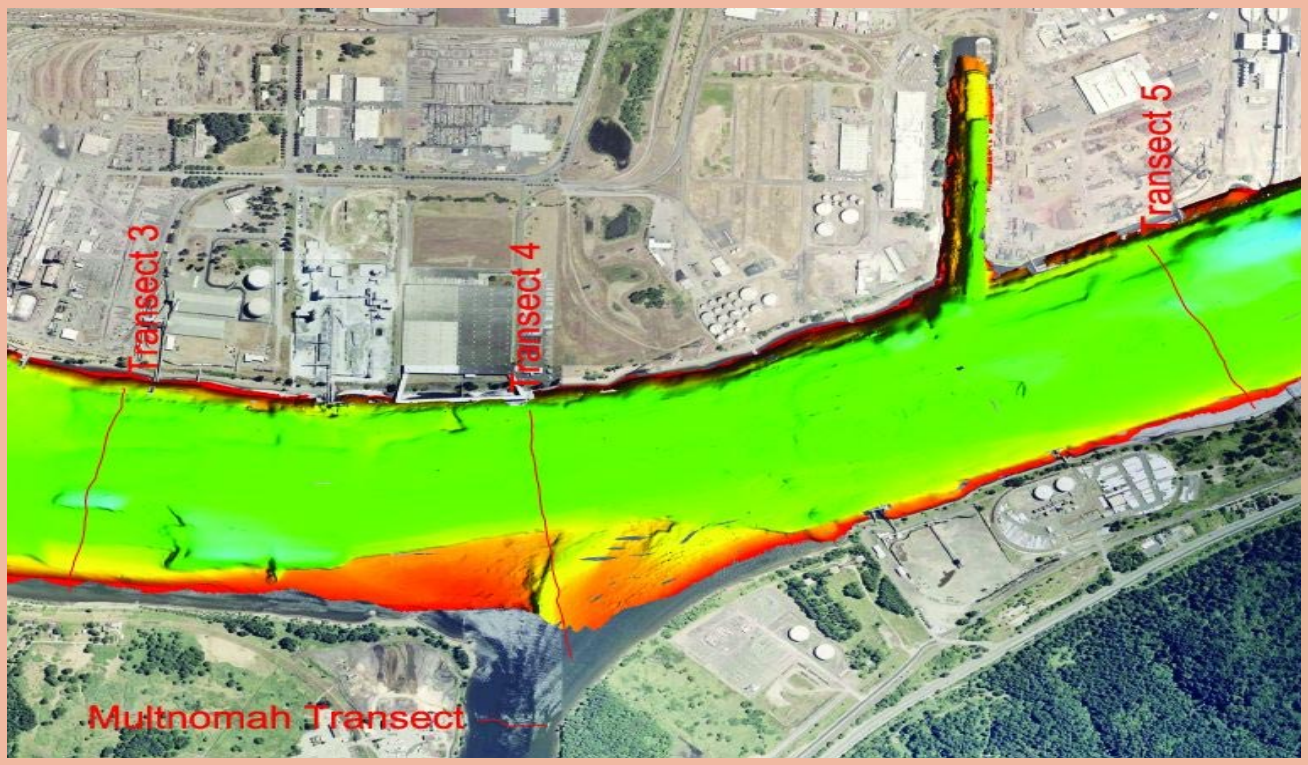
Willamette River Acoustic Doppler Current Profiler Survey Results

May 2003



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Privileged and Confidential: Work Product Prepared in Anticipation of Litigation

Willamette River Acoustic Doppler Current Profiler
Survey Results
May 2003

REGISTERED
PROFESSIONAL
LAND SURVEYOR

OREGON
JON L. DASLER
JANUARY 23, 1990
2420

EXP: 12/31/03

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Acronyms and Abbreviations

ADCP	Acoustic Doppler Current Profiler
cm	centimeters
DEA	David Evans and Associates, Inc.
kHz	kilo Hertz
Q	Total Flow
TIN	Triangular Irregular Network

May 2003
WILLAMETTE RIVER ACOUSTIC DOPPLER CURRENT PROFILER
SURVEY RESULTS

1.0 INTRODUCTION

In the Spring of 2002, while the Willamette River was at a high level, David Evans and Associates, Inc. (DEA) conducted a series of current monitoring transects in the Portland Harbor. This investigation was intended as an overview of current velocities and direction over the lower 15 miles of the Willamette River. Evidence of a substantial flow passing down Multnomah Channel was observed in the data from the initial investigation. These findings warranted a more thorough analysis of the area surrounding Multnomah Channel during a tidal exchange in the Portland Harbor. River flows in this area are complicated by flows down the Willamette River, the Columbia River (3 miles down river), Multnomah Channel (a 36 mile channel to the Columbia River near St. Helens, Oregon) and the influence of tidal exchanges in Multnomah Channel and the Columbia River.

In May of 2003 DEA conducted a follow-on ADCP investigation in the vicinity of the Multnomah Channel (Figure 1.) during lower river levels. The observations were conducted over a 14 hour period from high tide to high tide, through one low tide event. This report presents the methods and results of the May 2003 ADCP investigation.

2.0 ACOUSTIC DOPPLER CURRENT PROFILING (THEORY OF OPERATION)

The ADCP estimates horizontal and vertical velocity as a function of depth by using the Doppler effect to measure the radial relative velocity between the instrument and scatterers in the water column. Three acoustic beams in different directions are the minimal requirement for measuring the three velocity components. A fourth beam adds redundancy and an error estimate. The ADCP transmits a ping from each transducer element roughly once per second. The echo arrives back at the instrument over an extended period, with echoes from shallow depths arriving sooner than ones from greater ranges. Profiles are produced by range-gating the echo signal, which means the echo is broken into successive segments called depth bins which correspond to successively deeper depth ranges. The operator configures the length of each depth bin and the transmit pulse, which determines the degree of averaging in the vertical, depending on whether one is interested more in vertical resolution or profile penetration. The relative velocities are rotated from the transducers to the earth's reference frame using the units internal compass or an externally supplied heading. Finally, relative velocities and various ancillary parameters are stored on the survey vessel as raw data files. In shallow areas, such as in rivers, the ADCP can “lock on” to the bottom and use the bottom track as a very stable reference point from which to calculate absolute speed and direction of the unit. This information on the instrument speed and direction is then subtracted from the relative current information to produce true current velocity and direction.

3.0 DATA ACQUISITION

On May 13, 2003 DEA used the 30-foot survey vessel *John B. Preston* to conduct Acoustic Doppler Current Profile (ADCP) measurements across the lower Willamette River near Portland, Oregon. Four transects located near the mouth of Multnomah Channel were profiled six times during the tidal exchange. Appendix B includes a graph of the observed tides at Vancouver

Washington (5 miles up the Columbia River from the confluence with the Willamette) and observed tides on the Willamette at the Morrison Bridge (river mile 12.8). The graph also depicts the time each transect was made relative to the tidal exchange.

A RD Instruments 1200 kHz Workhorse Sentinel ADCP was deployed from a pole mounted on the starboard side of the vessel. The unit has an internal compass which was calibrated in the field with the resulting heading error reduced to less than 1 degree (0.7). A magnetic variation of 18.5 degrees was added to correct the data to true north. A draft correction of 1.35 feet was logged and applied to the ADCP data. The system was configured to collect data at 50 cm (1.64 feet) depth intervals and had a blank after transmit set to 25 cm (0.82 feet) to reduce spurious readings from close to the transducers. The 50 cm bin setting corresponds to approximately 7 cm per second precision on the readings. The set of depth bins recorded with each transmission cycle is referred to as an ensemble. Transit speed was kept to bare minimum to reduce the magnitude of the vessel vector relative to the river currents. This also enabled more along track acoustic pings to be averaged in post processing to improve the signal to noise ratio.

The 4 transect locations (Figure 1.) had been determined in advance and corresponded to specific areas of interest around the channel entrance. The river elevations were determined by downloading logged data at two gauges closest to transect locations. The Morrison Bridge Gauge and the Vancouver Gauge were downloaded from the U.S. Army Corps of Engineers web site and are included in Appendix B.

The ADCP Winriver software, which was used to log the raw data in the field, saves the files in sequential series starting with 0 and incremented by 1 each time logging is commenced. If a line was aborted the ADCP file count still updated. The files recorded in the field are listed in the daily log that can be found in Appendix C. The r.000 files are raw ADCP files. The w.000 are configuration files stored during acquisition, the w.001 files contain any post-processing changes to the data that may have been made. A summary of transect names and locations is provided in Table 1.

Table 1: Transect Locations

Transect	LOCATION DESCRIPTION
Mult	Across Multnomah Channel approximately 600 feet downstream from the Willamette
3	River Mile 2.5 cross section
4	River Mile 3.1 cross section of Willamette into Multnomah Channel
5	River Mile 4.0 cross section

4.0 DATA PROCESSING

The raw ADCP files were replayed using WinRiver software. After replay, a screen grab was taken and saved as a jpeg image for presentation in this report. Appendix A includes the jpeg image for each transect run. A 5 ensemble average was applied in the along track direction to improve the data quality. For calculation of flow (Q) through the transect from bank to bank, distances to the bank were measured from the ADCP transect tracklines in AutoCAD. The distances measured were to the edge of the TIN model of the bathymetric data collected previously by DEA. The Q calculations extrapolate the closest bank velocities over the distance to the bank and assume a bottom shape as specified by the user. For these profiles a triangular bottom shape was applied for the region being estimated. The Q information is located in the

lower right hand areas of each transect plot. In the upper right section of each transect plot is an X, Y graph depicting transect path and a depth averaged stick plot of the current vector.
The upper profile of each transect plot shows a color plot of current velocities perpendicular to the transect. The lower profile shows a color plot of the current direction which directly correlates to the velocity data above. A copy of the WinRiver software and all of the raw data files have been included on a CD-Rom located in the back of this report.

FIGURE 1: ADCP TRANSECT LOCATIONS

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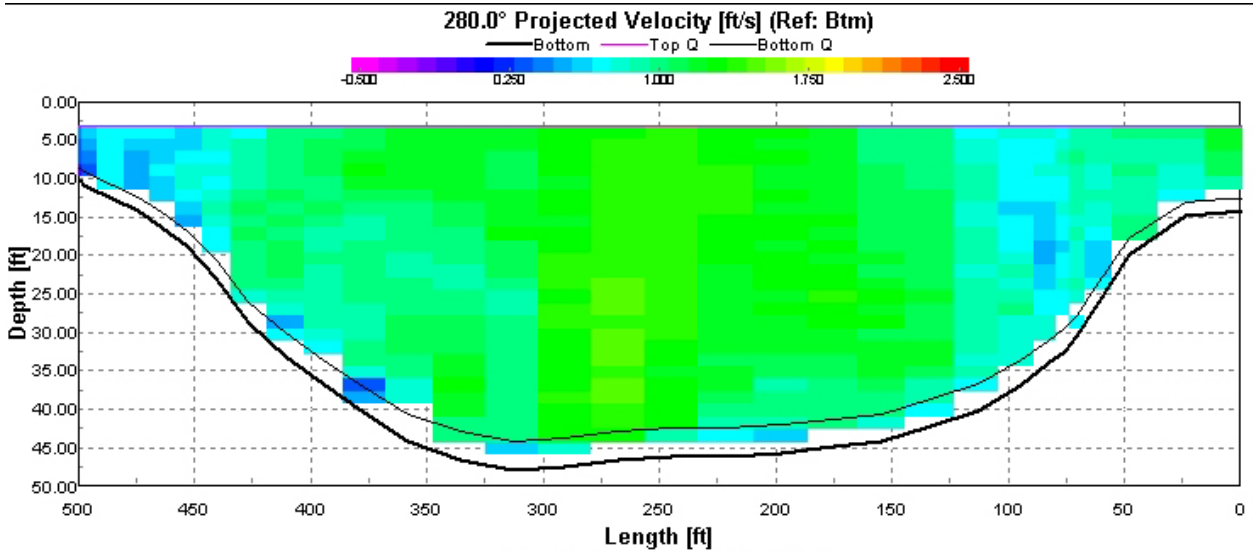
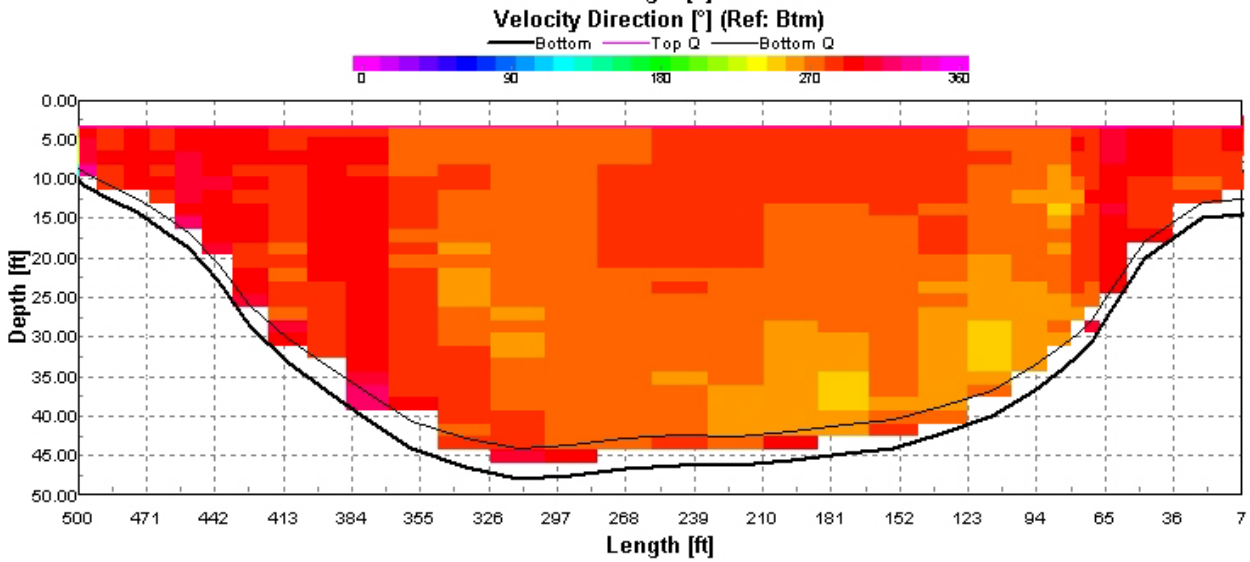
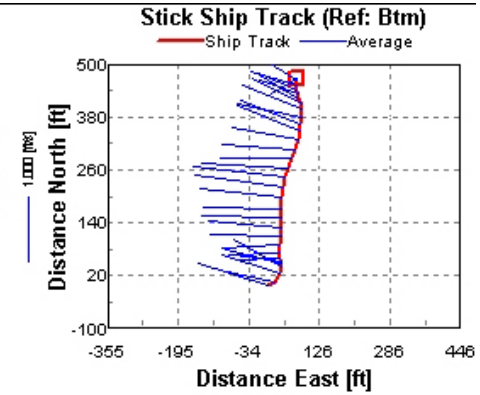
APPENDIX A

TRANSECT PROFILES



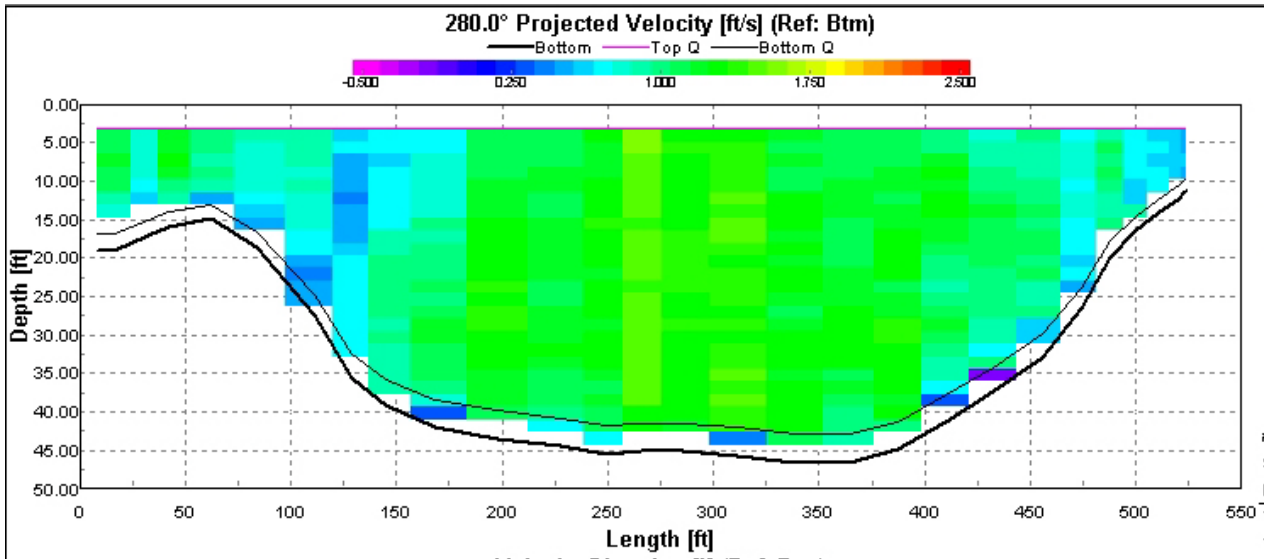


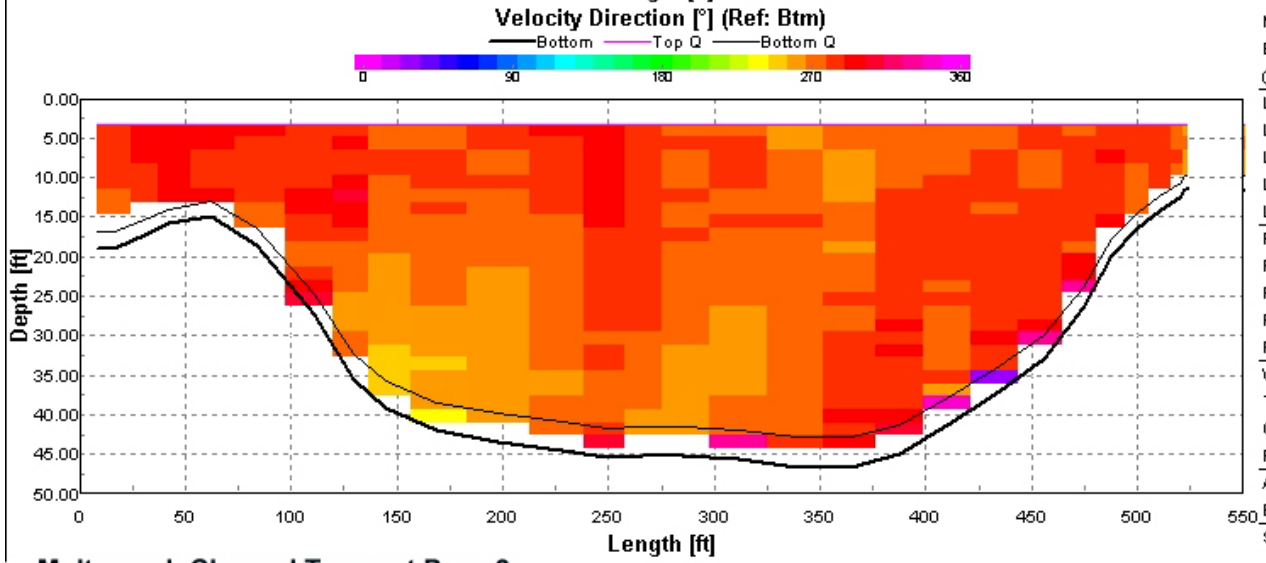


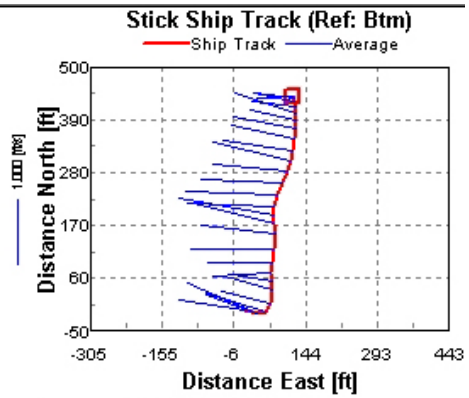
Discharge (Btm) Right to Left

# Ensembles	151	
Start Time	07:23:03	
Duration	226.35	[s]
Total Q	-18693.37	[ft³/s]
Top Q	-1733.68	[ft³/s]
Measured Q	-14920.88	[ft³/s]
Bottom Q	-1529.64	[ft³/s]
(T+M+B) Q	-18184.20	[ft³/s]
Left Distance	50.00	[ft]
Left Velocity	-0.611	[ft/s]
Left Depth	11.54	[ft]
Left Area	288.50	[ft²]
Left Q	-124.65	[ft³/s]
Right Distance	75.00	[ft]
Right Velocity	-0.998	[ft/s]
Right Depth	14.53	[ft]
Right Area	544.74	[ft²]
Right Q	-384.52	[ft³/s]
Width	598.94	[ft]
Total Area	18088.99	[ft²]
Q/Area	1.03	[ft/s]
Flow Dir.	278.45	[°]
Avg Course	8.67	[°]
Boat Speed	2.207	[ft/s]
Start Ens #	223	

