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SEDIMENT STAKE EROSION/ACCRETION MONITORING REPORT

ROUND 1A
PORTLAND HARBOR RI/FS

Prepared for

Lower Willamette Group

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1 INTRODUCTION

Bathymetric surveys were conducted in the reach of the Willamette River flowing through Portland, Oregon to determine areas of accumulation or erosion of sediment between December 2001 and July 2002. An additional bathymetric survey component was conducted in September 2002. Bathymetric changes occur in response to tidal effects and seasonal changes in river stage. Because of the limitations imposed by shallow water and proximity to shoreline features, these surveys were not able to capture the potential bathymetric changes in the nearshore environment. Changes in beach elevation become important when evaluating the temporal stability of sediments and their associated sediment quality.

A study using sets of index stakes placed in the intertidal regime at eight locations between river miles two and nine was conducted to evaluate potential changes in the beach elevation and to relate those changes to changes farther into the river channel determined by the bathymetric surveys. The duration of the study was from July 17, 2002 to December 20, 2002.

The objective of the study was to determine the erosion/deposition potential in nearshore areas and determine whether a relationship between those changes and changes farther offshore could be established. The nearshore data and possible relationship to erosion/deposition farther offshore are potentially useful in assessing various approaches, such as capping and attendant stability, for addressing contamination problems.

2 OVERVIEW OF THE FIELD PROGRAM

The field program consisted of installation of the stakes and periodic monitoring. This section summarizes the various aspects of the field program.

2.1 Deployment of the Stakes

Sediment stakes were successfully deployed at eight of nine proposed locations in the study area (Figure 1). At location 2 (Schnitzer Steel), no suitable area for deployment and monitoring was available.

At each sample location, three stakes were placed along a transect perpendicular to the shoreline. Appendix A contains photographs of each location. The target mudline elevations for the locations of the stakes along each transect were the 10th percentile (low stakes), 50th percentile (median stakes), and 90th percentile (high stakes) of the river stage measured at USGS gage station 14211720. Table 1 lists these elevations relative to the gage datum, NGVD 29, and NAVD 88 (project datum). The distribution of stakes at different elevations along a given transect allowed measurement of sediment changes under a variety of water level/river flow conditions.

A sediment stake consisted of a half-inch or three-quarter-inch diameter PVC pipe with the outer wall etched on one side at 1 cm intervals from the top of the stake down. Stakes were deployed by hand. A diver was used when water depth precluded access by wading. The instantaneous water surface elevation at the time of deployment was determined by querying the web site for USGS gage 14211720 and was used as a vertical reference for estimating where respective stakes should be placed to achieve the target mudline elevations. The stakes were driven into the sediment until the distance from the mudline to the top of a given stake was 30 cm. The lengths of the stakes were such that the penetration was approximately two feet. Stakes of a variety of lengths were prepared to address differing water levels and beach substrate conditions.

The precise horizontal location and vertical elevation of the top of each stake were determined and recorded by standard surveying methods during low tide intervals when all were visible. Mudline elevations at the point of penetration were determined by

subtracting 30 cm (one foot) from the elevation of the top of a given stake. Table 2 lists the horizontal coordinates and mudline elevations of all stakes at the point of penetration.

2.2 Monitoring Approach

Sediment levels relative to the tops of the stakes were recorded approximately once per month over the duration of the study from July 17 to December 20, 2002. The sediment levels were determined by measuring the distance from the top of each stake to the level of the surrounding unaffected sediment surface. Any debris such as trash, sticks/branches, weeds, and leaves that accumulated around the stakes was removed prior to making sediment level measurements. Local scour around the stakes was insignificant in all cases. The relationship between changes in beach mudline elevation and changes in mudline elevation farther offshore in the study area were investigated by comparing stake measurement data with data from bathymetric surveys in December 2001 and July 2002.

3 RESULTS AND DISCUSSION

Results and discussion will include river stage and discharge, a summary of the sediment stake measurement data, and comparison, where possible, of sediment stake measurements with changes indicated by the bathymetric surveys.

3.1 River Stage, Tides, and Flow Volume

The daily average the river stage and corresponding daily discharge recorded over the sediment stake study are presented in Figures 2 and 3, respectively. For informational purposes, Figures 4 and 5 show the same information for the entire 2002 calendar year. Over, the study interval, the river stage varied from 5.97 feet (gage datum) on July 22 to a low of 1.54 feet on October 13, after which a general increasing trend ensued, and the stage reached a high of 6.07 feet on December 17.

