21.8	Volume Eight: Options for Sustainability: Sector-Level Allocations and Investments	Abdul Rehman Gauhar Rehman Hassan Zia Munawwar	Apr 1997
R-22	Salinisation, Alkalinisation and Sodification on Irrigated Areas in Pakistan: Characterisation of the geochemical and physical processes and the impact of irrigation water on these processes by the use of a hydro-geochemical model (M.Sc Thesis published as Research Report)	Nicolas Condom	Mar 1997
R-23	Alternative Scenarios for Improved Operations at the Main Canal Level: A Study of Fordwah Branch, Chishtian Sub-Division Using A Mathematical Flow simulation Model(M.Sc Thesis published as Research Report)	Xavier Litrico	Mar 1997
R-24	Surface Irrigation Methods and Practices: Field Evaluation of the Irrigation Processes for Selected Basin Irrigation Systems during Rabi 1995-96 Season	Ineke Margot Kalwij	Mar 1997
R-25	Organizing Water Users for Distributary Management: Preliminary Results from a Pilot Study in the Hakra 4-R Distributary of the Eastern Sadiqia Canal System of Pakistan's Punjab Province	D.J. Bandaragoda Mehmood UI Hassan Zafar Iqbal Mirza M. Asghar Cheema Waheed uz Zaman	Apr 1997
R-26	Moving Towards Participatory Irrigation Management	D.J. Bandaragoda Yameen Memon	May 1997
R-27	Fluctuations in Canal Water Supplies: A Case Study	Shahid Sarwar H.M. Nafees M.S. Shafique	June 1997
R-28	Hydraulic Characteristics of Pilot Distributaries in the Mirpurkhas, Sanghar and Nawabshah Districts, Sindh, Pakistan	Bakhshal Lashari Gaylord V. Skogerboe Rubina Siddiqui	June 1997
R-29	Integration of Agricultural Commodity Markets in the South Punjab, Pakistan	Zubair Tahir	July 1997
R-30	Impact of Irrigation, Salinity and Cultural Practices on Wheat Yields in Southeastern Punjab, Pakistan	Florence Pintus	Aug 1997
R-31	Relating Farmers' Practices to Cotton Yields in Southeastern Punjab, Pakistan	P.D.B.J. Meerbach	Aug 1997
R-32	An Evaluation of Outlet Calibration Methods: A contribution to the study on Collective Action for Water Management below the Outlet, Hakra 6-R Distributary	Arjen During	Aug 1997
R-33	Farmers' use of Basin, Furrow and Bed-and-Furrow Irrigation Systems and the possibilities for traditional farmers to adopt the Bed-and-Furrow Irrigation Method.	Nanda M. Berkhout Farhat Yasmeen Rakhshanda Maqsood Ineke M. Kalwij	Sep 1997
R-34	Financial Feasibility Analysis of Operation and Maintenance Costs for Water Users Federations on three distributaries in Province of Sindh, Pakistan.	Amin Sohani	Sep 1997
R-35	Assessing the Field Irrigation Performance and Alternative Management Options for Basin Surface Irrigation Systems through Hydrodynamic Modelling.	Ineke Margot Kalwij	Oct 1997
R-36	Socio-Economic Baseline Survey for Three Pilot Distributaries in Sindh Province, Pakistan.	Yameen Memon Mehmood UI Hassan Don Jayatissa Bandaragoda	Nov 1997

Report No.	Title	Author	Year
R-37	Socio-Economic Basline Survey for a Pilot Project on Water Users Organizations in the Hakra 4-R Distributary Command Area, Punjab.	Muhammad Asghar Cheema Zafar Iqbal Mirza Mehmood Ul Hassan Don Jayatissa Bandaragoda	Dec 1997