Multnomah Channel Transect Pass 1



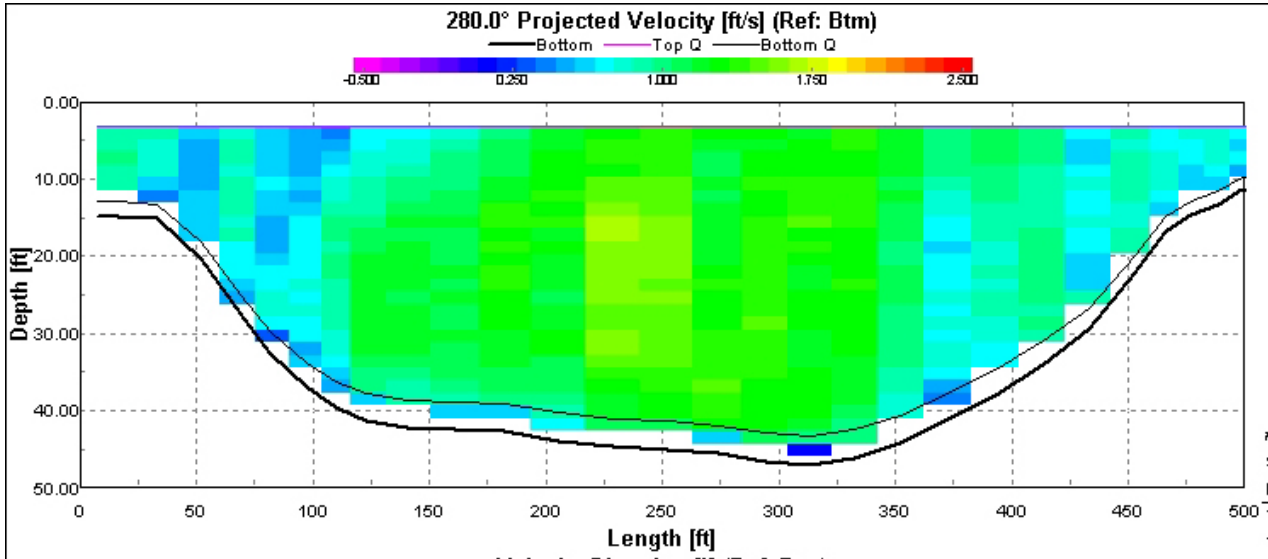


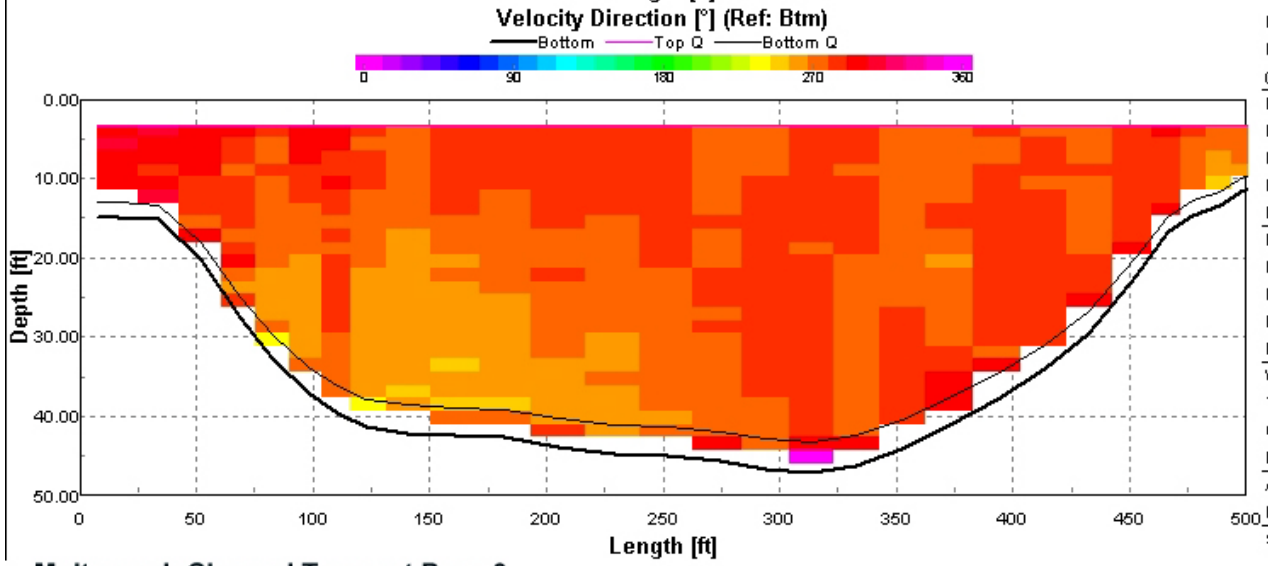


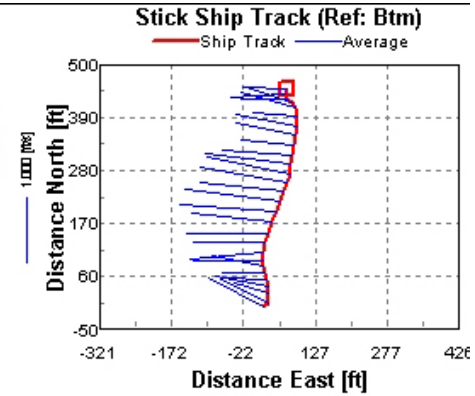
Discharge (Btm) Left to Right

# Ensembles	131	
Start Time	09:17:41	
Duration	196.17	[s]
Total Q	18542.43	[ft³/s]
Top Q	1715.47	[ft³/s]
Measured Q	14871.22	[ft³/s]
Bottom Q	1395.26	[ft³/s]
(T+M+B) Q	17981.95	[ft³/s]
Left Distance	75.00	[ft]
Left Velocity	0.895	[ft/s]
Left Depth	17.86	[ft]
Left Area	669.75	[ft²]
Left Q	424.02	[ft³/s]
Right Distance	50.00	[ft]
Right Velocity	0.606	[ft/s]
Right Depth	12.74	[ft]
Right Area	318.38	[ft²]
Right Q	136.46	[ft³/s]
Width	580.06	[ft]
Total Area	17728.00	[ft²]
Q/Area	1.05	[ft/s]
Flow Dir.	277.85	[°]
Avg Course	14.84	[°]
Boat Speed	2.663	[ft/s]
Start Ens #	9	

Multnomah Channel Transect Pass 2



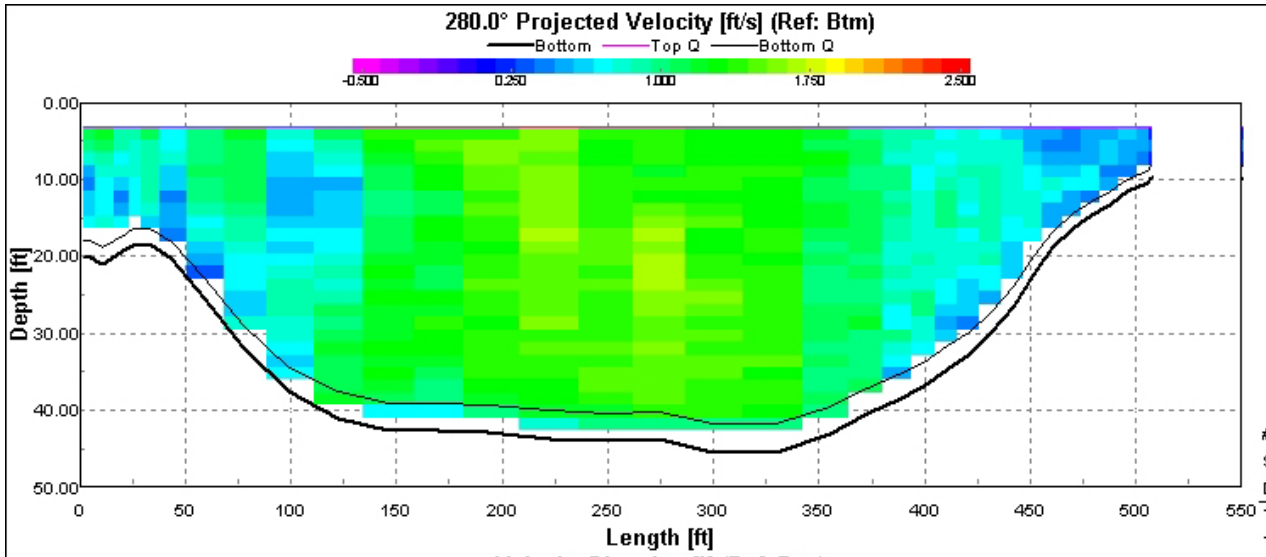


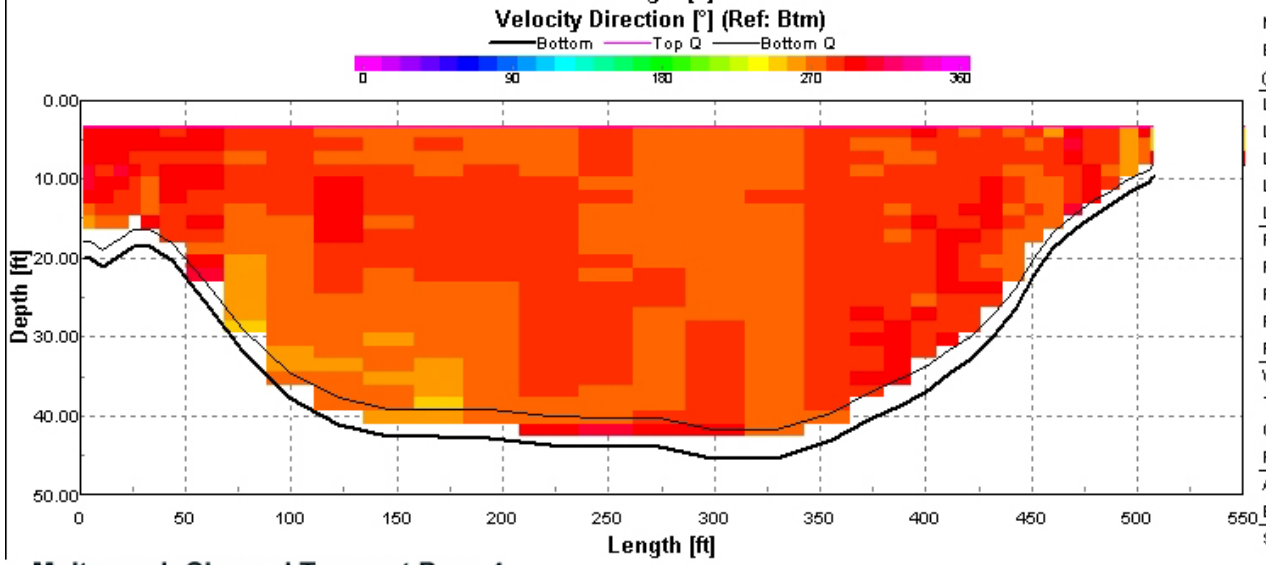


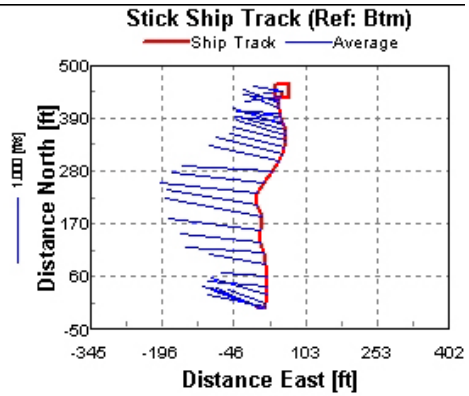
Discharge (Btm) Left to Right

# Ensembles	138	
Start Time	11:53:16	
Duration	206.73	[s]
Total Q	18194.59	[ft³/s]
Top Q	1702.53	[ft³/s]
Measured Q	14583.57	[ft³/s]
Bottom Q	1378.20	[ft³/s]
(T+M+B) Q	17664.29	[ft³/s]
Left Distance	75.00	[ft]
Left Velocity	0.892	[ft/s]
Left Depth	14.90	[ft]
Left Area	558.65	[ft²]
Left Q	352.45	[ft³/s]
Right Distance	50.00	[ft]
Right Velocity	0.782	[ft/s]
Right Depth	12.86	[ft]
Right Area	321.53	[ft²]
Right Q	177.85	[ft³/s]
Width	580.75	[ft]
Total Area	17506.46	[ft²]
Q/Area	1.04	[ft/s]
Flow Dir.	276.45	[°]
Avg Course	8.35	[°]
Boat Speed	2.411	[ft/s]
Start Ens #	44	

Multnomah Channel Transect Pass 3



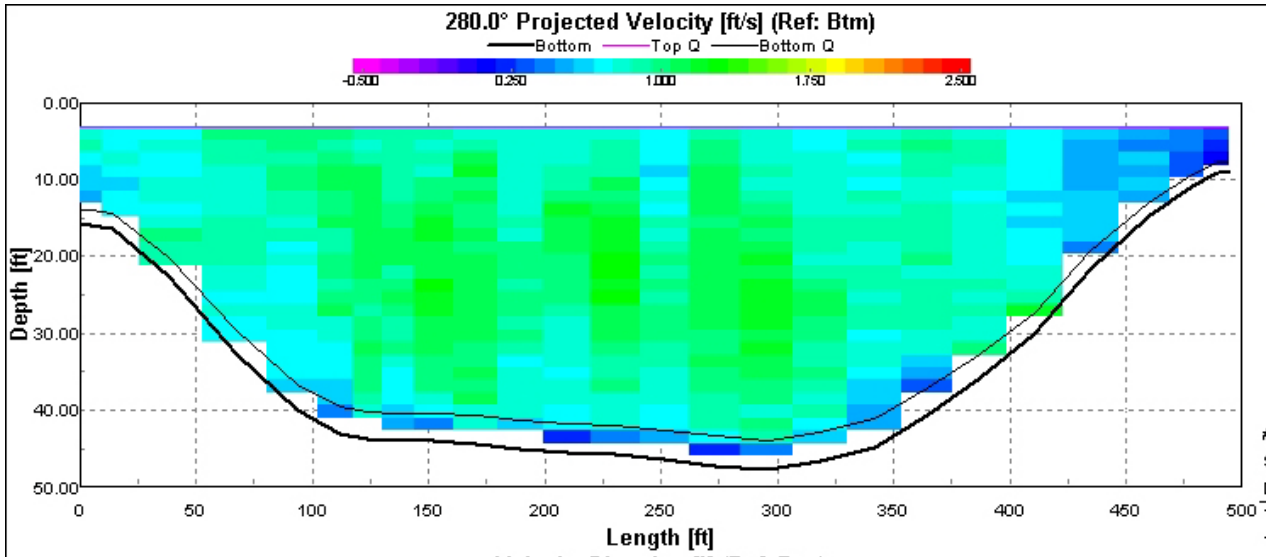


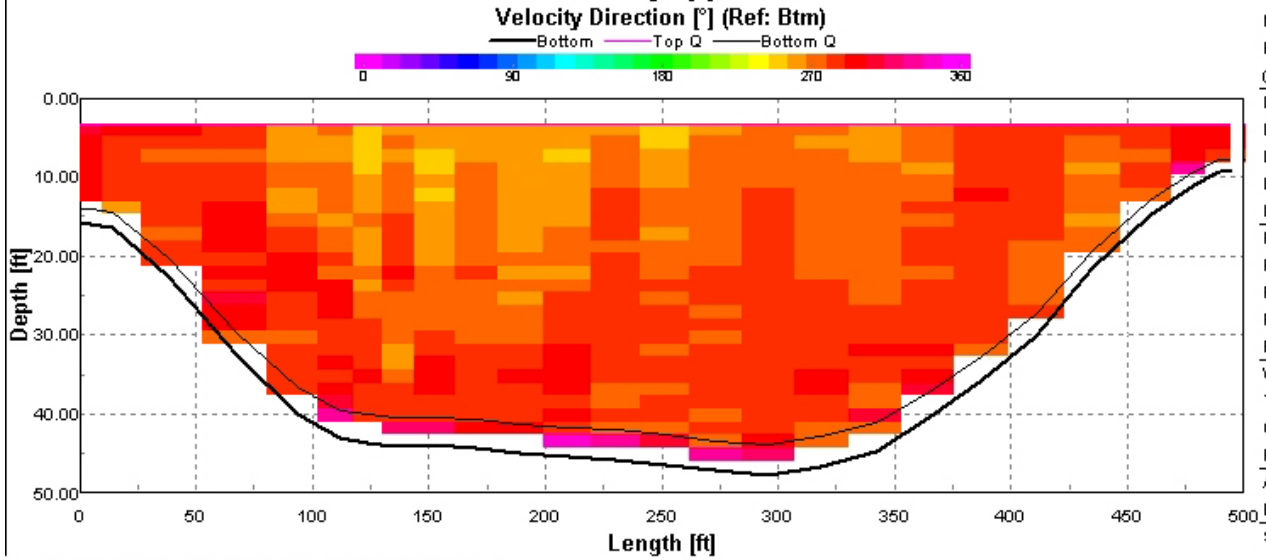


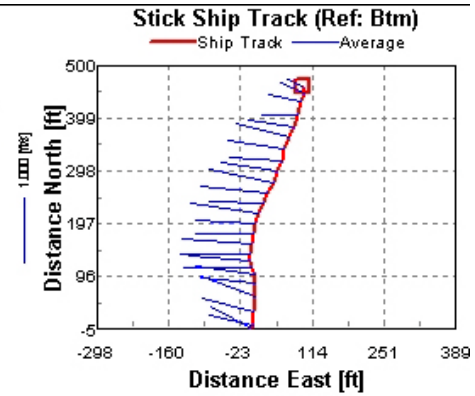
Discharge (Btm) Left to Right

# Ensembles	166	
Start Time	14:09:04	
Duration	248.98	[s]
Total Q	18535.22	[ft³/s]
Top Q	1729.10	[ft³/s]
Measured Q	14752.91	[ft³/s]
Bottom Q	1391.47	[ft³/s]
(T+M+B) Q	17873.48	[ft³/s]
Left Distance	100.00	[ft]
Left Velocity	0.813	[ft/s]
Left Depth	20.55	[ft]
Left Area	1027.32	[ft²]
Left Q	590.56	[ft³/s]
Right Distance	40.00	[ft]
Right Velocity	0.472	[ft/s]
Right Depth	10.65	[ft]
Right Area	213.10	[ft²]
Right Q	71.18	[ft³/s]
Width	591.54	[ft]
Total Area	17502.45	[ft²]
Q/Area	1.06	[ft/s]
Flow Dir.	280.54	[°]
Avg Course	6.63	[°]
Boat Speed	2.036	[ft/s]
Start Ens #	5	