Tidal excursions influence the river stage at Portland, so instantaneous surface elevations would consist of the fluctuating tidal elevation superposed on daily-average values. The tidal range varies throughout the year, but for the purposes of this study was assumed to be approximately four feet. Thus, the range of surface elevations over a given day would be approximately the daily-average value plus and minus a two-foot tidal signal.

The lowest river discharge recorded was 8,080 cubic feet per second (cfs) on August 18. No river discharge data are available after September 30, but the general trend apparent from 28 years of record (Figure 3) is for increasing discharge volume after the summertime lows.

3.2 Erosion/Deposition at Shallow Stakes

Measurements of the mudline elevations at the shallow stakes during the study are presented in Table 3 and illustrated in Figure 6. Values less than 30 cm indicate sediment accretion, and values greater than 30 cm indicate erosion. A comparison between the mudline elevations of the stakes and the water surface elevation approximated by adding a two-foot tidal elevation to the daily-average gage height indicates that all the low stakes would have been “wetted” part or all of each day of the study.

The measurements show no consistent pattern of change among the eight low stakes. The only location that showed any significant accretion was the Gasco location (4), where approximately 13 cm accumulated by September 19. However, that was followed by a period of erosion leading to a net accumulation of 4 cm. A consistent pattern of sediment erosion was measured at the GATX (7) and Equilon locations (9), both of which were upstream of the Gasco location. All three locations are on the west side of the river. Erosion of 13 cm and 16 cm was seen at the GATX and Equilon locations, respectively. Changes in sediment level at the Atofina location (6), which lay between the GATX and Gasco locations, fluctuated between plus and minus 2 cm of the initial mudline.

After the initial accretion measured on September 19, the Gasco location experienced erosion similar to the Equilon location. Between September 19 and December 20, erosion was 9 cm at the Gasco location and 8 cm at the Equilon location. During the same interval, erosion was 5 cm at the GATX location.

Changes in sediment level at the Coast Guard (8) and Terminal 4 (3) locations fluctuated between plus and minus 2 cm of the initial level on July 17. The sediment level at the GE location (1) stayed the same over the first two months of the study and then eroded 4 cm by the end of the study.

3.3 Erosion/Deposition at Median Stakes

The erosion/deposition measurements from the median stakes are presented in Table 4 and illustrated in Figure 7. Stakes could not be maintained at the Willamette Cove location, possibly because of human interference, so no consistent measurements could be made.

Because of varying differences between the actual mudline elevations where the stakes were placed and the target mudline elevation, the frequency and duration that each was “wetted” varied among the locations. The stake at the Terminal 4 location was 0.86 feet higher, and the stake at the Equilon location was 1.07 feet lower than the target of +4.96 feet (gage datum). The other mudline elevations ranged from 0.04 feet higher to 0.92 feet lower. These differences in targeted and actual mudline elevations were due to:

- Local beach slope conditions at each location
- The difficulty of gauging vertical distances at spots displaced from the water surface at the beach
- The possibility of river stage at a given location differing from the gage height

Because the mudline elevation of the median stake at the Terminal 4 location was the highest, it would have been wetted the least frequently of any of the median stakes. Comparison of the daily values of the gage height plus the two-foot tidal addition to the mudline elevation of the stake indicates that the stake at Terminal 4 would have been wetted approximately 25 percent of the days during the study. A similar comparison shows that the stake at the Equilon location would have been wetted approximately 96 percent of the time. The degree to which river flow would have been able to influence sediment levels at each respective stake is therefore not the same at all locations. Therefore, direct comparisons of the amount and timing of sediment level changes among the median stakes should be viewed with caution.

Figure 7 shows that little change occurred at the General Electric and Coast Guard locations. Except for measurements on August 5 indicating erosion at the Terminal 4 and GATX locations, the general trend is of accretion during the period when river stage and volume discharge were decreasing and of erosion as river stage and discharge increased after the summertime lows. The largest change from initial sediment levels was a deposition of 20 cm at the Equilon location. This may be a reflection of this stake being set at the deepest mudline elevation, which would have resulted in its being "wetted" more frequently and for longer durations than the others.