R-38	Baseline Survey for Farmers Organizations of Shahpur and Mirwal Small Dams, Punjab, Pakistan.	Muhammad Asghar Cheema Don Jayatissa Bandaragoda	Dec 1997
R-39	<b>Monitoring and Evaluation of Irrigation and Drainage Facilities for Pilot Distributaries in Sindh Province, Pakistan</b>		
R-39.1	Volume One: Objectives, Stakeholders, Approaches and Methodology	M.S. Shafique B.K. Lashari M. Akhtar Bhatti Gaylord V. Skogerboe	Dec 1997
R-39.2	Volume Two: Bareji Distributary, Mirpurkhas District	B.K. Lashari Waryam Balouch Ghulam Mustafa Talpur Muhammad Nadeem Asghar Ali Memon Badrul Hassan Memon M. Akhtar Bhatti M.S. Shafique Gaylord V. Skogerboe	Dec 1997
R-39.3	Volume Three: Dhoro Naro Minor, Nawabshah District	B.K. Lashari Abdul Rehman Soomro Nizamuddin Bharchoond Muneer Ahmed Mangrio Parvez Ahmed Pirzado Fateh Mohammad Mari M. Akhtar Bhatti M.S. Shafique Gaylord V. Skogerboe	Dec 1997
R-39.4	Volume Four: Heran Distributary, Sanghar District	B.K. Lashari M. Naveed Khayal Niaz Hussain Sial Abdul Majeed Ansari Abdul Jalil Ursani Ghulam Shabir Soomoro M. Ghous Laghari M. Akhtar Bhatti M.S. Shafique Gaylord V. Skogerboe	Dec 1997
R-40	<b>Maintenane Plans for Irrigation Facilities of Pilot Distributaries in Sindh Province, Pakistan.</b>		
R-40.1	Volume One: Dhoro Naro Minor, Nawabshah District	Abdul Rehman Soomro Munir Ahmed Mangrio Nizamuddin Bharchoond Fateh Muhammad Mari Parvez Ahmed Pirzado Bakhshal Lashari M. Akhtar Bhatti Gaylord V. Skogerboe	Dec 1997
R-40.2	Volume Two: Heran Distributary, Sanghar District	Abdul Majeed Ansari Niaz Hussain Sial Abdul Jalil Ursani Ghulam Shabir M. Ghous Laghari M. Naveed Khayal Bakhshal Lashari M. Akhtar Bhatti Gaylord V. Skogerboe	Dec 1997

Report No.	Title	Author	Year
R-40.3	Volume Three: Bareji Distributary, Mirpurkhas District	Asghar Ali Memon Waryam Balouch Ghulam Mustafa Talpur Muhammad Nadeem Badrul Hassan Memon Bakhshal Lashari M. Akhtar Bhatti Gaylord V. Skogerboe	Dec 1997
R-41	<b>Preliminary Business Plans</b>	Pervaiz Ahmad Pirzada Mohsin Khatri Syed Daniyal Haider	Dec 1997
R-41.1	Volume One: Dhoro Naro Minor, Nawabshah District	Muhammad Nadeem Mohsin Khatri Syed Daniyal Haider	Dec 1997
R-41.2	Volume Two: Bareji Distributary, Mirpurkhas District	Niaz Hussain Sial Mohsin Khatri Syed Daniyal Haider	Dec 1997
R-41.3	Volume Three: Heran Distributary, Sanghar District	D.J. Bandaragoda Gaylord V. Skogerboe Yameen Memon	Dec 1997
R-42	Prospects for Farmer-Managed Irrigated Agriculture in the Sindh Province of Pakistan. Final Report.	Mehmood Ul Hassan Yameen Memon	Jan 1998
R-43	Study Tour of Pakistani Pilot Project Farmer-Leaders to Nepal	Waheed uz Zaman	Feb 1998
R-44	Self-Help Maintenance Activities by the Water Users Federation of Hakra 4-R Distributary	Soil Survey of Pakistan IIMI-Pakistan	Mar 1998
R-45	Semi-Detailed Soil Survey of Chishtian Irrigation Sub-Division	Annemiek Terpstra	Mar 1998
R-46	Tenancy and Water Management in South-Eastern Punjab, Pakistan	IIMI Cemagref	Apr 1998
R-47	The Collaboration between the International Irrigation Management Institute and Cemagref in Pakistan: Proceeding of a one-day workshop	Paul Willem Vehmeyer Raza ur Rehman Abbasi Mushtaq A. Khan Abdul Hakeem Khan Gaylord V. Skogerboe	Apr 1998