Multnomah Channel Transect Pass 4



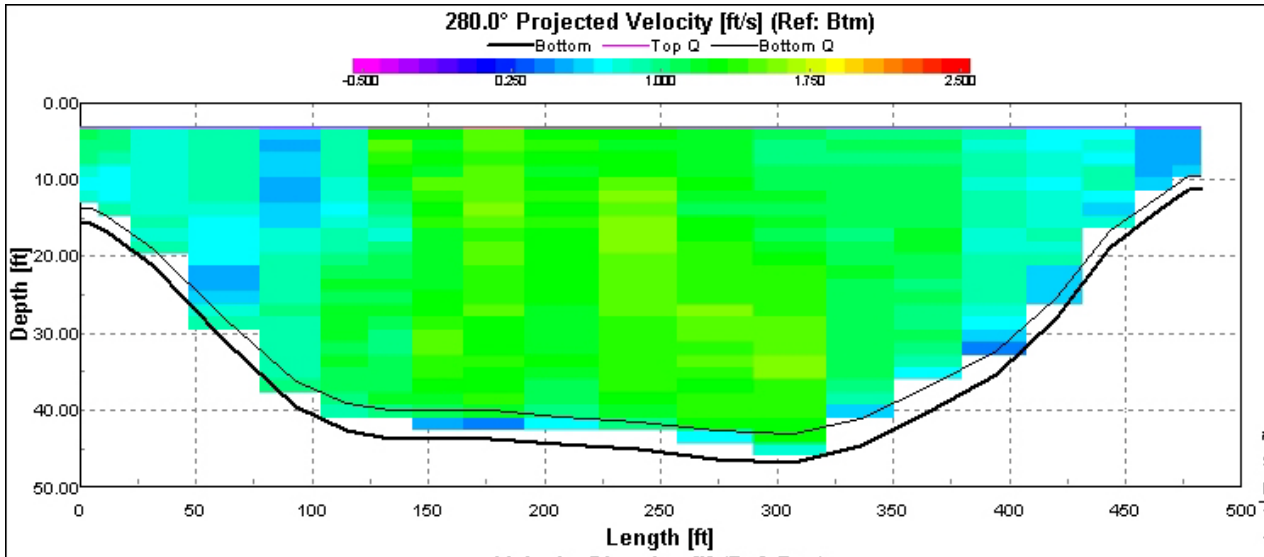


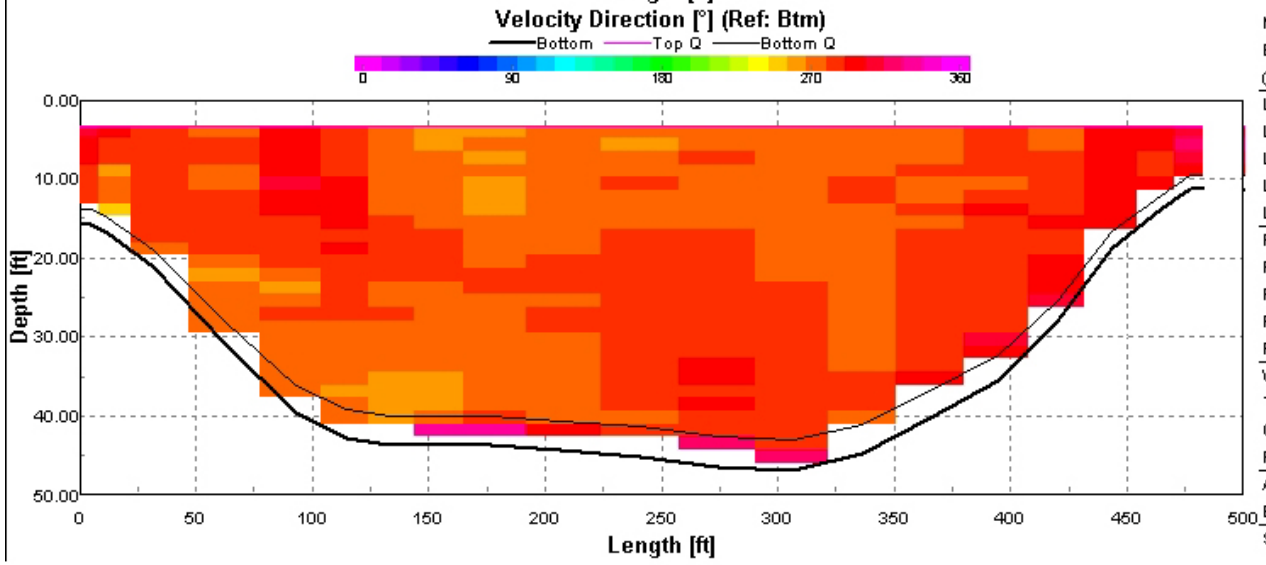


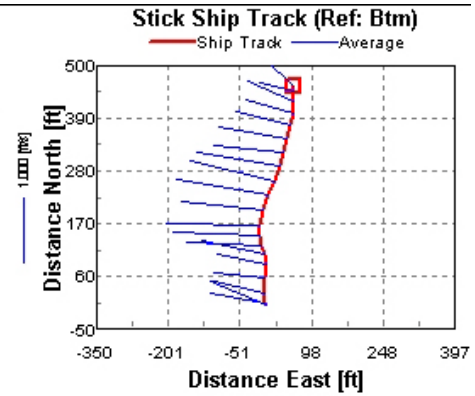
Discharge (Btm) Left to Right

# Ensembles	125	
Start Time	16:09:36	
Duration	187.12	[s]
Total Q	15190.58	[ft³/s]
Top Q	1397.82	[ft³/s]
Measured Q	12042.90	[ft³/s]
Bottom Q	1201.52	[ft³/s]
(T+M+B) Q	14642.24	[ft³/s]
Left Distance	125.00	[ft]
Left Velocity	0.706	[ft/s]
Left Depth	16.06	[ft]
Left Area	1003.47	[ft²]
Left Q	500.72	[ft³/s]
Right Distance	40.00	[ft]
Right Velocity	0.337	[ft/s]
Right Depth	9.98	[ft]
Right Area	199.66	[ft²]
Right Q	47.61	[ft³/s]
Width	635.31	[ft]
Total Area	18275.43	[ft²]
Q/Area	0.83	[ft/s]
Flow Dir.	277.02	[°]
Avg Course	11.68	[°]
Boat Speed	2.613	[ft/s]
Start Ens #	25	

Multnomah Channel Transect Pass 5



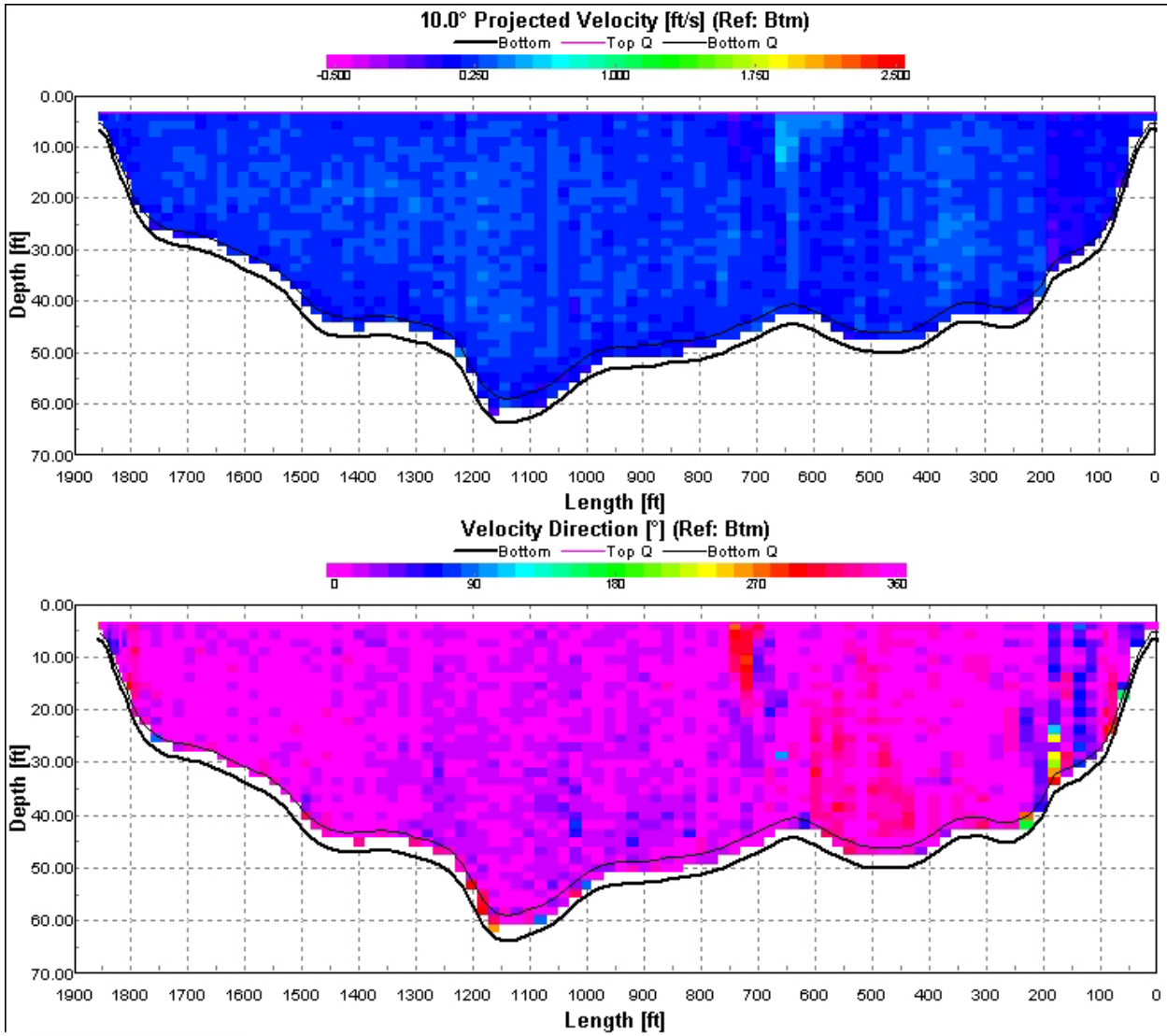


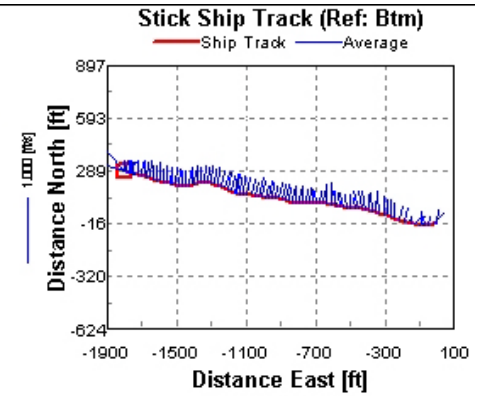


Discharge (Btm) Left to Right

# Ensembles	98	
Start Time	18:00:16	
Duration	146.38	[s]
Total Q	18789.74	[ft³/s]
Top Q	1715.14	[ft³/s]
Measured Q	15048.28	[ft³/s]
Bottom Q	1422.26	[ft³/s]
(T+M+B) Q	18185.68	[ft³/s]
Left Distance	100.00	[ft]
Left Velocity	0.884	[ft/s]
Left Depth	16.18	[ft]
Left Area	808.96	[ft²]
Left Q	505.70	[ft³/s]
Right Distance	35.00	[ft]
Right Velocity	0.585	[ft/s]
Right Depth	13.59	[ft]
Right Area	237.89	[ft²]
Right Q	98.36	[ft³/s]
Width	596.79	[ft]
Total Area	17958.47	[ft²]
Q/Area	1.05	[ft/s]
Flow Dir.	279.06	[°]
Avg Course	7.44	[°]
Boat Speed	3.254	[ft/s]
Start Ens #	35	

Multnomah Channel Transect Pass 6

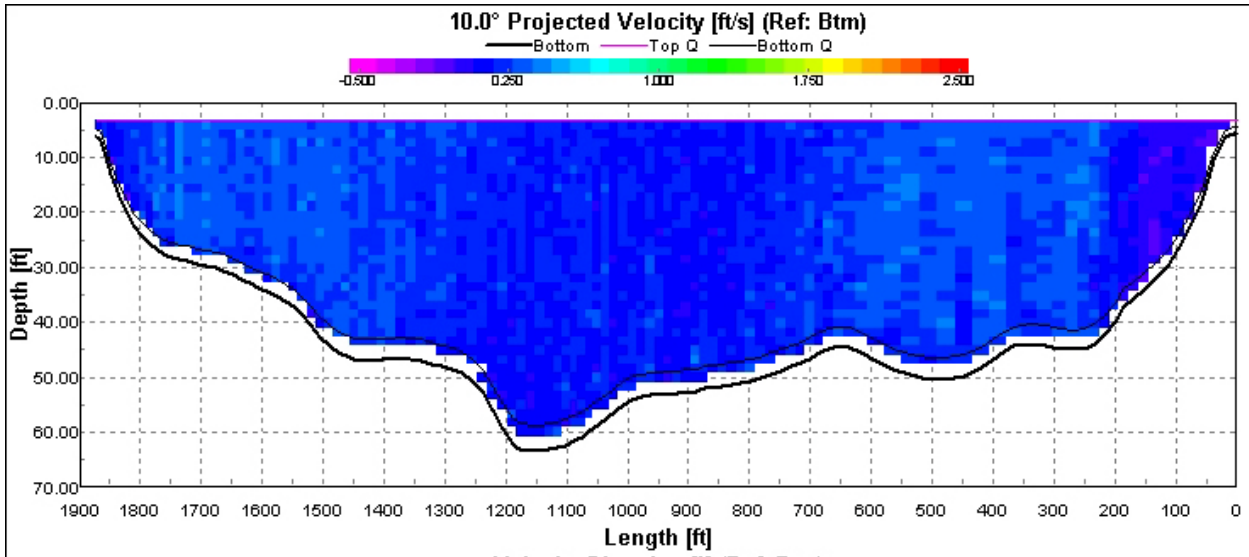


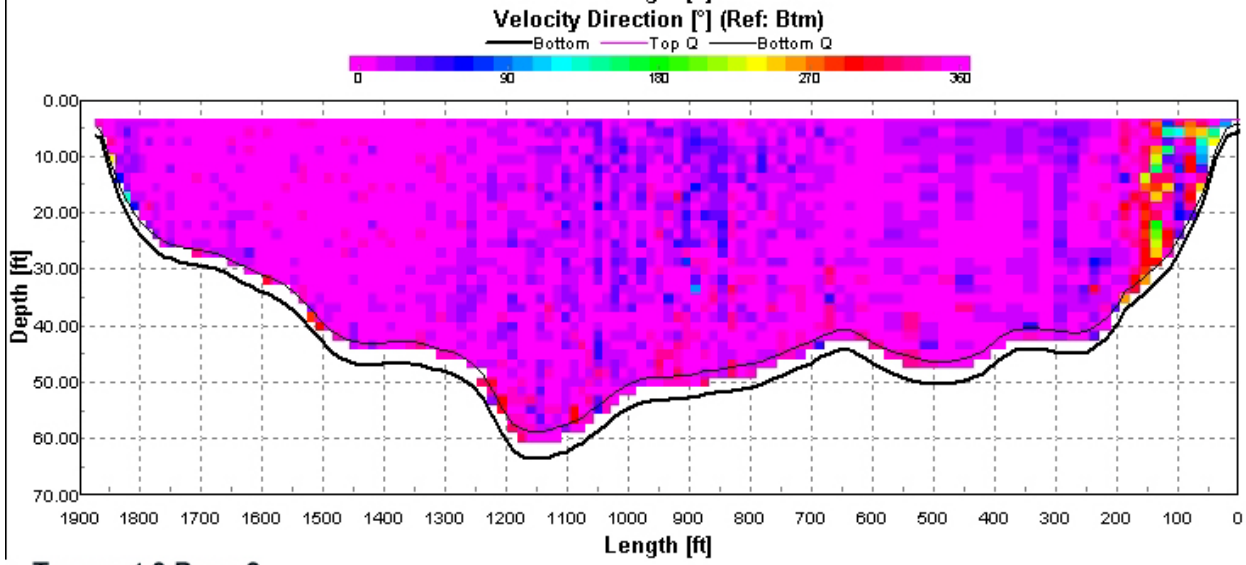


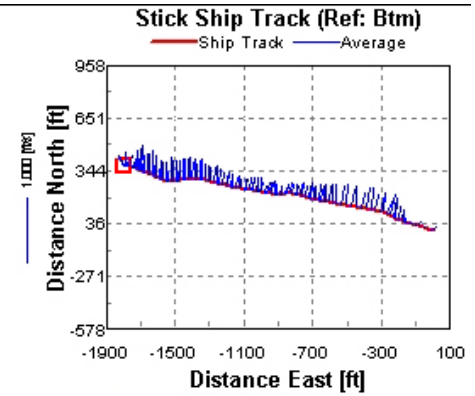
Discharge (Btm) Right to Left

# Ensembles	497	
Start Time	05:39:03	
Duration	752.06	[s]
Total Q	18923.60	[ft³/s]
Top Q	1545.92	[ft³/s]
Measured Q	15870.26	[ft³/s]
Bottom Q	1299.46	[ft³/s]
(T+M+B) Q	18715.64	[ft³/s]
Left Distance	60.00	[ft]
Left Velocity	1.249	[ft/s]
Left Depth	6.65	[ft]
Left Area	199.59	[ft²]
Left Q	176.20	[ft³/s]
Right Distance	50.00	[ft]
Right Velocity	0.210	[ft/s]
Right Depth	8.56	[ft]
Right Area	213.90	[ft²]
Right Q	31.76	[ft³/s]
Width	1938.50	[ft]
Total Area	79900.49	[ft²]
Q/Area	0.24	[ft/s]
Flow Dir.	5.11	[°]
Avg Course	279.11	[°]
Boat Speed	2.471	[ft/s]
Start Ens #	996	

Transect 3 Pass 1



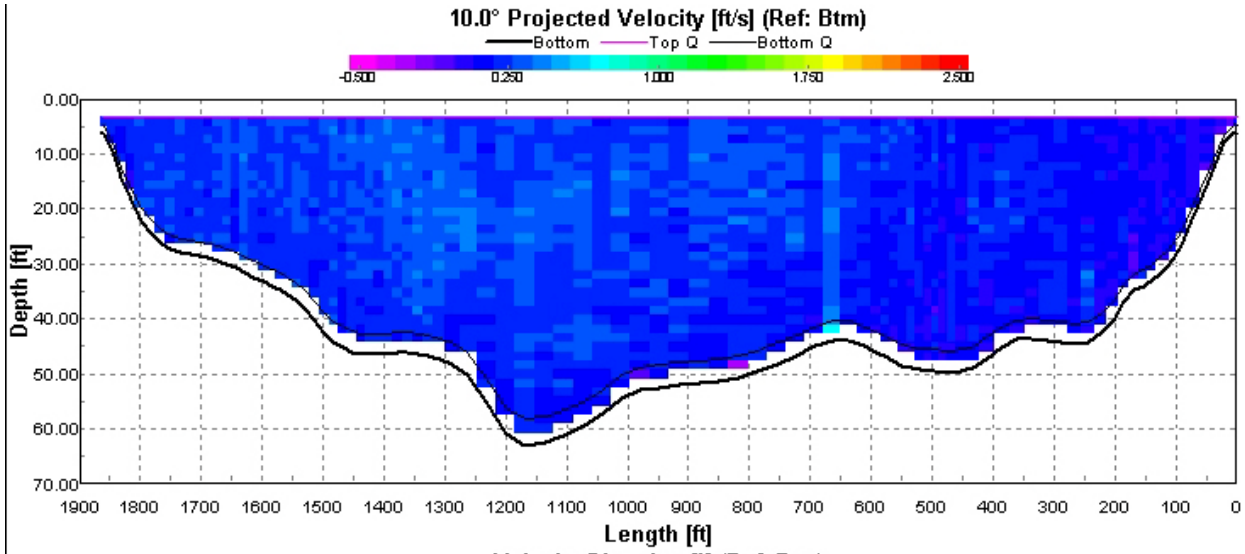


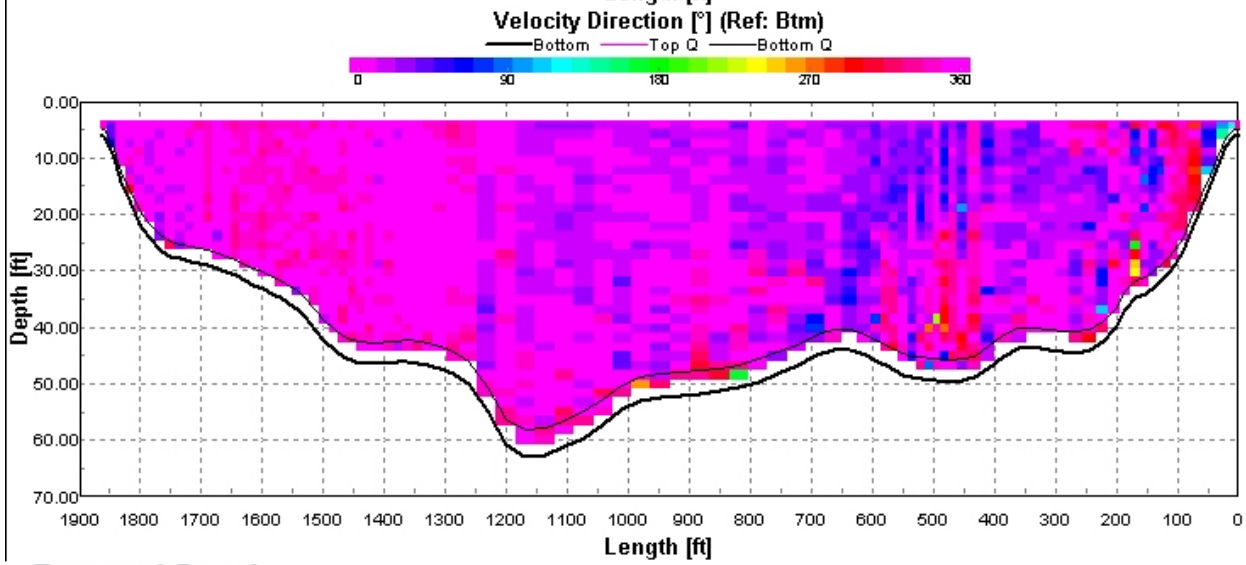


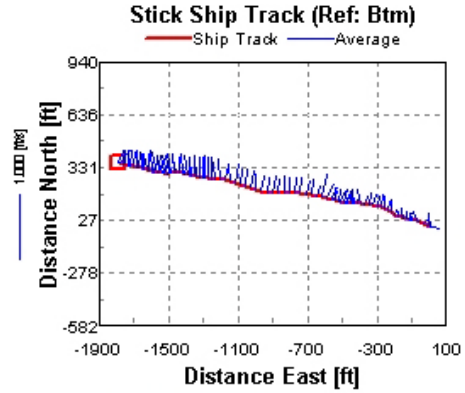
Discharge (Btm) Right to Left

# Ensembles	578	
Start Time	07:59:27	
Duration	872.12	[s]
Total Q	17882.30	[ft³/s]
Top Q	1497.55	[ft³/s]
Measured Q	15106.05	[ft³/s]
Bottom Q	1240.36	[ft³/s]
(T+M+B) Q	17843.96	[ft³/s]
Left Distance	75.00	[ft]
Left Velocity	0.159	[ft/s]
Left Depth	6.97	[ft]
Left Area	261.39	[ft²]
Left Q	29.31	[ft³/s]
Right Distance	40.00	[ft]
Right Velocity	0.055	[ft/s]
Right Depth	11.61	[ft]
Right Area	232.14	[ft²]
Right Q	9.03	[ft³/s]
Width	1985.16	[ft]
Total Area	80442.43	[ft²]
Q/Area	0.22	[ft/s]
Flow Dir.	6.73	[°]
Avg Course	281.92	[°]
Boat Speed	2.146	[ft/s]
Start Ens #	78	