The explanation for the erosion measured at the Terminal 4 and GATX locations between the initial deployment and the first measurement approximately three weeks later is unclear. The relatively small change in the sediment level at the Terminal 4 location over the next two measurement intervals and then the apparent erosion of 10 cm between October 17 and December 20 is likely because the stake was out of the water during the summertime low elevations, but returned to the influence of river flow as the river stage increased in the fall.

The minor fluctuations in sediment level at the Coast Guard location may be a result of its being a relatively protected area with no flow-through connection with the river. Thus, the local flows result from tidal exchange and do not include any contribution from direct river flow.

While the measurements at the low stake at the Equilon location indicated erosion over the entire study interval, the measurements at the median stake showed deposition of 20 cm over the first three months of the study and erosion of 4 cm over the last two months. Without other measurements, it is not possible to determine if this represents offshore sediment movement. Measurements at the low and median stakes at the Gasco location have the same general trend.

3.4 Erosion/Deposition at High Stakes

Changes in the mudline elevations measures at the high stakes are presented in Table 5 and illustrated in Figure 8. High stakes could not be maintained at the Willamette Cove location, possibly because of human interference, so no consistent measurements could be made.

The data indicate little change in sediment levels at all locations except the Gasco location (Figure 8). At the Gasco location, measurements at the high stake showed consistent erosional trends over the study interval, totaling a net loss of 19 cm by the end of the study. Over the first two months of the study, measurements at the low and median stakes at the Gasco location indicated accretion, after which erosion began.

The reason for there being noticeable change at the Gasco location and only minor, if any, changes at the other high stake locations is because of the actual mudline elevations. The target mudline elevation for high stakes was +9.99 feet (gage datum). The actual mudline elevations for high stakes ranged from 2.91 feet lower than the target at the Gasco location to 2.43 feet higher at the Atofina location. The placement of some of the high stakes was limited by beach conditions, and for others, the distance from the existing waterline made it very difficult to judge the elevation of the stake location chosen.

Adding two feet to the daily gage height and comparing to the mudline elevations of all the high stakes indicates that only the stake at the Gasco location would have been wetted and only during the first and last weeks of the study interval. Alternatively adding three feet, which is a large tidal elevation, to the daily gage height and doing a similar comparison shows that the high stakes at the Gasco, Coast Guard, and Equilon locations would have been wetted during the first two weeks and the last week of the study interval.

In addition to varying mudline elevations, the study interval included the seasonal period when river stage is typically at its minimum, so it would have been the interval when it was least likely that the river stage could reach the 90th percentile elevation. Thus, the high stake at the Gasco location was the one with the greatest potential of being reached by water frequently enough to influence sediment levels at the stake. It is tenuous to draw conclusions about accretion and erosion at the other high stakes on the basis of the sediment stake measurements.

3.5 Sediment Stake Measurements and Sediment Level Changes Determined by Bathymetric Surveys

Changes in bathymetry measured between December 2001 and July 2002 indicate a trend of a downstream increase in the percentage of cells in the nearshore area (<20 feet deep) demonstrating erosion from River Miles 8 to 9 (Equilon location) to River Miles 3 to 4 (General Electric location). Conversely, the percentage of cells demonstrating accretion showed a decreasing downstream trend along the same reach. No such consistent trend appears in the plots of sediment level measurements at the low stakes, which show the highest erosion rates at the Equilon and GATX locations. These two locations lie between River Miles 7 and 9.

Sediment level measurements at the median stakes, which are farther inshore than the low stakes, showed a greater tendency toward accretion in the locations between River Miles 6 to 9 than in River Miles 3 to 6. Note that most of the stations lay between River Miles 6 to 9, so the data may not be representative.

Accretion at the median stakes and erosion at the low stakes at a given location may signify a limited trend of offshore sediment movement at some of the locations for a portion of the year. An example of this possible pattern can be seen in the comparison of measurements at low and median stakes at the Equilon location–erosion and accretion tend to mirror each other. Even so, the progression of accretion or erosion at the Gasco location is similar at the low and median stakes, which may indicate the stakes are close enough together that they reflect the same processes.