R-48	Methodologies for Developing Downstream Gauge Ratings for Operating Canal Discharge Regulating Structures	Olaf Verheijen	Apr 1998
R-49	Community Irrigation Systems in the Province of Balochistan	M. Aslam J.C. van Dam	Apr 1998
R-50	Modelling Soil Salinity and Sodicity Processes in an Unsaturated Zone using LEACHM: A Case Study from the Chishtian Irrigation Sub-Division	Waheed-uz-Zaman Anwar Iqbal Abdul Hamid Gaylord V. Skogerboe	May 1998
R-51	Water Measurement Training for Subsystem Management of Hakra 4-R Distributary by the Water Users Federation	Mobin ud Din Ahmad E.G. van Waijjen Marcel Kuper Steven Visser	May 1998
R-52	Comparison of Different Tools to Assess the Water Distribution in Secondary Canals with Ungated Outlets	Gilles Belaud Abdul Hakeem Khan Ghulam Nabi	May 1998
R-53	Sediment Behavior of Sangro Distributary, Mirpurkhas Sub-division, Sindh	Patrice Garin Marcel Kuper Frederic Labbe Pierre Strosser	May 1998
R-54	Evaluation of the Integrated Approach Developed in the Context of the IIMI-CEMAGREF Collaboration in Pakistan		

Report No.	Title	Author	Year
R-55	Development of a Modified Low-Cost Pitot Tube for Measuring Pump Discharges	M.S. Shafique Nisar Hussain Bukhari M. Mohsin Hafeez	June 1998
R-56	Institutional and Physical Determinants of Water Management Performance at the Tertiary Level: The Dynamics of Watercourse Maintenance in the Pakistan Punjab.	Cris H. de Klein Robina Wahaj	June 1998
R-57	Formalization of Water Users Associations by Farmer Leaders of Hakra 4-R Distributary.	Waheed uz Zaman Nasir Sultan Bilal Asghar Muhammad Amjad Kamran	July 1998
R-58	Water Balance in Dhoro Naro Minor Command Area Sindh, Pakistan	Bea Keller Gabor Jaimes	July 1998
R-59	Performance Assessment of the Water Distribution System in the Chishtian Sub-division at the Main and Secondary Canal Level	Zaigham Habib Marcel Kuper	July 1998
R-60	Transition from local level Management to State Regulation: Formalization of Water Allocation Rules in Pakistan	Mehmood ul Hassan Abdul Hamid D.J. Bandaragoda	Aug 1998
R-61	Multiple Uses of Irrigation Water in the Hakra 6-R Distributary Command Area, Punjab, Pakistan	Waqar A. Jehangir Muhammad Mudasser Mahmood ul Hassan Zulfiqar Ali	Aug 1998
R-62	Field Discharge Calibration of Head Regulators, Mirpurkhas Sub-Division, Jamrao Canal, Nara Circle, Sindh Province, Pakistan	Abdul Hakeem Khan Gaylord V. Skogerboe Rubina Siddiqi Bakhshal Lashari Zahid Hussain Jalbani Muhammad Ali Khuwaja Muhammad Hashim Memon Waqar Hussain Khokhar	Aug 1998
R-63	Training Farmers to Organize Farmers: Lessons Learned in Social Organization for Irrigated Agriculture at the Hakra 4-R Distributary	Mehmood ul Hassan Zafar Iqbal Mirza D.J. Bandaragoda	Sep 1998
R-64	Physical Characteristics and Operational Performance of Mirpur Khas Sub-Division, Jamrao Canal Division, Nara Circle, Sindh Province, Pakistan	Abdul Hakeem Khan Rubina Siddiqui Zahid Hussain Jalbani Muhammad Ali Khowaja Waqar Hussain Khokhar Muhammad Hashim Memon Bakhshal Lashari Gaylord V. Skogerboe	Sep 1998