Transect 3 Pass 2



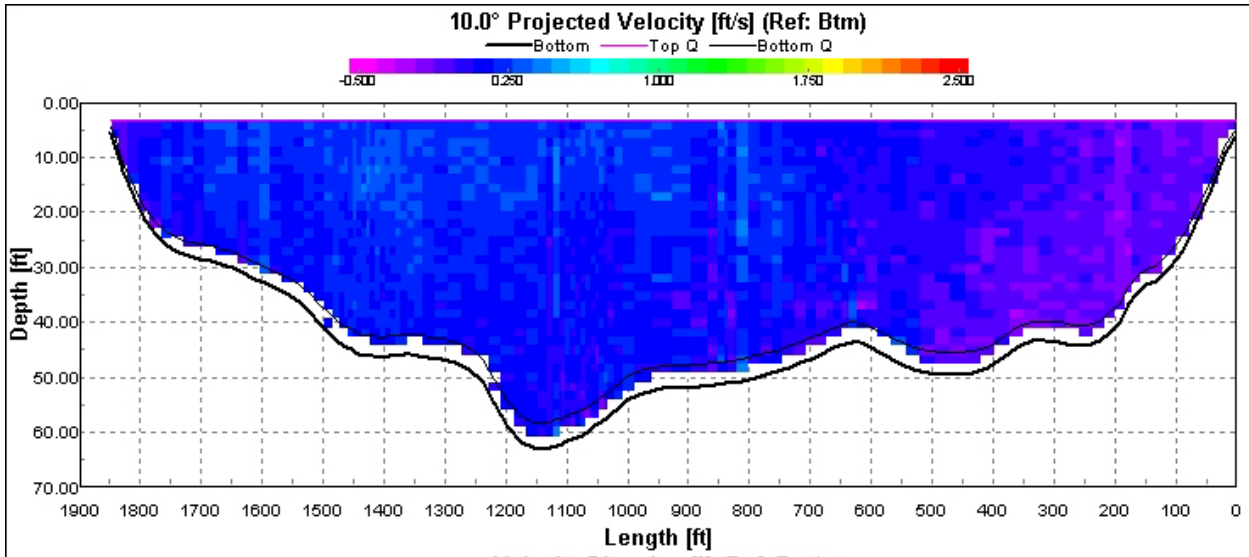


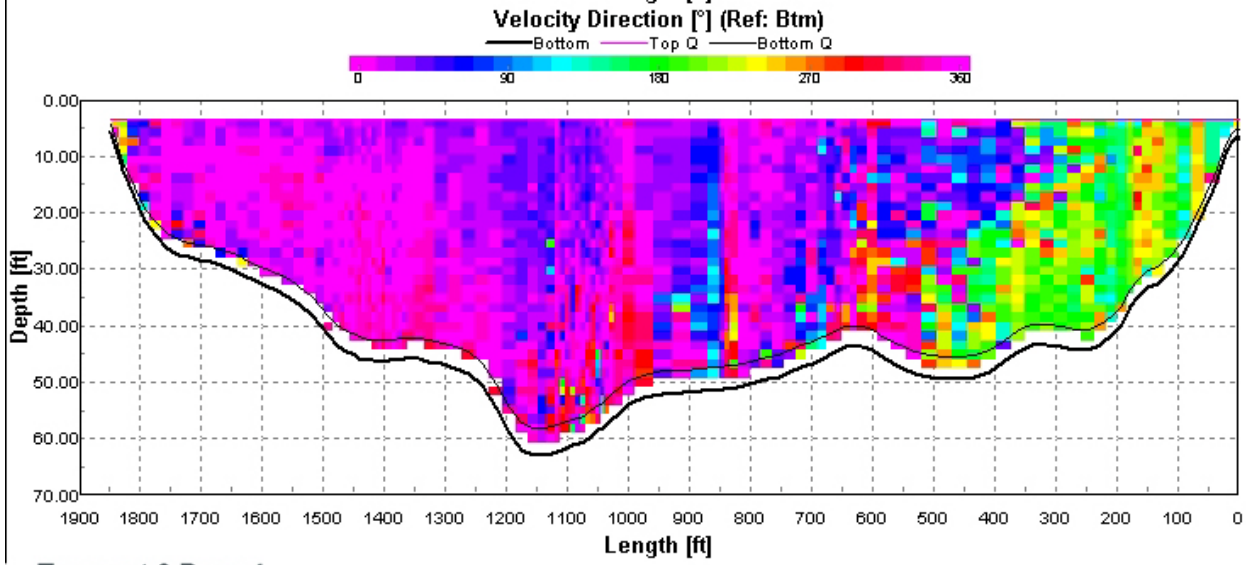


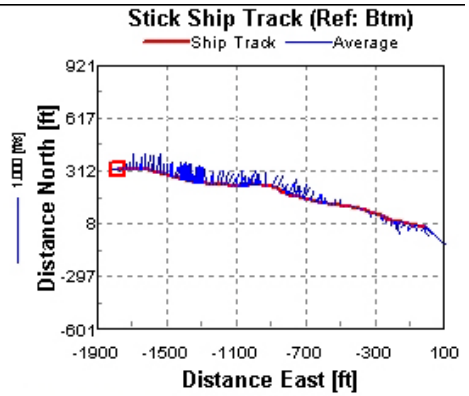
Discharge (Btm) Right to Left

# Ensembles	475	
Start Time	10:36:55	
Duration	715.93	[s]
Total Q	17622.38	[ft³/s]
Top Q	1456.08	[ft³/s]
Measured Q	14879.34	[ft³/s]
Bottom Q	1240.50	[ft³/s]
(T+M+B) Q	17575.92	[ft³/s]
Left Distance	50.00	[ft]
Left Velocity	0.199	[ft/s]
Left Depth	10.66	[ft]
Left Area	266.50	[ft²]
Left Q	37.41	[ft³/s]
Right Distance	30.00	[ft]
Right Velocity	0.114	[ft/s]
Right Depth	7.50	[ft]
Right Area	112.50	[ft²]
Right Q	9.05	[ft³/s]
Width	1904.79	[ft]
Total Area	79045.77	[ft²]
Q/Area	0.22	[ft/s]
Flow Dir.	3.15	[°]
Avg Course	281.46	[°]
Boat Speed	2.599	[ft/s]
Start Ens #	40	

Transect 3 Pass 3



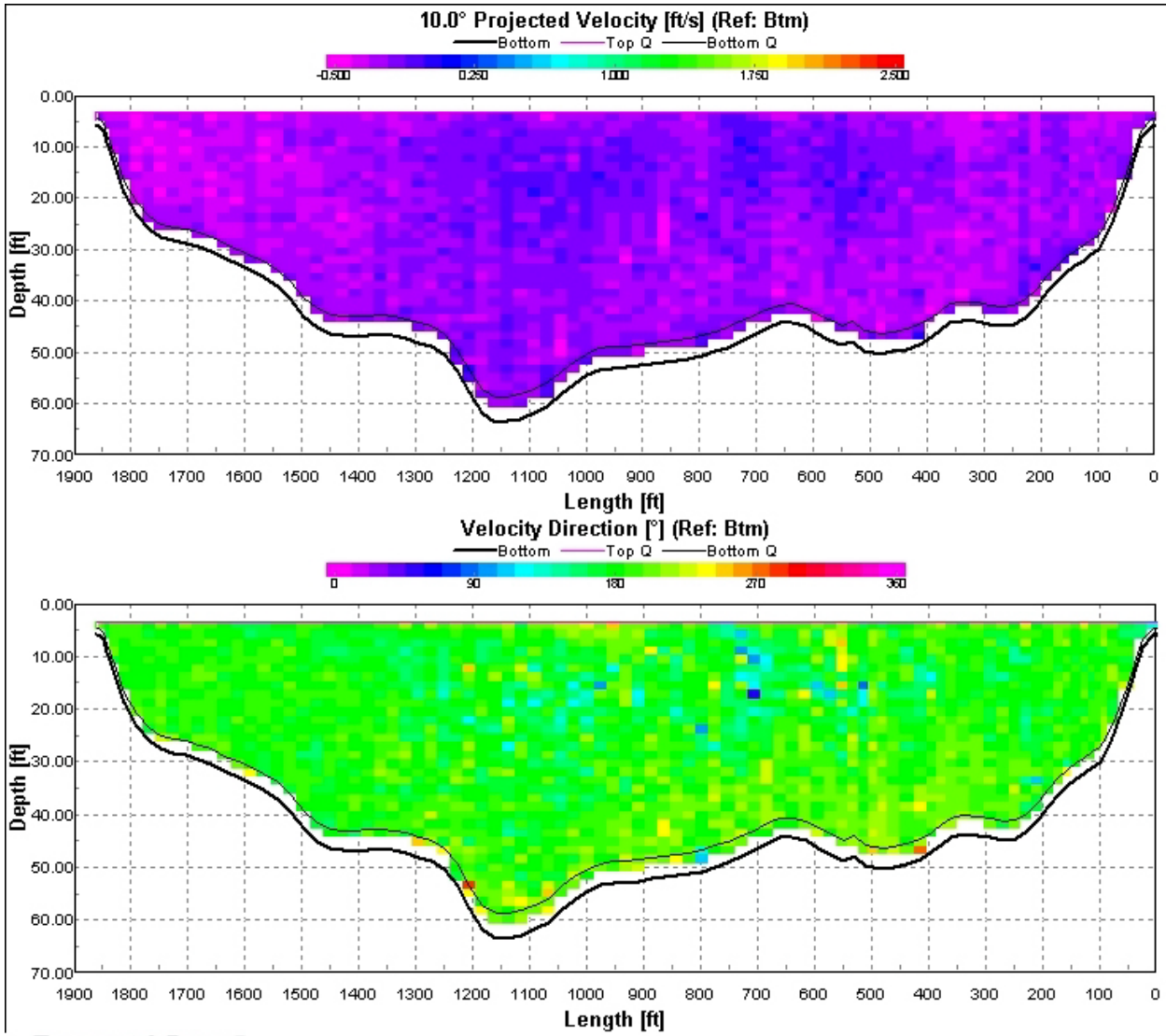


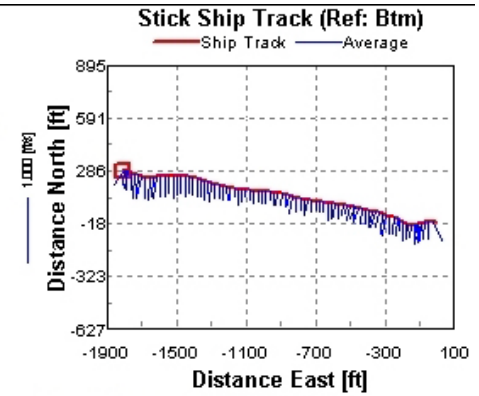


Discharge (Btm) Right to Left

# Ensembles	575	
Start Time	12:54:57	
Duration	867.72	[s]
Total Q	8839.96	[ft³/s]
Top Q	681.49	[ft³/s]
Measured Q	7585.62	[ft³/s]
Bottom Q	598.17	[ft³/s]
(T+M+B) Q	8865.28	[ft³/s]
Left Distance	75.00	[ft]
Left Velocity	-0.062	[ft/s]
Left Depth	10.85	[ft]
Left Area	406.76	[ft²]
Left Q	-17.79	[ft³/s]
Right Distance	25.00	[ft]
Right Velocity	-0.119	[ft/s]
Right Depth	7.13	[ft]
Right Area	89.18	[ft²]
Right Q	-7.53	[ft³/s]
Width	1912.67	[ft]
Total Area	78482.70	[ft²]
Q/Area	0.11	[ft/s]
Flow Dir.	10.42	[°]
Avg Course	280.42	[°]
Boat Speed	2.132	[ft/s]
Start Ens #	41	

Transect 3 Pass 4

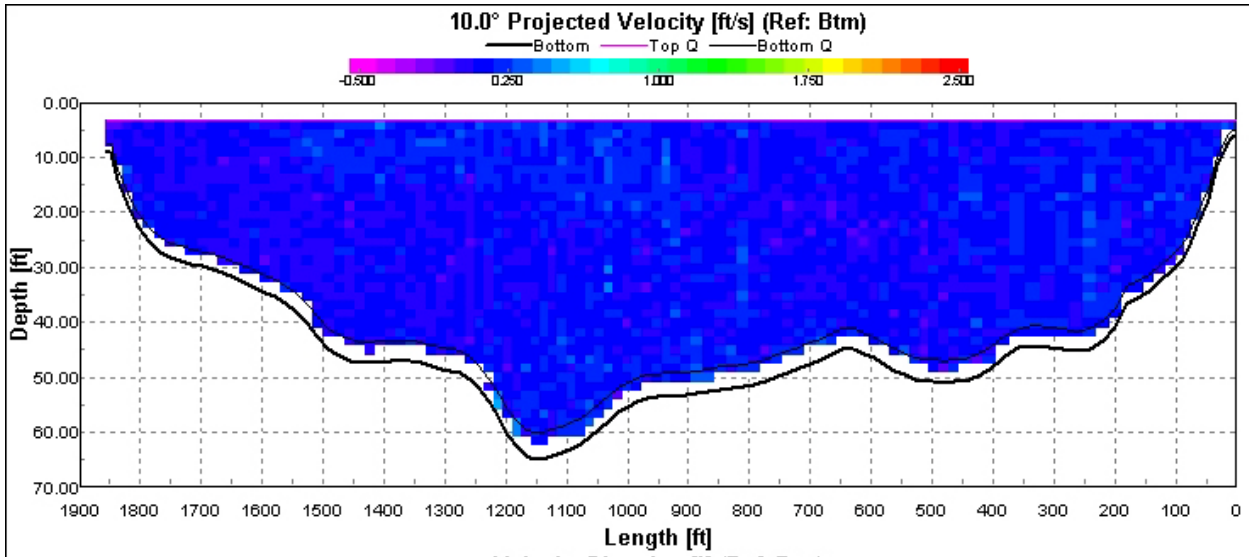


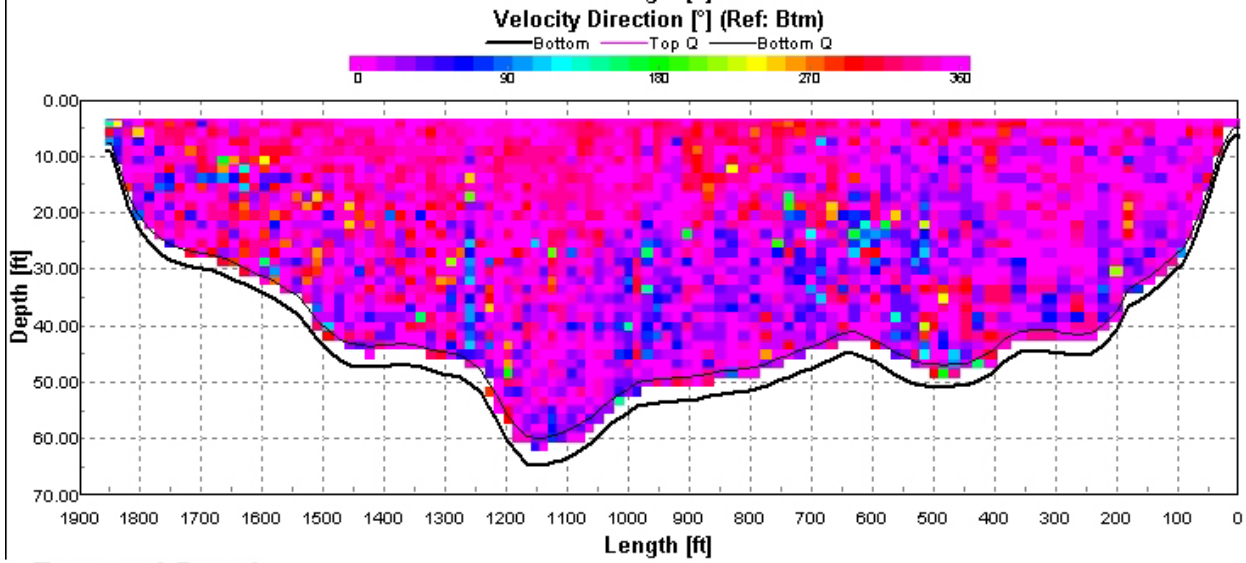


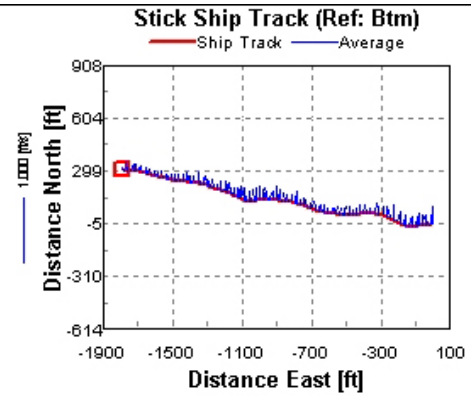
Discharge (Btm) Right to Left

# Ensembles	457	
Start Time	15:03:53	
Duration	688.11	[s]
Total Q	-17955.67	[ft³/s]
Top Q	-1606.12	[ft³/s]
Measured Q	-14985.35	[ft³/s]
Bottom Q	-1278.31	[ft³/s]
(T+M+B) Q	-17869.78	[ft³/s]
Left Distance	60.00	[ft]
Left Velocity	-0.247	[ft/s]
Left Depth	7.40	[ft]
Left Area	221.98	[ft²]
Left Q	-38.79	[ft³/s]
Right Distance	35.00	[ft]
Right Velocity	-0.294	[ft/s]
Right Depth	12.97	[ft]
Right Area	226.90	[ft²]
Right Q	-47.09	[ft³/s]
Width	1925.92	[ft]
Total Area	79682.68	[ft²]
Q/Area	0.23	[ft/s]
Flow Dir.	185.19	[°]
Avg Course	279.06	[°]
Boat Speed	2.707	[ft/s]
Start Ens #	8	