Figure 9 shows bathymetric changes determined from surveys in December 2001 and July 2002. The general pattern illustrated in the figure is of accretion of less that one foot in the vicinity of all sediment stake locations except at the Coast Guard location. At the Coast Guard location, the indication was of erosion of less than one foot. From Figure 6, which shows sediment elevation changes at the low stakes, accretion in the first two months of the stake monitoring interval is clearly apparent only at the Gasco location. The first two months of the sediment stake study are the closest in time to the performance of the second bathymetric survey. The strongest indications of erosion during the same interval are at the Equilon, GATX, and Willamette Cove locations. Changes in sediment elevation measured at the other low stakes showed little change either through accretion or erosion. On the basis of this comparison, there is no consistent relation between changes of sediment elevation in the vicinity of the stake locations determined from bathymetric surveys and changes determined from sediment stake measurements at the low stakes.

Figure 7, which shows elevation changes at the median stakes, indicates accretion at the Equilon, Atofina, and Gasco locations during the first two months and erosion at the GATX and Terminal 4 locations during the first three weeks. There is no consistent pattern of either accretion or erosion at the other median stake locations during the first two months of the sediment stake study. Similar to results of measurements at the low stakes, there is no consistent relation between sediment elevation changes measured at the median stakes and changes determined by bathymetric soundings farther offshore in the vicinity of the stake locations.

Because of the high mudline elevations of the high stakes and of the seasonal period when river stage is typically lowest, it is unlikely that erosion and accretion were influenced much by river processes. Comparison with erosion and accretion farther offshore would therefore have questionable validity.

4 LIMITATIONS

Sediment erosion and accretion in the study area are dynamic processes that respond to the shape of the shoreline, width of the river channel, and the stage and speed of the river. Because fluctuations in river stage and discharge are highly seasonal, it follows that sediment processes will also be seasonal. The sediment stake study spanned five months, and while it included the low-flow portion of the year and portions of the transitions before and after, it did not include the portion of the year when flows are typically highest. For example, the general trend among sediment measurements when river stage and discharge began increasing from the summertime lows was one of increasing erosion, which is what would be expected. Because the period when the highest stage and discharge conditions occurred was not captured, there is no information about how much more erosion may have occurred during that period. Thus, observations and resulting conclusions made during the study interval are not representative of typical annual conditions that can be expected to occur year after year. Similarly, sediment level changes determined from changes in bathymetry between December 2001 and July 2002 and changes indicated by the sediment stake measurements are not strictly comparable because they do not span the same interval.

5 RECOMMENDATIONS

To assess long-term trends in sediment erosion and accretion in the study area, measurements should be continued for at least a year. While this would be only one annual cycle, it would allow making more accurate inferences about long-term patterns of sediment erosion and accretion by examining how that year's river stage and flow deviated from long-term average river conditions. The stakes themselves appear to be a simple and accurate means for measuring localized changes in mudline elevation.

TABLES

Table 1
Target Elevations for Sediment Stakes (feet)

Percentile	Gage Datum	NGVD 29	NAVD 88
10th (Low Stakes)	2.59	4.14	7.55
50th (Median Stakes)	4.96	6.51	9.92
90th (High Stakes)	9.99	11.54	14.95
Conversion	0.00	1.55	4.96

Notes: Elevation relative to Gage datum = Elevation relative to NAVD88 minus 4.96 feet
Elevation relative to NGVD29 = Elevation relative to NAVD 88 minus 3.41 feet