R-65	<b>GIS Metadata for an Irrigation System</b>	Mobin-ud-Din Ahmad Yann Chemin	Oct 1998
R-65.1	Volume I: Chishtian Sub-Division	Salman Asif Samia Ali	
R-65.2	Volume II: Selected Watercourses within Chishtian Sub-Division	Samia Ali Yann Chemin Salman Asif Mobin-ud-Din Ahmad	Oct 1998
R-66	Application of Crop-Based Irrigation Operations to Chashma Right Bank Canal	Juan Carlos Alurralde Carlos A. Gandarillas Gaylord V. Skogerboe	Oct 1998
R-67	A Gender Analysis of Casual Hired Labor in Irrigated Agriculture in the Pakistan Punjab	Cris H. De Klein	Nov 1998
R-68	Pre-Takeover Comparative Performance of Water Users Organizations of Hakra 4-R Distributary, Punjab, Pakistan	Wahee-uz-Zaman Abdul Hamid	Nov 1998
R-69	Preliminary Business Plan for the Water Users Federation of the Hakra 4-R Distributary	Mehmood Ul Hassan Mohsin Khatri	Nov 1998

Report No.	Title	Author	Year
R-70	<b>Waterlogging and Salinity Management in the Sindh Province</b>		
R-70.1	Volume I: Irrigated Landscape: Resource Availability across the Hydrological Divides:	Gauhar Rehman Asghar Hussain Abdul Hamid Amjad Siddique Almas Mehmooda Tabassum Muhammad Anas Nomani Kamran Yousaf	Dec 1998
R-70.1a	Supplement I.A: Improved Water Management Practices for the Rice-Wheat Cropping Systems in Sindh Province, Pakistan	Muhammad Aslam	Dec 1998
R-70.1b	Supplement I.B: Farmers' Perspectives on Warah Branch Canal Operations	Muhammad Akhtar Bhatti Abdul Rehman Soomro Pervez Ahmed Pirzado Munir Ahmed Mungrio Gauhar Rehman	Dec 1998
R-70.1c	Supplement I.C: Drainage in the LBOD Project: Operational Concerns and Quality of Pumped Effluent	Shafqat Ijaz	Dec 1998
R-70.1d	Supplement I.D: Drainage in the LBOD Project: Impact Assessment	Rubina Butt Nausheen Munir Muhammad Iftikhar Bhatti Amjad Siddique Almas Gauhar Rehman Asghar Hussain M. Tariq Soomro Mehmooda Tabassum Kamran Yousaf	Dec 1998
R-70.2	Volume II: The Farming System: Potential for Investment and Returns in Sindh, Pakistan	Waqar A. Jehangir Nazim Ali	Dec 1998
R-70.3	Volume III: Strategy for Resource Allocations and Management Across the Hydrological Divides	Abdul Rehman Gauhar Rehman	Dec 1998
R-71	Coordinated Services for Irrigated Agriculture in Pakistan: Proceedings of the National Workshop October 29-30, 1998	Mehmood Ul Hassan Prachanda Pradhan	Dec 1998
R-72	Scheduling Model for Crop-Based Irrigation Operations	Kobkiat Pongput Juan Carlos Alurralde Gaylord V. Skogerboe	Dec 1998
R-73 MREP R-233	Waterlogging, Salinity and Crop Yield Relationships (Joint Report with Mona Reclamation Experimental Project)	M. Akram Kahlown Muhammad Iqbal Gaylord V. Skogerboe Saeed ur Rehman	Dec 1998
R-74	Development and Use of Rectangular Channels with a Single Current Meter Measurement for Recording Farm Water Deliveries	Nisar Hussain Bukhari Muhammad Mohsin Hafeez M.S.Shafique Gaylord V. Skogerboe	Dec 1998
R-75	Water Level Fluctuations and Discharge Variability in Mirpurkhas Sub-Division, Jamrao Canal, Nara Circle, Sindh Province, Pakistan	Abdul Hakeem Khan Bakhshai Lashari Muhammad Ali Khawaja Asghar Ali Memon Gaylord V. Skogerboe	Dec 1998