Transect 3 Pass 5



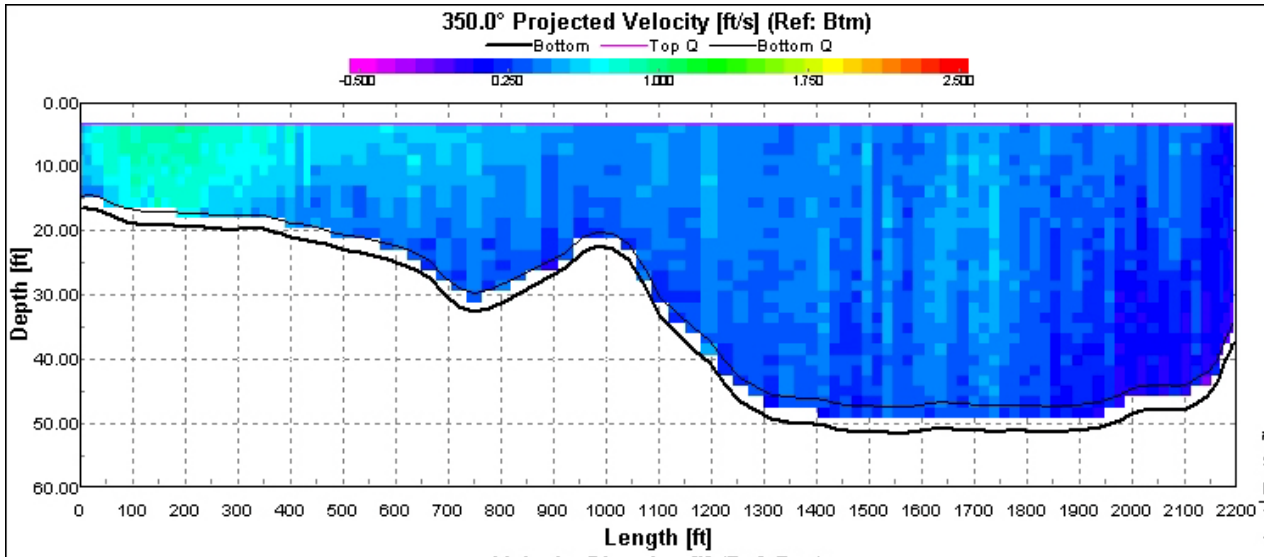


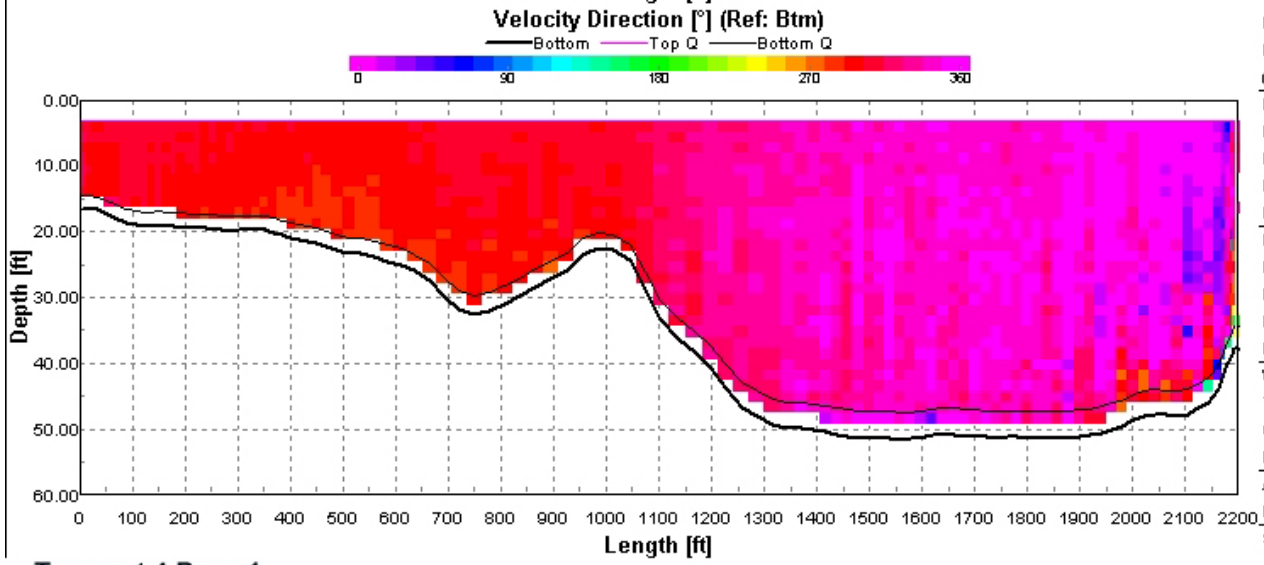


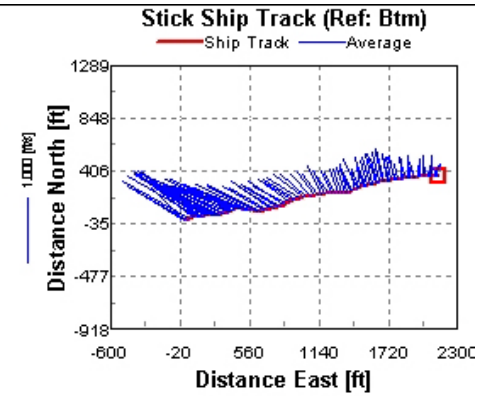
Discharge (Btm) Right to Left

# Ensembles	539	
Start Time	16:47:41	
Duration	811.86	[s]
Total Q	10011.15	[ft³/s]
Top Q	828.17	[ft³/s]
Measured Q	8454.30	[ft³/s]
Bottom Q	687.77	[ft³/s]
(T+M+B) Q	9970.24	[ft³/s]
Left Distance	90.00	[ft]
Left Velocity	0.041	[ft/s]
Left Depth	12.19	[ft]
Left Area	548.53	[ft²]
Left Q	15.92	[ft³/s]
Right Distance	40.00	[ft]
Right Velocity	0.237	[ft/s]
Right Depth	7.46	[ft]
Right Area	149.18	[ft²]
Right Q	24.98	[ft³/s]
Width	1947.99	[ft]
Total Area	80813.88	[ft²]
Q/Area	0.12	[ft/s]
Flow Dir.	356.28	[°]
Avg Course	279.85	[°]
Boat Speed	2.280	[ft/s]
Start Ens #	26	

Transect 3 Pass 6



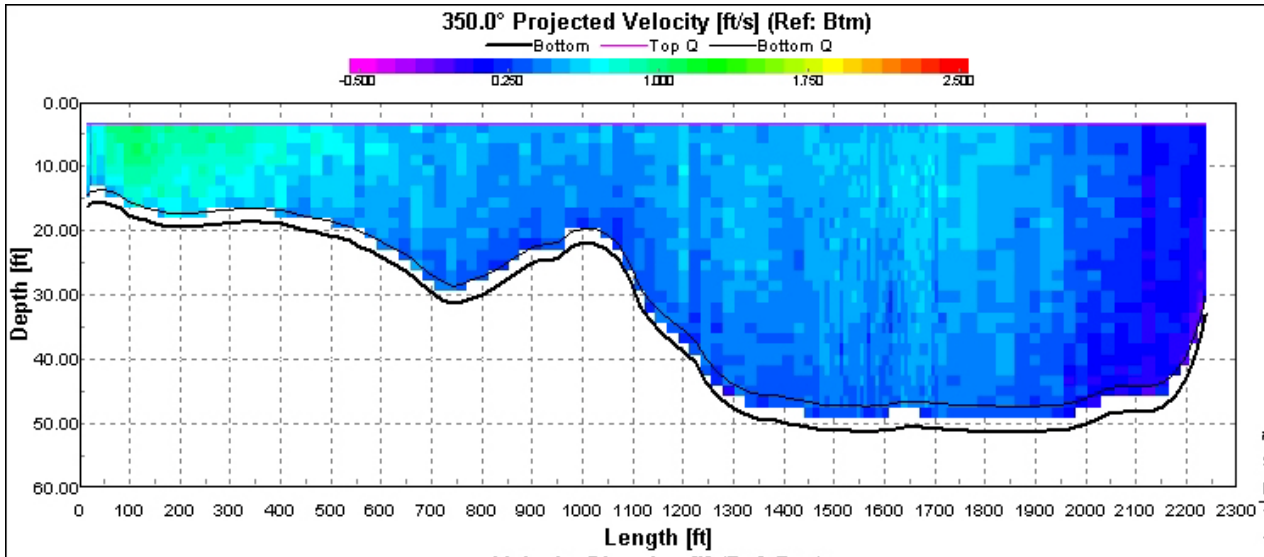


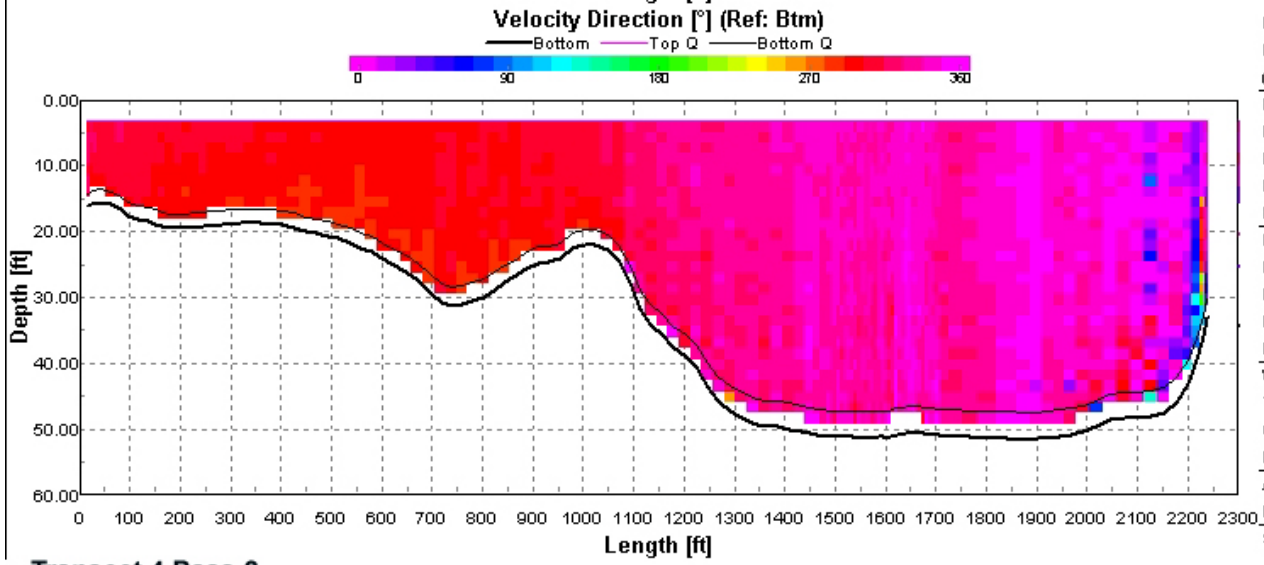


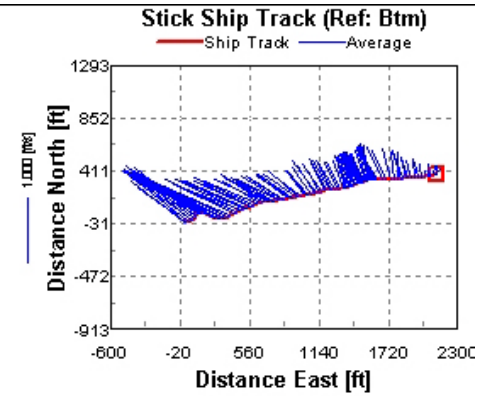
Discharge (Btm) Left to Right

# Ensembles	518	
Start Time	06:26:34	
Duration	781.67	[s]
Total Q	33542.32	[ft³/s]
Top Q	3542.29	[ft³/s]
Measured Q	25313.81	[ft³/s]
Bottom Q	2588.38	[ft³/s]
(T+M+B) Q	31444.47	[ft³/s]
Left Distance	450.00	[ft]
Left Velocity	0.774	[ft/s]
Left Depth	16.36	[ft]
Left Area	3680.21	[ft²]
Left Q	2012.94	[ft³/s]
Right Distance	50.00	[ft]
Right Velocity	0.125	[ft/s]
Right Depth	38.45	[ft]
Right Area	961.17	[ft²]
Right Q	84.92	[ft³/s]
Width	2659.52	[ft]
Total Area	82497.64	[ft²]
Q/Area	0.41	[ft/s]
Flow Dir.	321.20	[°]
Avg Course	80.02	[°]
Boat Speed	2.803	[ft/s]
Start Ens #	2879	

Transect 4 Pass 1



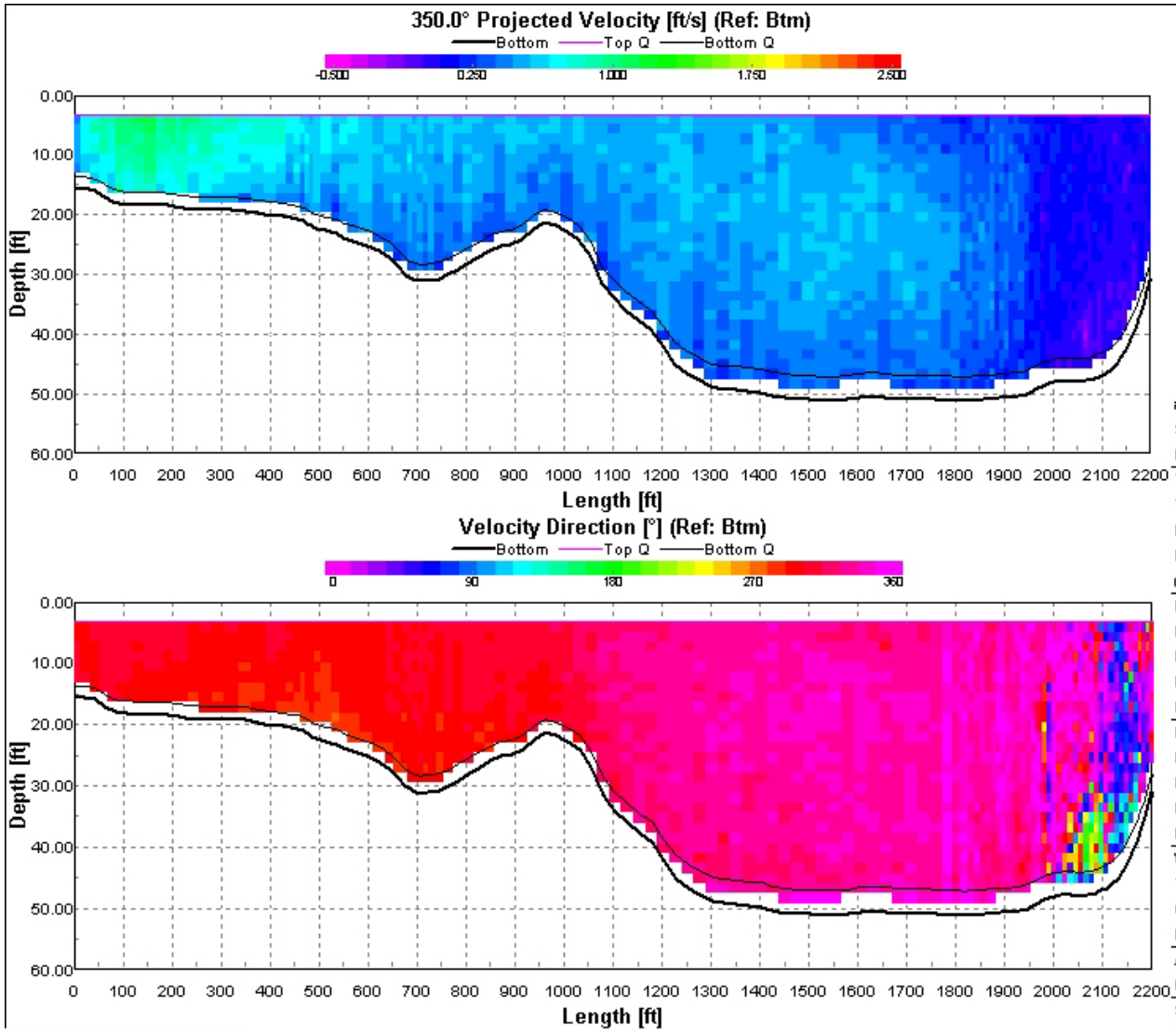


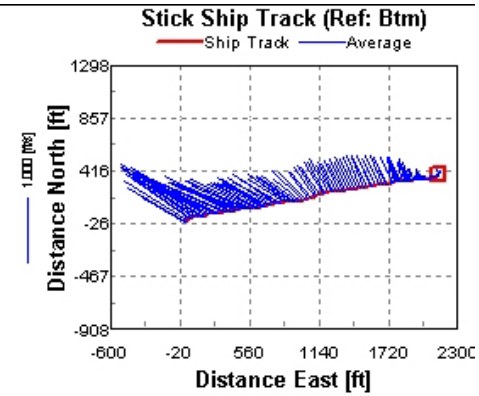


Discharge (Btm) Left to Right

# Ensembles	618	
Start Time	08:22:21	
Duration	931.05	[s]
Total Q	36525.00	[ft³/s]
Top Q	3957.14	[ft³/s]
Measured Q	28457.79	[ft³/s]
Bottom Q	2877.61	[ft³/s]
(T+M+B) Q	35292.54	[ft³/s]
Left Distance	300.00	[ft]
Left Velocity	0.690	[ft/s]
Left Depth	15.88	[ft]
Left Area	2382.72	[ft²]
Left Q	1162.69	[ft³/s]
Right Distance	60.00	[ft]
Right Velocity	0.093	[ft/s]
Right Depth	35.48	[ft]
Right Area	1064.34	[ft²]
Right Q	69.77	[ft³/s]
Width	2518.77	[ft]
Total Area	80612.63	[ft²]
Q/Area	0.45	[ft/s]
Flow Dir.	322.92	[°]
Avg Course	79.46	[°]
Boat Speed	2.401	[ft/s]
Start Ens #	11	

Transect 4 Pass 2

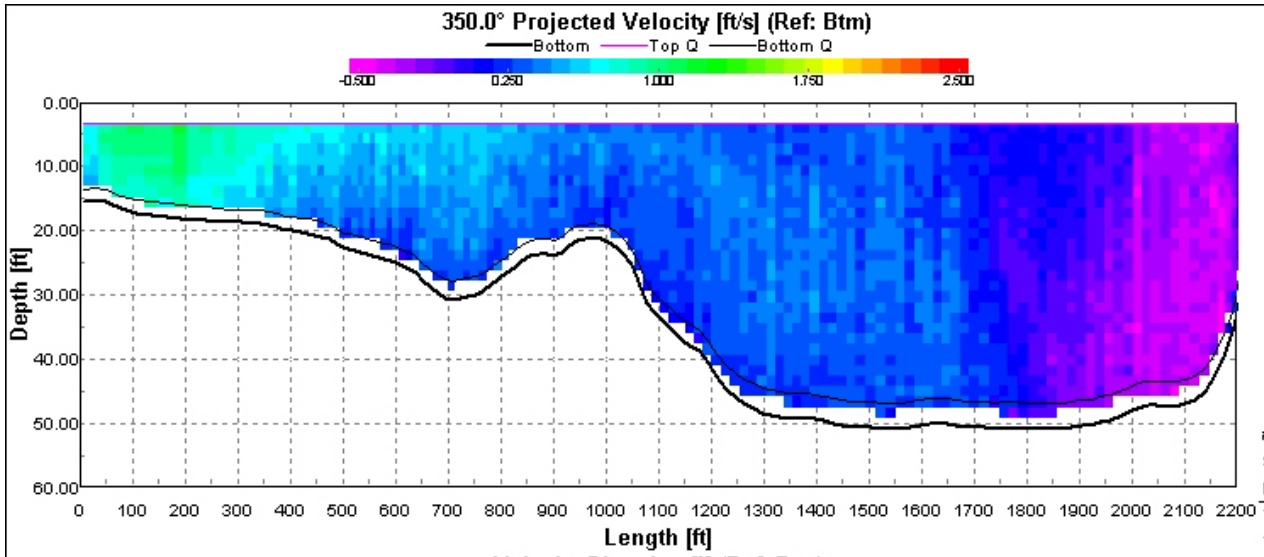


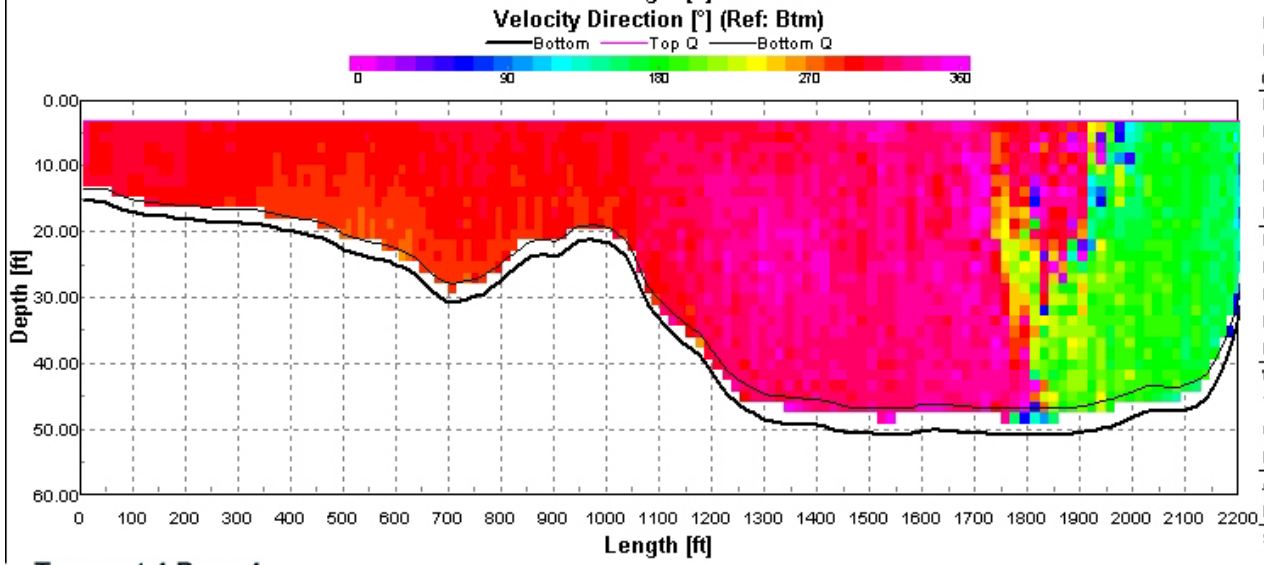


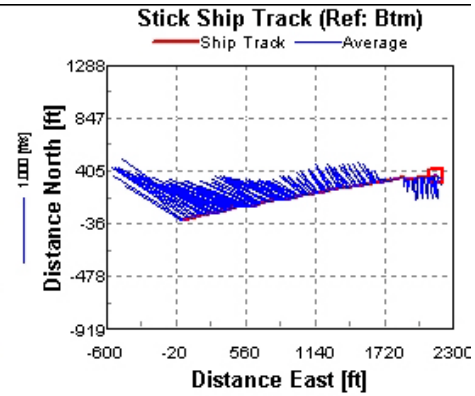
Discharge (Btm) Left to Right

# Ensembles	624	
Start Time	10:58:28	
Duration	940.20	[s]
Total Q	35058.65	[ft³/s]
Top Q	3874.75	[ft³/s]
Measured Q	26959.11	[ft³/s]
Bottom Q	2766.38	[ft³/s]
(T+M+B) Q	33600.24	[ft³/s]
Left Distance	300.00	[ft]
Left Velocity	0.873	[ft/s]
Left Depth	15.45	[ft]
Left Area	2317.51	[ft²]
Left Q	1430.19	[ft³/s]
Right Distance	30.00	[ft]
Right Velocity	0.082	[ft/s]
Right Depth	32.26	[ft]
Right Area	483.97	[ft²]
Right Q	28.23	[ft³/s]
Width	2500.68	[ft]
Total Area	79744.10	[ft²]
Q/Area	0.44	[ft/s]
Flow Dir.	317.10	[°]
Avg Course	79.61	[°]
Boat Speed	2.336	[ft/s]
Start Ens #	8	