Table 2
Coordinates and Mudline Elevations for Sediment Stakes

Location	Sediment Stake	Northing(1) (feet)	Easting(1) (feet)	Latitude NAD 1983 (°N)	Longitude NAD 1983 (°W)	Mudline Elevation NAVD88 Datum (feet)	Mudline Elevation Gage Datum (feet)
General Electric	1L	718660.8	7615358.4	45° 36' 54.17"	122° 47' 35.75"	6.93	1.97
	1M	718645.5	7615325.2	45° 36' 54.01"	122° 47' 36.21"	9.11	4.15
	1H	718627.3	7615284.9	45° 36' 53.82"	122° 47' 36.77"	14.89	9.93
Terminal 4	3L	713910.2	7619605.5	45° 36' 08.47"	122° 46' 34.13"	7.86	2.90
	3M	713925.2	7619610.8	45° 36' 08.62"	122° 46' 34.07"	10.78	5.82
	3H	713950.9	7619619.8	45° 36' 08.88"	122° 46' 33.95"	14.29	9.33
Gasco	4L	705823.1	7623542.8	45° 34' 49.75"	122° 45' 35.59"	7.23	2.27
	4M	705804.1	7623535.0	45° 34' 49.56"	122° 45' 35.69"	9.96	5.00
	4H	705793.5	7623528.7	45° 34' 49.45"	122° 45' 35.78"	12.04	7.08
Willamette Cove	5L	705618.6	7627491.8	45° 34' 48.81"	122° 44' 40.01"	7.38	2.42
	5M	705712.9	7627480.4	45° 34' 49.74"	122° 44' 40.21"	12.10	7.14
	5H	705813.8	7627504.4	45° 34' 50.74"	122° 44' 39.91"	15.65	10.69
Atofina	6L	702780.1	7627394.3	45° 34' 20.77"	122° 44' 40.27"	7.02	2.06
	6M	702760.2	7627374.3	45° 34' 20.57"	122° 44' 40.54"	9.69	4.73
	6H	702714.6	7627331.4	45° 34' 20.11"	122° 44' 41.13"	17.38	12.42
GATX	7L	701444.3	7628522.6	45° 34' 07.90"	122° 44' 23.89"	7.07	2.11
	7M	701461.2	7628440.7	45° 34' 08.04"	122° 44' 25.05"	9.47	4.51
	7H	701478.3	7628356.3	45° 34' 08.19"	122° 44' 26.24"	16.27	11.31
Coast Guard	8L	701942.8	7632757.5	45° 34' 13.97"	122° 43' 24.58"	7.01	2.05
	8M	701954.2	7632752.7	45° 34' 14.08"	122° 43' 24.65"	9.00	4.04
	8H	701976.7	7632740.6	45° 34' 14.30"	122° 43' 24.83"	13.41	8.45
Equilon	9L	696756.7	7633304.4	45° 33' 22.94"	122° 43' 14.89"	6.52	1.56
	9M	696708.5	7633245.4	45° 33' 22.44"	122° 43' 15.70"	8.85	3.89
	9H	696687.8	7633216.3	45° 33' 22.23"	122° 43' 16.10"	13.69	8.73

Notes: (1) U.S. State Plane, Oregon North Zone NAD 1983
L, M, H **L**ow, **M**edian, **H**igh

Table 3
Sediment Level Measurements at the Low Stakes

Transect Number	Location	Stake Installation 7/17/2002 (cm)*	Stake Monitoring 8/5/2002 (cm)*	Stake Monitoring 9/19/2002 (cm)*	Stake Monitoring 10/17/2002 (cm)*	Stake Monitoring 11/20/2002 (cm)*	Stake Monitoring 12/20/2002 (cm)*
1	General Electric	30	30	30	33	34	34
3	Terminal 4	30	31	31	32	32	29
4	Gasco	30	19	17	21	22	26
5	Willamette Cove	30	34	35	34	32	31.5
6	Atofina	30	31	28	28	30	32
7	GATX	30	35	38	39	39	43
8	Coast Guard	27	25	25	28	27	29
9	Equilon	30	31	38	43	44	46

Note: * Distance from top of stake to ground surface

Table 4
Sediment Level Measurements at the Median Stakes

Transect Number	Location	Stake Installation 7/17/2002 (cm)*	Stake Monitoring 8/5/2002 (cm)*	Stake Monitoring 9/19/2002 (cm)*	Stake Monitoring 10/17/2002 (cm)*	Stake Monitoring 11/20/2002 (cm)*	Stake Monitoring 12/20/2002 (cm)*
1	General Electric	30	30	28	30	28	27
3	Terminal 4	30	38	36	35	41	45
4	Gasco	30	26	20	20	27	35
5	Willamette Cove	30			30		
6	Atofina	30	30	23	20	22	30
7	GATX	30	34	28	31	39	42
8	Coast Guard	30	31	31	31	31	30
9	Equilon	30	25	13	10	11	15