Transect 4 Pass 3



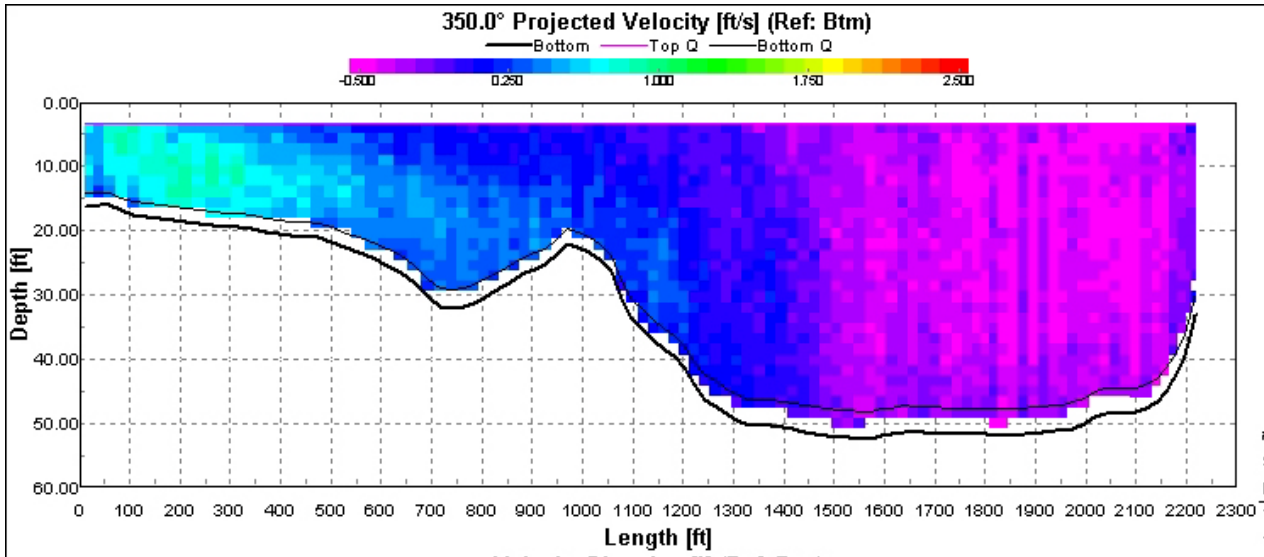


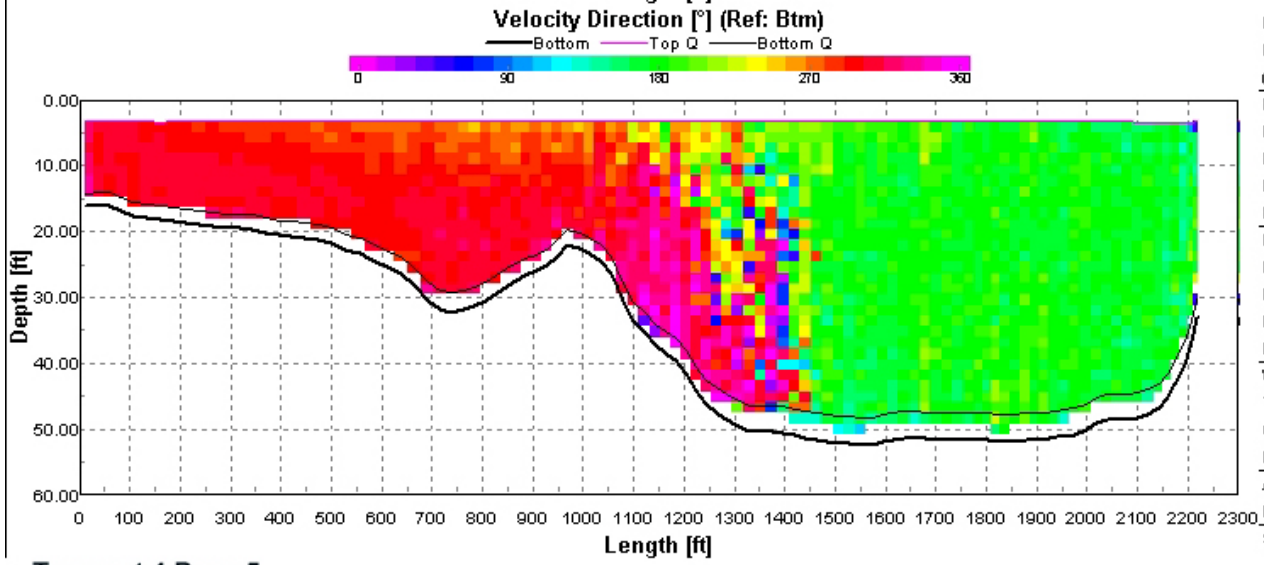


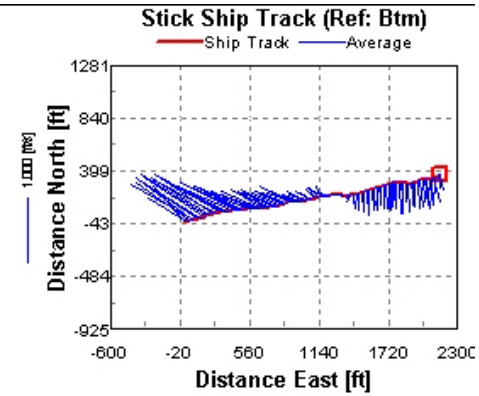
Discharge (Btm) Left to Right

# Ensembles	663	
Start Time	13:19:16	
Duration	999.03	[s]
Total Q	21442.14	[ft³/s]
Top Q	2853.16	[ft³/s]
Measured Q	15416.24	[ft³/s]
Bottom Q	1820.40	[ft³/s]
(T+M+B) Q	20089.79	[ft³/s]
Left Distance	300.00	[ft]
Left Velocity	0.898	[ft/s]
Left Depth	15.21	[ft]
Left Area	2281.59	[ft²]
Left Q	1449.14	[ft³/s]
Right Distance	50.00	[ft]
Right Velocity	-0.164	[ft/s]
Right Depth	33.46	[ft]
Right Area	836.57	[ft²]
Right Q	-96.80	[ft³/s]
Width	2529.05	[ft]
Total Area	79442.89	[ft²]
Q/Area	0.27	[ft/s]
Flow Dir.	299.72	[°]
Avg Course	80.10	[°]
Boat Speed	2.205	[ft/s]
Start Ens #	23	

Transect 4 Pass 4



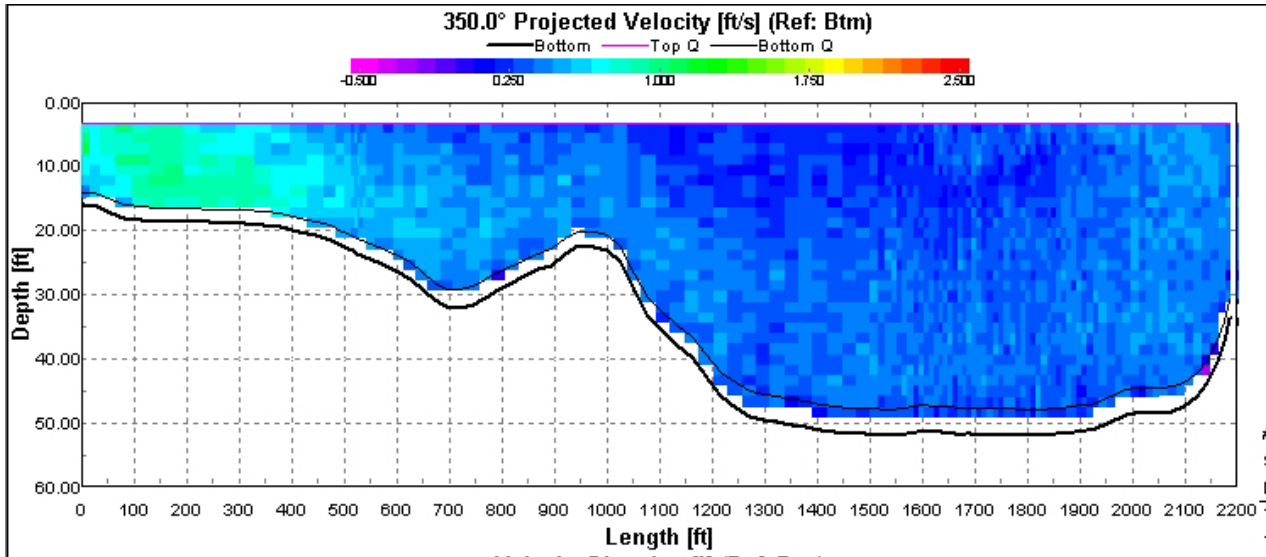


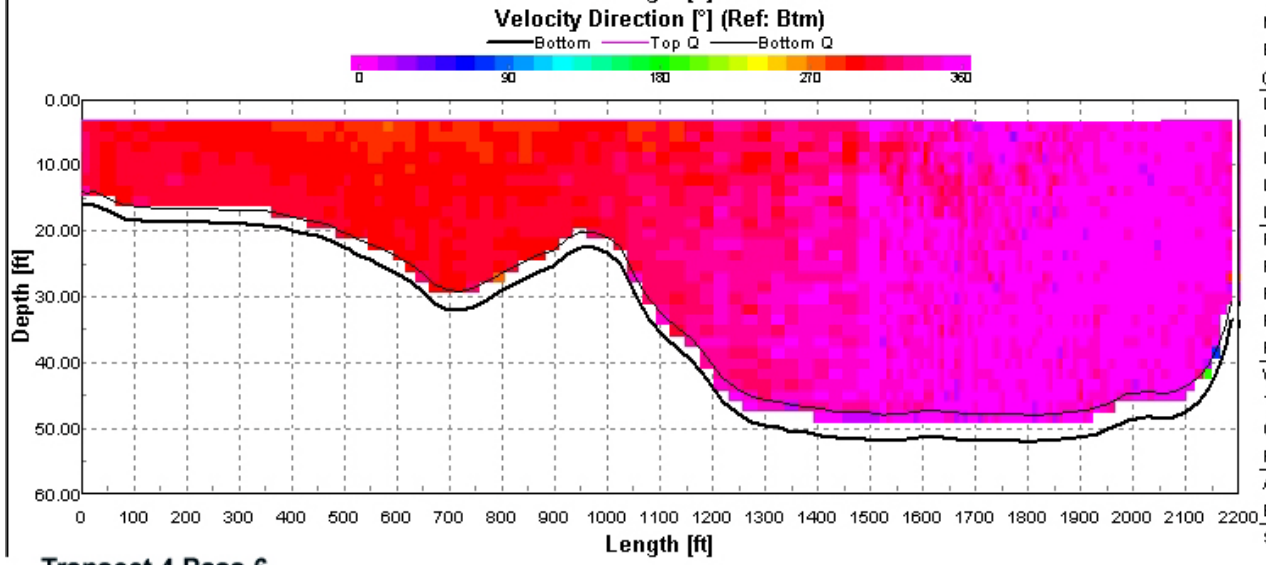


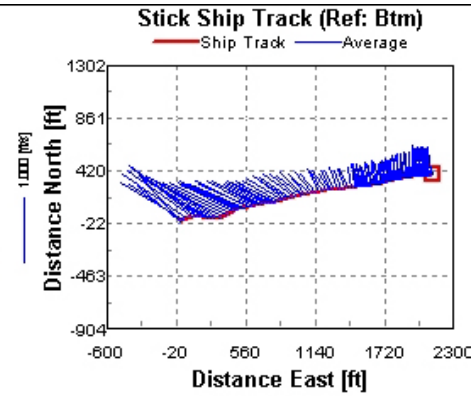
Discharge (Btm) Left to Right

# Ensembles	504	
Start Time	15:25:25	
Duration	759.03	[s]
Total Q	-496.48	[ft³/s]
Top Q	853.53	[ft³/s]
Measured Q	-2894.66	[ft³/s]
Bottom Q	269.46	[ft³/s]
(T+M+B) Q	-1771.66	[ft³/s]
Left Distance	350.00	[ft]
Left Velocity	0.704	[ft/s]
Left Depth	15.96	[ft]
Left Area	2792.48	[ft²]
Left Q	1390.25	[ft³/s]
Right Distance	50.00	[ft]
Right Velocity	-0.184	[ft/s]
Right Depth	35.33	[ft]
Right Area	883.36	[ft²]
Right Q	-115.07	[ft³/s]
Width	2576.27	[ft]
Total Area	82088.62	[ft²]
Q/Area	0.01	[ft/s]
Flow Dir.	237.99	[°]
Avg Course	80.20	[°]
Boat Speed	2.917	[ft/s]
Start Ens #	34	

Transect 4 Pass 5



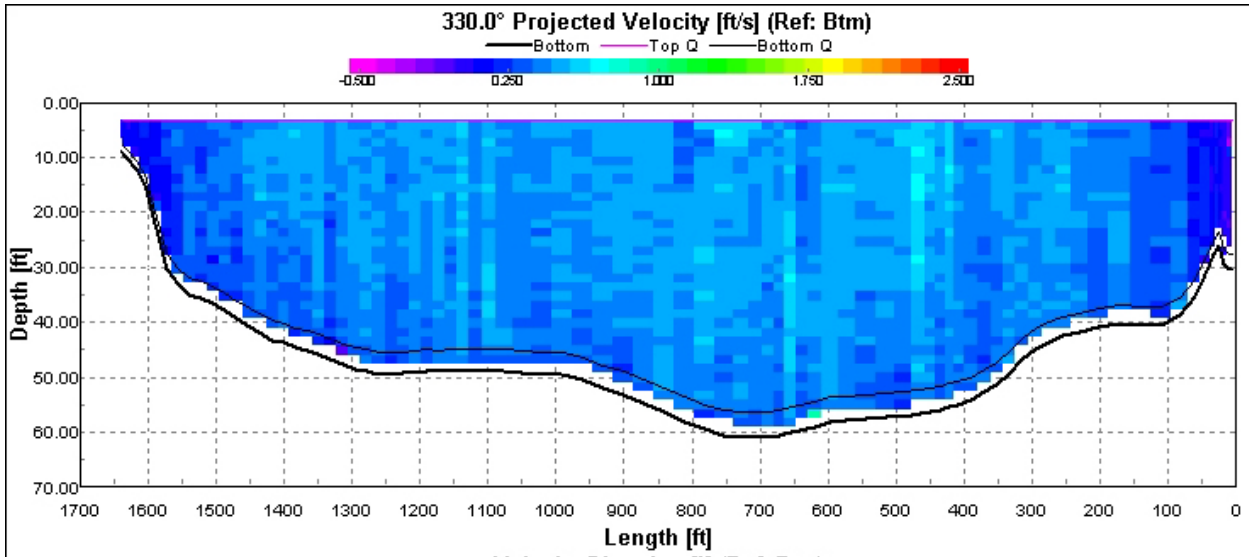


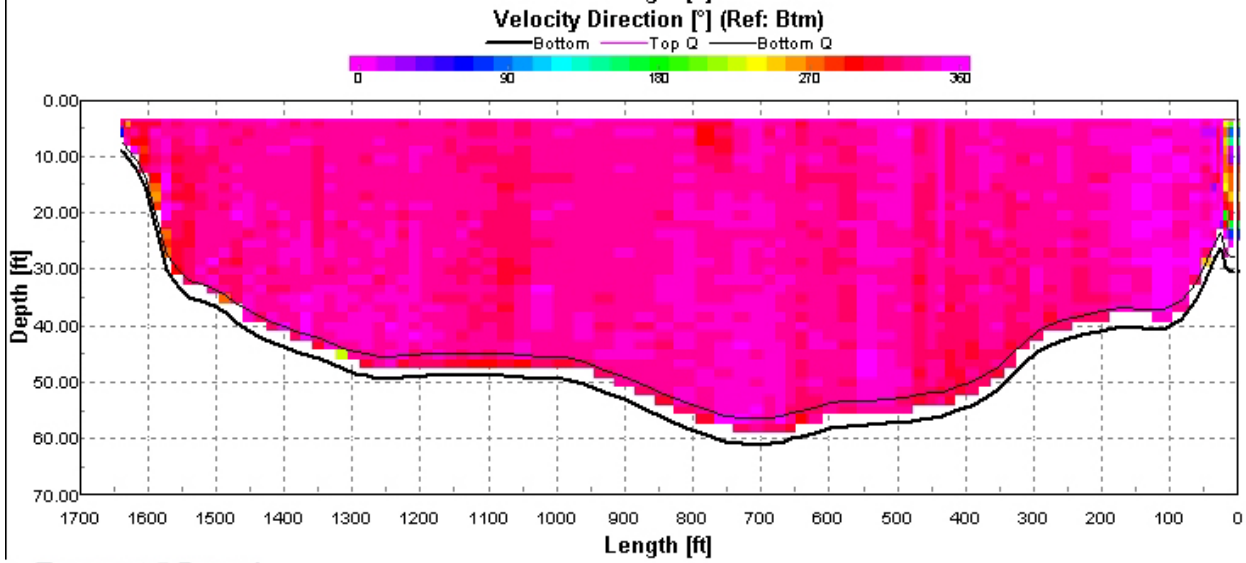


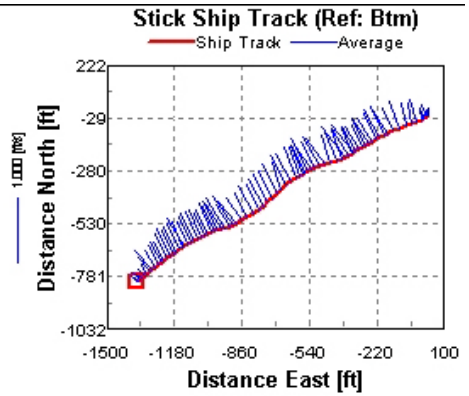
Discharge (Btm) Left to Right

# Ensembles	608	
Start Time	17:11:28	
Duration	915.98	[s]
Total Q	34004.39	[ft³/s]
Top Q	3688.55	[ft³/s]
Measured Q	25830.45	[ft³/s]
Bottom Q	2554.76	[ft³/s]
(T+M+B) Q	32073.76	[ft³/s]
Left Distance	350.00	[ft]
Left Velocity	0.871	[ft/s]
Left Depth	15.99	[ft]
Left Area	2798.65	[ft²]
Left Q	1723.23	[ft³/s]
Right Distance	40.00	[ft]
Right Velocity	0.400	[ft/s]
Right Depth	36.71	[ft]
Right Area	734.12	[ft²]
Right Q	207.40	[ft³/s]
Width	2543.10	[ft]
Total Area	81619.69	[ft²]
Q/Area	0.42	[ft/s]
Flow Dir.	329.43	[°]
Avg Course	79.38	[°]
Boat Speed	2.384	[ft/s]
Start Ens #	13	

Transect 4 Pass 6



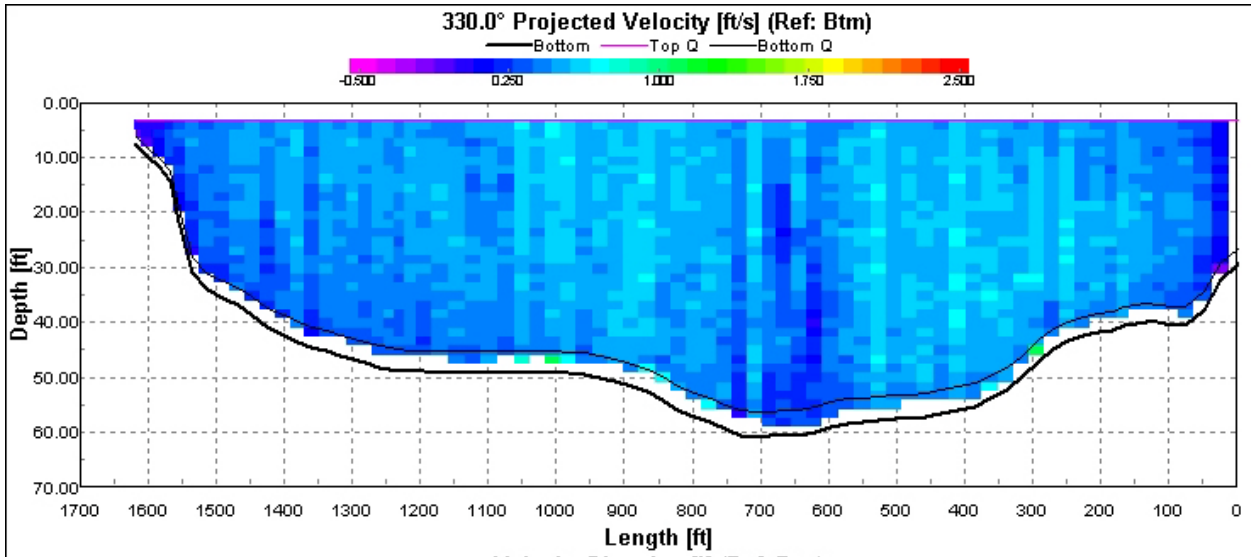


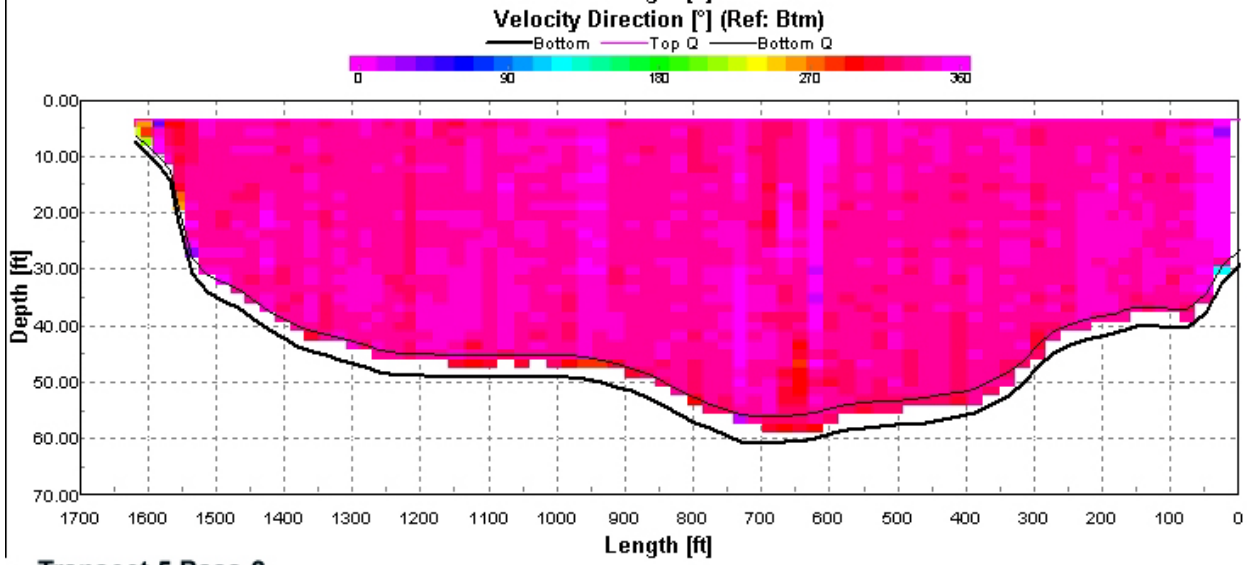


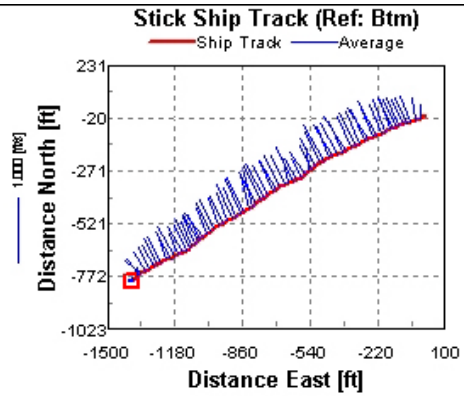
Discharge (Btm) Right to Left

# Ensembles	417	
Start Time	06:48:41	
Duration	631.43	[s]
Total Q	32581.78	[ft³/s]
Top Q	2434.20	[ft³/s]
Measured Q	27964.19	[ft³/s]
Bottom Q	2107.37	[ft³/s]
(T+M+B) Q	32505.76	[ft³/s]
Left Distance	75.00	[ft]
Left Velocity	0.106	[ft/s]
Left Depth	9.54	[ft]
Left Area	357.60	[ft²]
Left Q	26.74	[ft³/s]
Right Distance	100.00	[ft]
Right Velocity	0.047	[ft/s]
Right Depth	29.85	[ft]
Right Area	1492.36	[ft²]
Right Q	49.27	[ft³/s]
Width	1757.05	[ft]
Total Area	77112.71	[ft²]
Q/Area	0.42	[ft/s]
Flow Dir.	331.78	[°]
Avg Course	239.62	[°]
Boat Speed	2.594	[ft/s]
Start Ens #	3756	

Transect 5 Pass 1



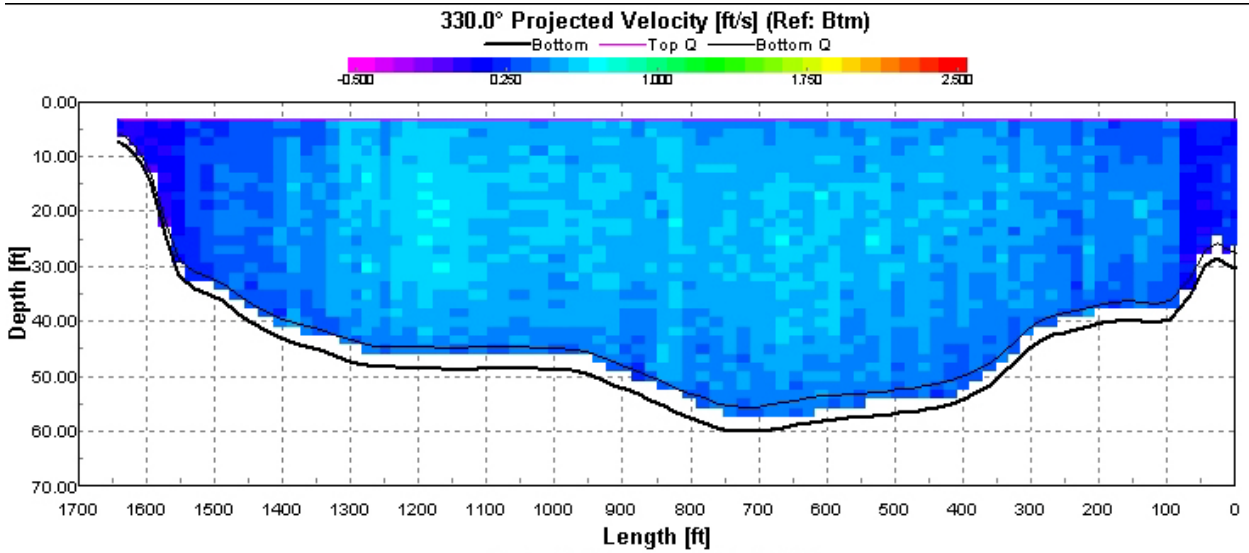


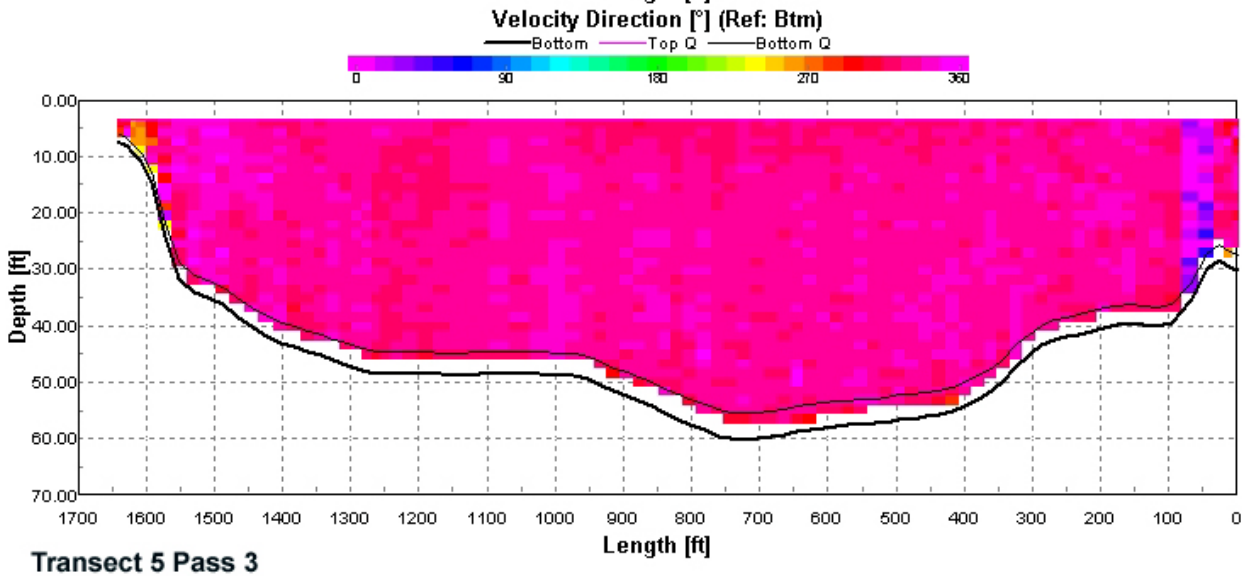


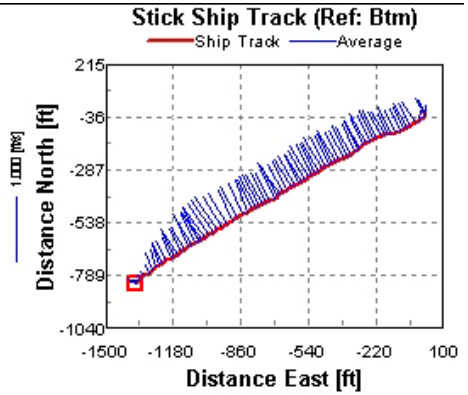
Discharge (Btm) Right to Left

# Ensembles	382	
Start Time	08:53:47	
Duration	576.32	[s]
Total Q	35737.76	[ft³/s]
Top Q	2672.81	[ft³/s]
Measured Q	30295.88	[ft³/s]
Bottom Q	2329.06	[ft³/s]
(T+M+B) Q	35297.75	[ft³/s]
Left Distance	60.00	[ft]
Left Velocity	0.067	[ft/s]
Left Depth	8.11	[ft]
Left Area	243.27	[ft²]
Left Q	11.56	[ft³/s]
Right Distance	125.00	[ft]
Right Velocity	0.279	[ft/s]
Right Depth	34.77	[ft]
Right Area	2172.99	[ft²]
Right Q	428.46	[ft³/s]
Width	1784.97	[ft]
Total Area	77822.41	[ft²]
Q/Area	0.46	[ft/s]
Flow Dir.	333.74	[°]
Avg Course	240.32	[°]
Boat Speed	2.810	[ft/s]
Start Ens #	2	

Transect 5 Pass 2



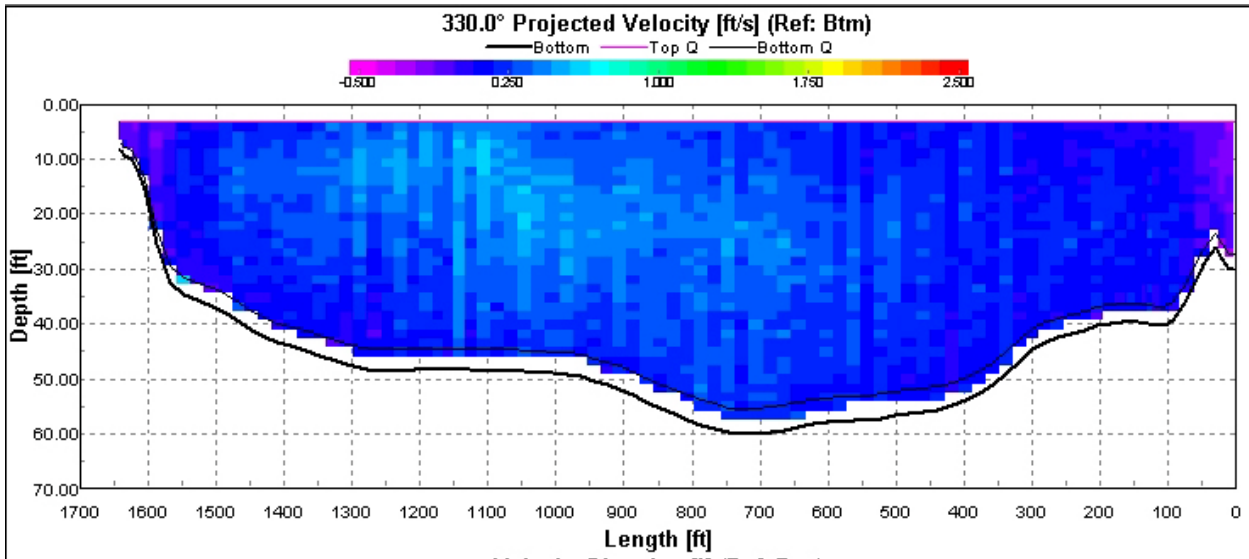


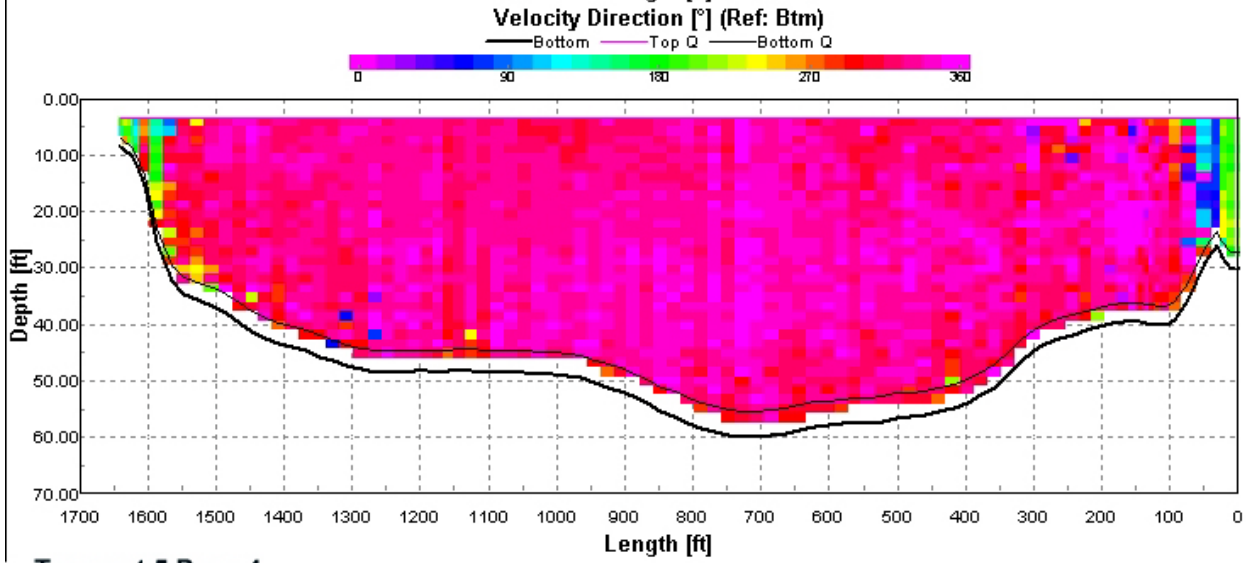


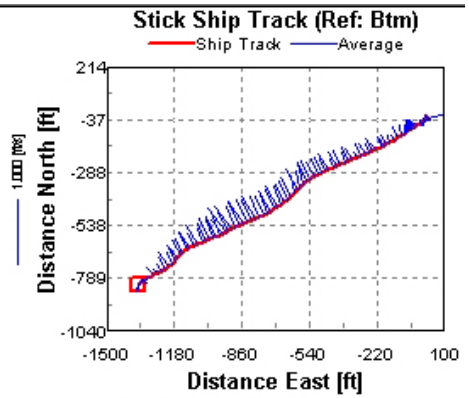
Discharge (Btm) Right to Left

# Ensembles	425	
Start Time	11:27:39	
Duration	641.43	[s]
Total Q	35005.53	[ft³/s]
Top Q	2600.84	[ft³/s]
Measured Q	29895.32	[ft³/s]
Bottom Q	2198.13	[ft³/s]
(T+M+B) Q	34694.29	[ft³/s]
Left Distance	40.00	[ft]
Left Velocity	0.086	[ft/s]
Left Depth	7.81	[ft]
Left Area	156.25	[ft²]
Left Q	9.50	[ft³/s]
Right Distance	125.00	[ft]
Right Velocity	0.229	[ft/s]
Right Depth	29.80	[ft]
Right Area	1862.47	[ft²]
Right Q	301.74	[ft³/s]
Width	1762.37	[ft]
Total Area	76651.26	[ft²]
Q/Area	0.46	[ft/s]
Flow Dir.	330.87	[°]
Avg Course	238.85	[°]
Boat Speed	2.553	[ft/s]
Start Ens #	17	

Transect 5 Pass 3



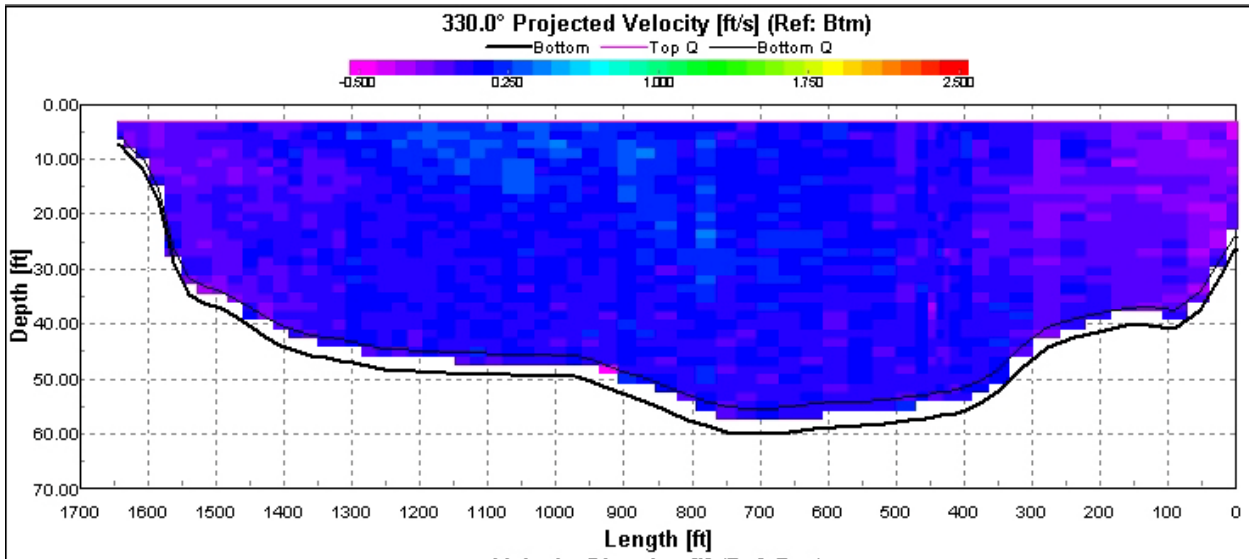


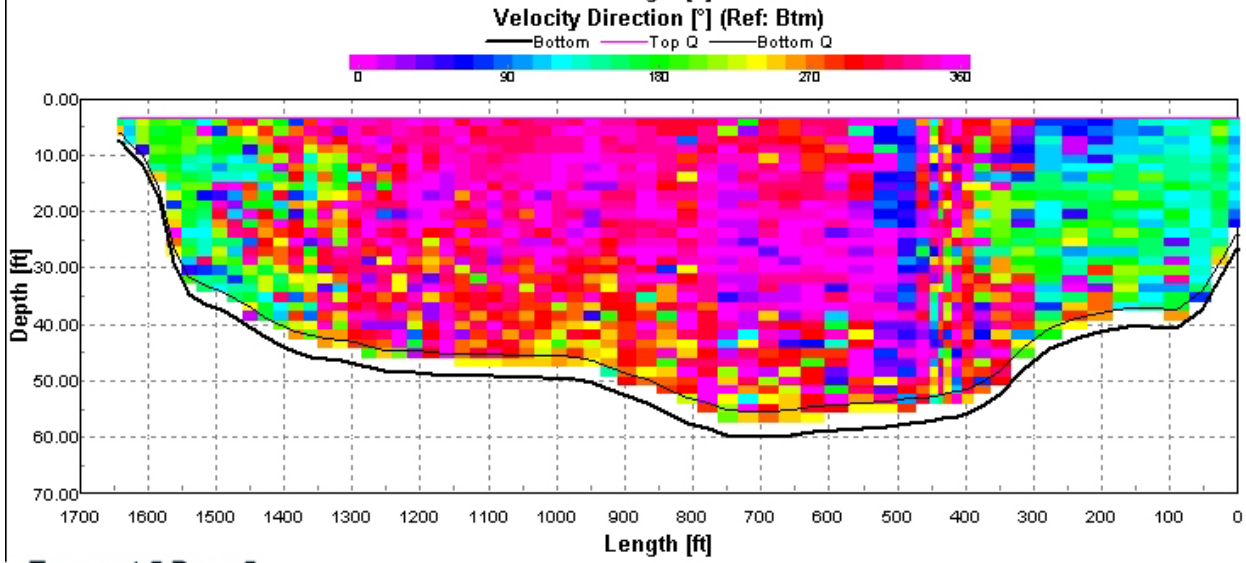


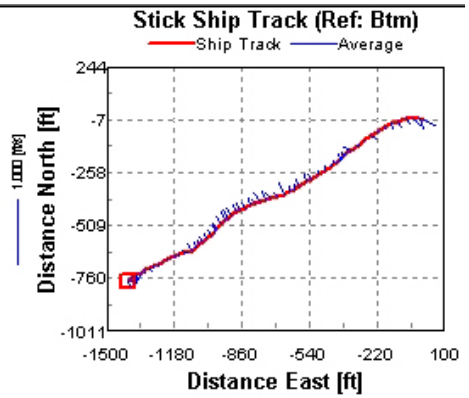
Discharge (Btm) Right to Left

# Ensembles	448	
Start Time	13:45:18	
Duration	676.01	[s]
Total Q	18358.93	[ft³/s]
Top Q	1368.96	[ft³/s]
Measured Q	16051.84	[ft³/s]
Bottom Q	1174.20	[ft³/s]
(T+M+B) Q	18595.00	[ft³/s]
Left Distance	50.00	[ft]
Left Velocity	-0.101	[ft/s]
Left Depth	9.03	[ft]
Left Area	225.85	[ft²]
Left Q	-16.13	[ft³/s]
Right Distance	125.00	[ft]
Right Velocity	-0.172	[ft/s]
Right Depth	28.92	[ft]
Right Area	1807.21	[ft²]
Right Q	-219.94	[ft³/s]
Width	1758.30	[ft]
Total Area	76539.44	[ft²]
Q/Area	0.24	[ft/s]
Flow Dir.	331.45	[°]
Avg Course	238.96	[°]
Boat Speed	2.426	[ft/s]
Start Ens #	15	

Transect 5 Pass 4



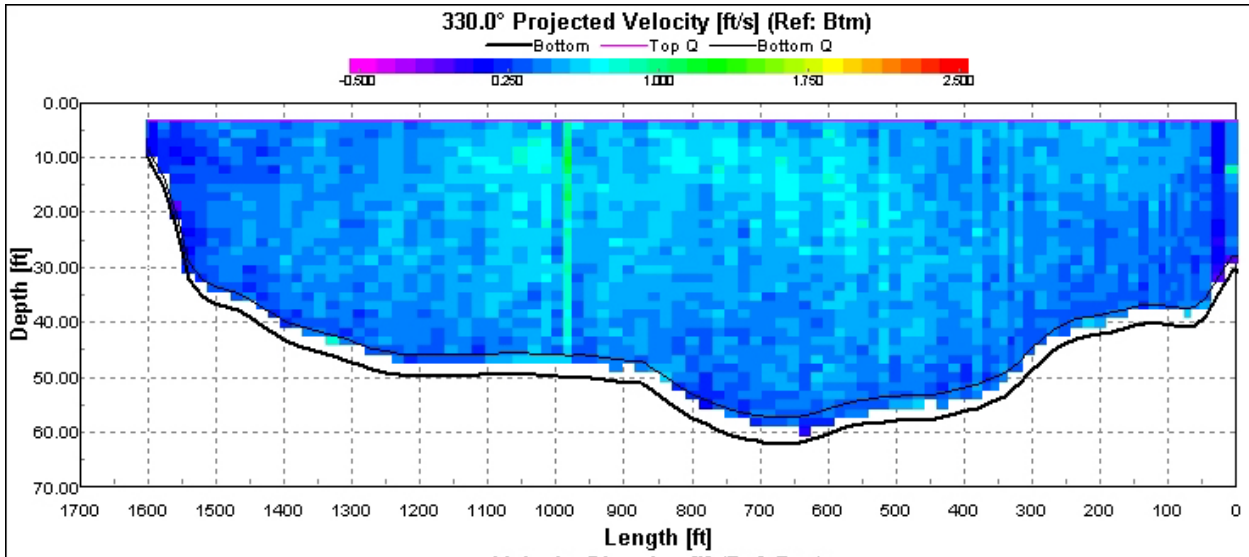


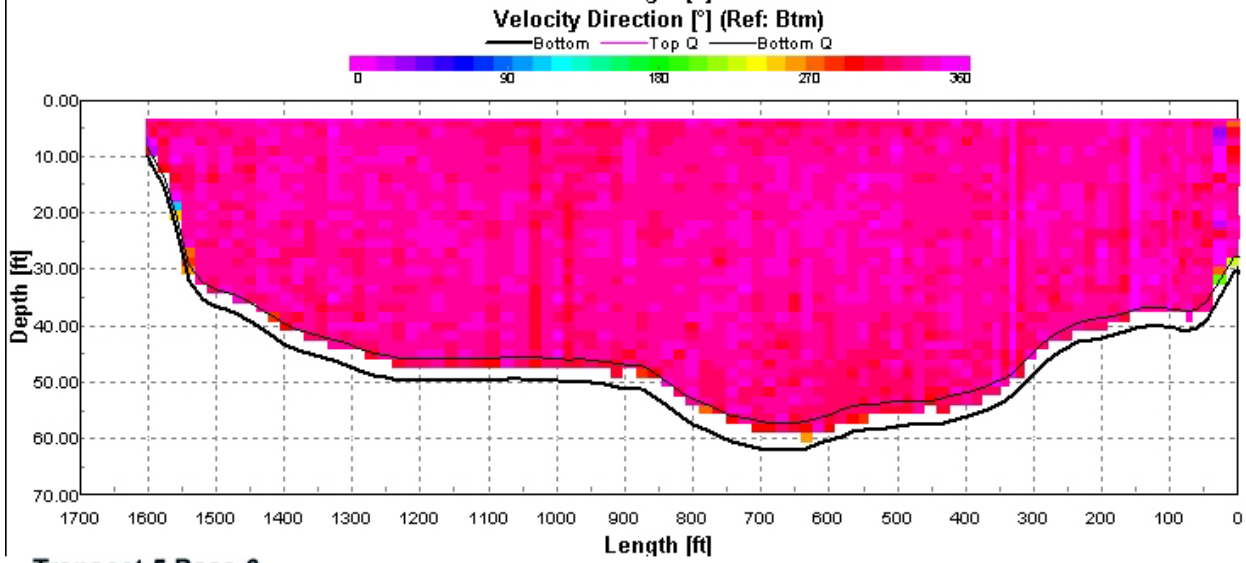


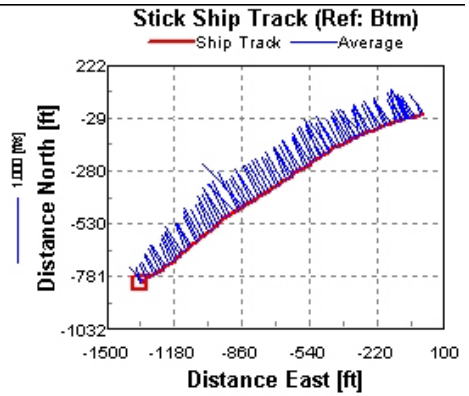
Discharge (Btm) Right to Left

# Ensembles	323	
Start Time	15:47:16	
Duration	485.92	[s]
Total Q	3705.99	[ft³/s]
Top Q	221.07	[ft³/s]
Measured Q	3493.63	[ft³/s]
Bottom Q	221.79	[ft³/s]
(T+M+B) Q	3936.48	[ft³/s]
Left Distance	45.00	[ft]
Left Velocity	-0.080	[ft/s]
Left Depth	8.82	[ft]
Left Area	198.43	[ft²]
Left Q	-11.26	[ft³/s]
Right Distance	125.00	[ft]
Right Velocity	-0.172	[ft/s]
Right Depth	28.82	[ft]
Right Area	1801.52	[ft²]
Right Q	-219.23	[ft³/s]
Width	1773.44	[ft]
Total Area	77699.98	[ft²]
Q/Area	0.05	[ft/s]
Flow Dir.	332.58	[°]
Avg Course	241.37	[°]
Boat Speed	3.375	[ft/s]
Start Ens #	51	

Transect 5 Pass 5







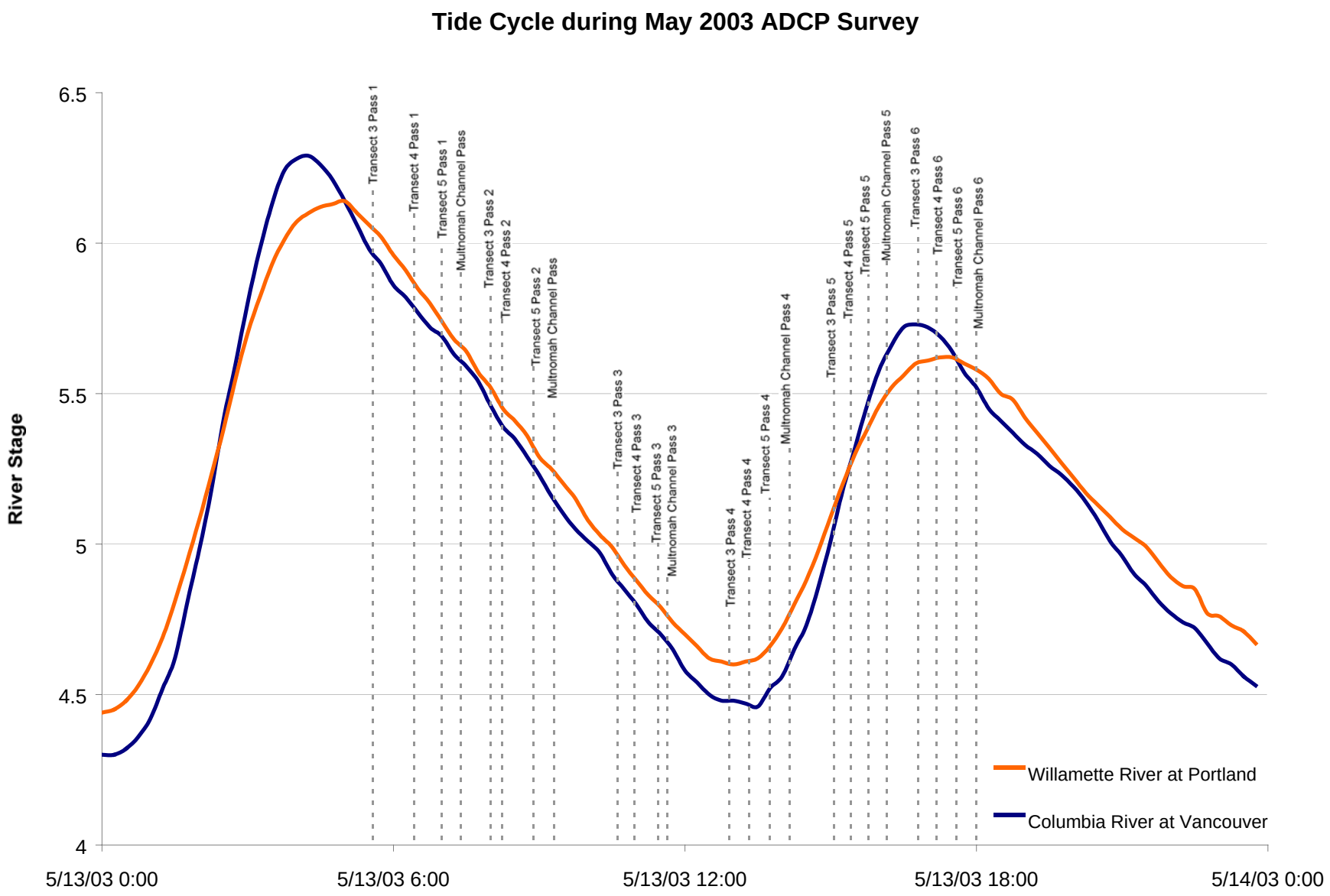
Discharge (Btm) Right to Left

# Ensembles	471	
Start Time	17:35:43	
Duration	709.26	[s]
Total Q	36368.96	[ft³/s]
Top Q	2689.17	[ft³/s]
Measured Q	30848.47	[ft³/s]
Bottom Q	2404.98	[ft³/s]
(T+M+B) Q	35942.62	[ft³/s]
Left Distance	60.00	[ft]
Left Velocity	0.216	[ft/s]
Left Depth	12.55	[ft]
Left Area	376.42	[ft²]
Left Q	57.56	[ft³/s]
Right Distance	125.00	[ft]
Right Velocity	0.257	[ft/s]
Right Depth	32.44	[ft]
Right Area	2027.75	[ft²]
Right Q	368.77	[ft³/s]
Width	1756.92	[ft]
Total Area	78277.38	[ft²]
Q/Area	0.46	[ft/s]
Flow Dir.	331.15	[°]
Avg Course	239.18	[°]
Boat Speed	2.256	[ft/s]
Start Ens #	7	

Transect 5 Pass 6

APPENDIX B

TIDE CYCLES - WILLAMETTE AND COLUMBIA RIVERS
MAY 13, 2003


Tide Cycle during May 2003 ADCP Survey
River Stage
6.5
6
5.5
5
4.5
4
5/13/03 0:00
5/13/03 6:00
5/13/03 12:00
5/13/03 18:00
5/14/03 0:00
Transect 3 Pass 1
Transect 4 Pass 1
Transect 5 Pass 1
Multnomah Channel Pass
Transect 3 Pass 2
Transect 4 Pass 2
Transect 5 Pass 2
Multnomah Channel Pass
Transect 3 Pass 3
Transect 4 Pass 3
Transect 5 Pass 3
Multnomah Channel Pass 3
Transect 3 Pass 4
Transect 4 Pass 4
Transect 5 Pass 4
Multnomah Channel Pass 4
Transect 3 Pass 5
Transect 4 Pass 5
Transect 5 Pass 5
Multnomah Channel Pass 5
Transect 3 Pass 6
Transect 4 Pass 6
Transect 5 Pass 6
Multnomah Channel Pass 6
Willamette River at Portland
Columbia River at Vancouver

APPENDIX C

DEA HYDRO SURVEY LOGS

DEA HYDRO SURVEY LOG

Date of Survey: 05/12/2003
Survey Crew: N. Lesnikowski, M. Stecher
Navigation: POS M/V DGPS, Trimble MS750 DGPS

Weather: clear skies
Vessel: Preston
Equipment: RDI 1200 kHz ADCP

Seas:calm

TIME	GAUGE	RPM	LINE	AZIMUTH	REMARKS
1500					Arrive Fred's Marina
1700					Launch Preston
1845					Compass Calibration
2000					Return To Marina

DEA HYDRO SURVEY LOG

Date of Survey: 05/13/2003
Survey Crew: N. Lesnikowski, M. Stecher
Navigation: POS M/V DGPS, Trimble MS750 DGPS

Weather: clear skies
Vessel: Preston
Equipment: RDI 1200 kHz ADCP

Seas:calm

Time	Gauge	RPM	Line	Azimuth	Remarks
350					Arrive at Fred's Marina
430					Synchronize system clocks to GPS
531			16	W	Transect 3 Pass 1 (TRAN320030513053118_000R)
					Abort for vessel traffic
539			16	W	Transect 3 Pass 1 (TRAN3000r.000)
626			2	E	Transect 4 Pass 1 (TRAN40001r.000)
648			15	W	Transect 5 Pass 1 (TRAN5000r.000)
					ens 3885 tractor tug wake
723			1	N	Multnomah Transect Pass 1 (MULT_000r.000)
744	5.6				Terminal 5 Staff Gage (CRD)
759			16	W	Transect 3 Pass 2 (TRAN3002r.000)
822			2	E	Transect 4 Pass 2 (TRAN4002r.000)
848			15	W	Transect 5 Pass 2 (TRAN5002r.000)
					Abort for vessel traffic, large wake
853			15	W	Transect 5 Pass 2 (TRAN5003r.000)
918			1	N	Multnomah Transect Pass 2 (MULT000r.000)
1018	5.1				Terminal 5 Staff Gage (CRD)
1037			16	W	Transect 3 Pass 3 (TRAN3003r.000)
1058			2	E	Transect 4 Pass 3 (TRAN4003r.000)
1127			15	W	Transect 5 Pass 3 (TRAN5004r.000)
1153			1	N	Multnomah Transect Pass 3 (MULT_001r.000)
1226			1		Position Check T52
1235	4.65				Terminal 5 Staff Gage (CRD)
1255			16	W	Transect 3 Pass 4 (TRAN3004r.000)
1319			2	E	Transect 4 Pass 4 (TRAN4004r.000)
1345			15a	W	Transect 5 Pass 4 (TRAN5005r.000)
1409			1	N	Multnomah Transect Pass 4 (MULT002r.000)
1423	5.1				Terminal 5 Staff Gage (CRD)
1433			1		Position Check T52
1506			16	W	Transect 3 Pass 5 (TRAN3005r.000)
1525			2	E	Transect 4 Pass 5 (TRAN4005r.000)
1547			15	W	Transect 5 Pass 5 (TRAN5006r.000)
1609			1	N	Multnomah Transect Pass 5 (MULT_003r.000)
1634	5.7				Terminal 5 Staff Gage (CRD)
1648			16	W	Transect 3 Pass 6 (TRAN3006r.000)
1711			2	E	Transect 4 Pass 6 (TRAN4006r.000)
1735			15	W	Transect 5 Pass 6 (TRAN5007r.000)
1800			1	N	Multnomah Transect Pass 6 (MULT_004r.000)