Note: * Distance from top of stake to ground surface

Table 5
Sediment Level Measurements at the High Stakes

Transect Number	Location	Stake Installation 7/17/2002 (cm)*	Stake Monitoring 8/5/2002 (cm)*	Stake Monitoring 9/19/2002 (cm)*	Stake Monitoring 10/17/2002 (cm)*	Stake Monitoring 11/20/2002 (cm)*	Stake Monitoring 12/20/2002 (cm)*
1	General Electric	30	30	30	30	27	26
3	Terminal 4	30	30	30	30	30	30
4	Gasco	30	35	36	37	37	39
5	Willamette Cove	30					
6	Atofina	30	29	28	29	27	27
7	GATX	30	30	30	30	26	26
8	Coast Guard	30	30	30	30	30	30
9	Equilon	30	30	29	29	29	28

Note: * Distance from top of stake to ground surface

FIGURES

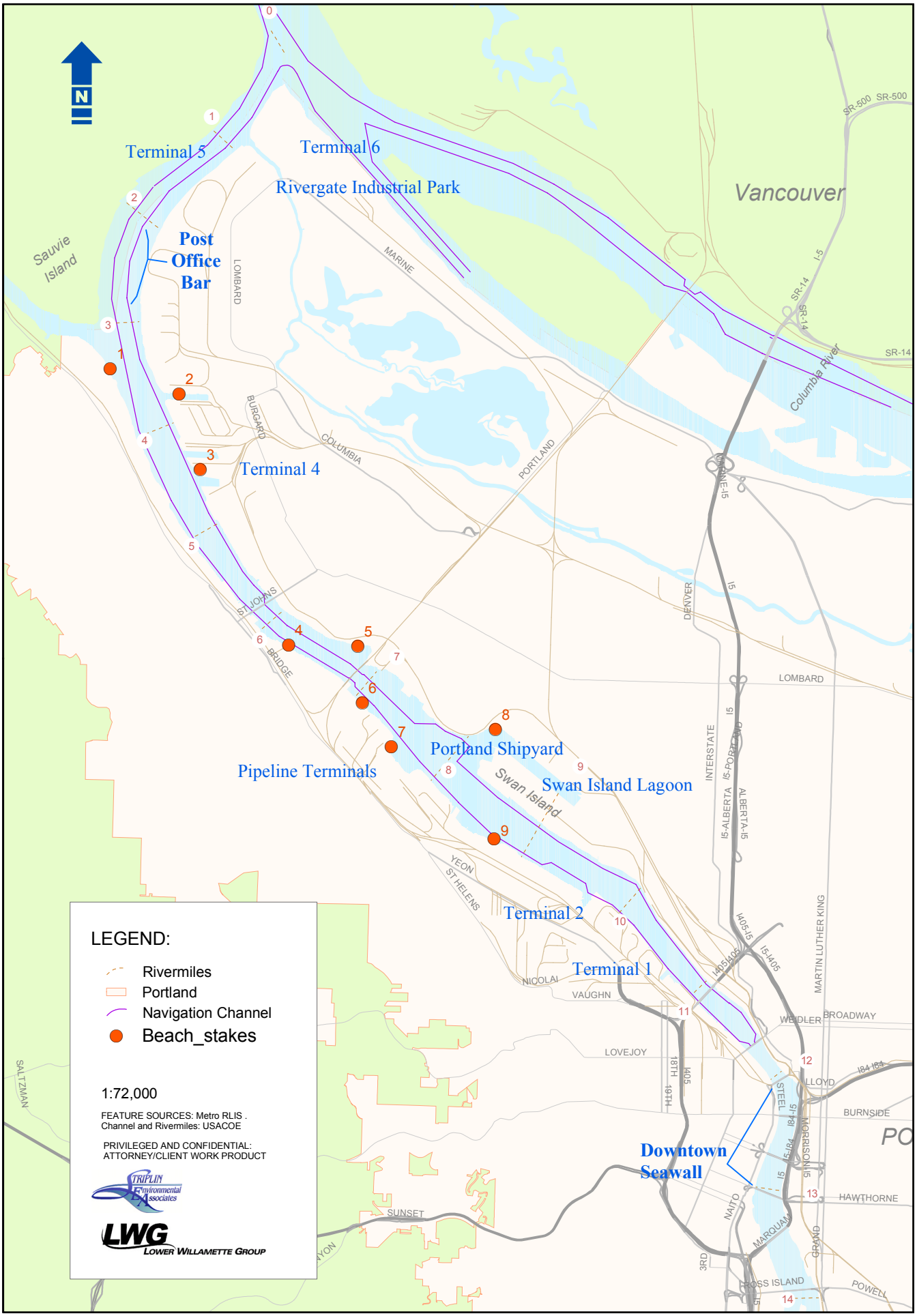

Figure 1. Beach Stake Location Map

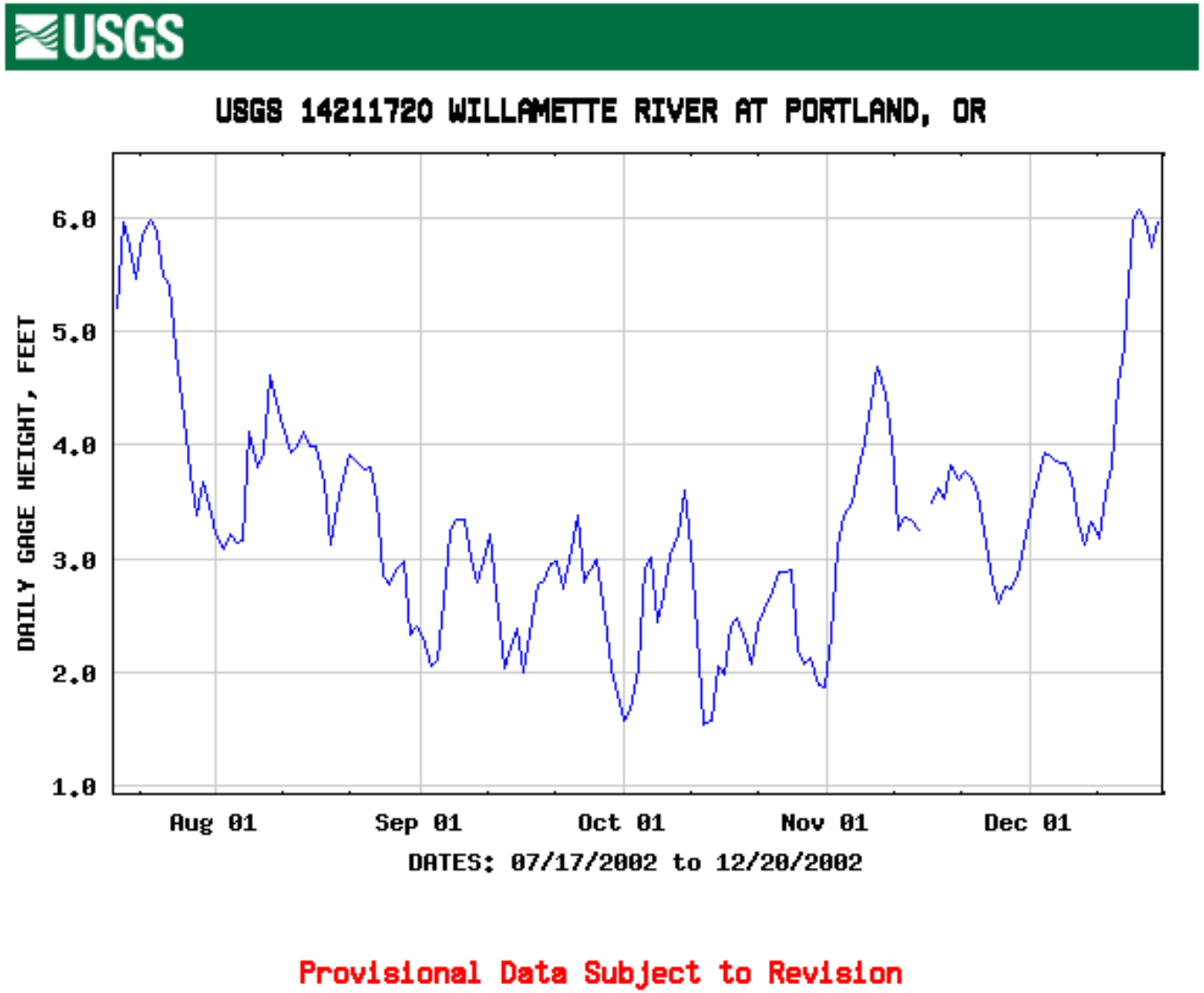

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Figure 2
Daily Gauge Height of the Willamette River at Portland, Oregon—July 17 to December 20, 2002
Round 1A Portland Harbor RI/FS

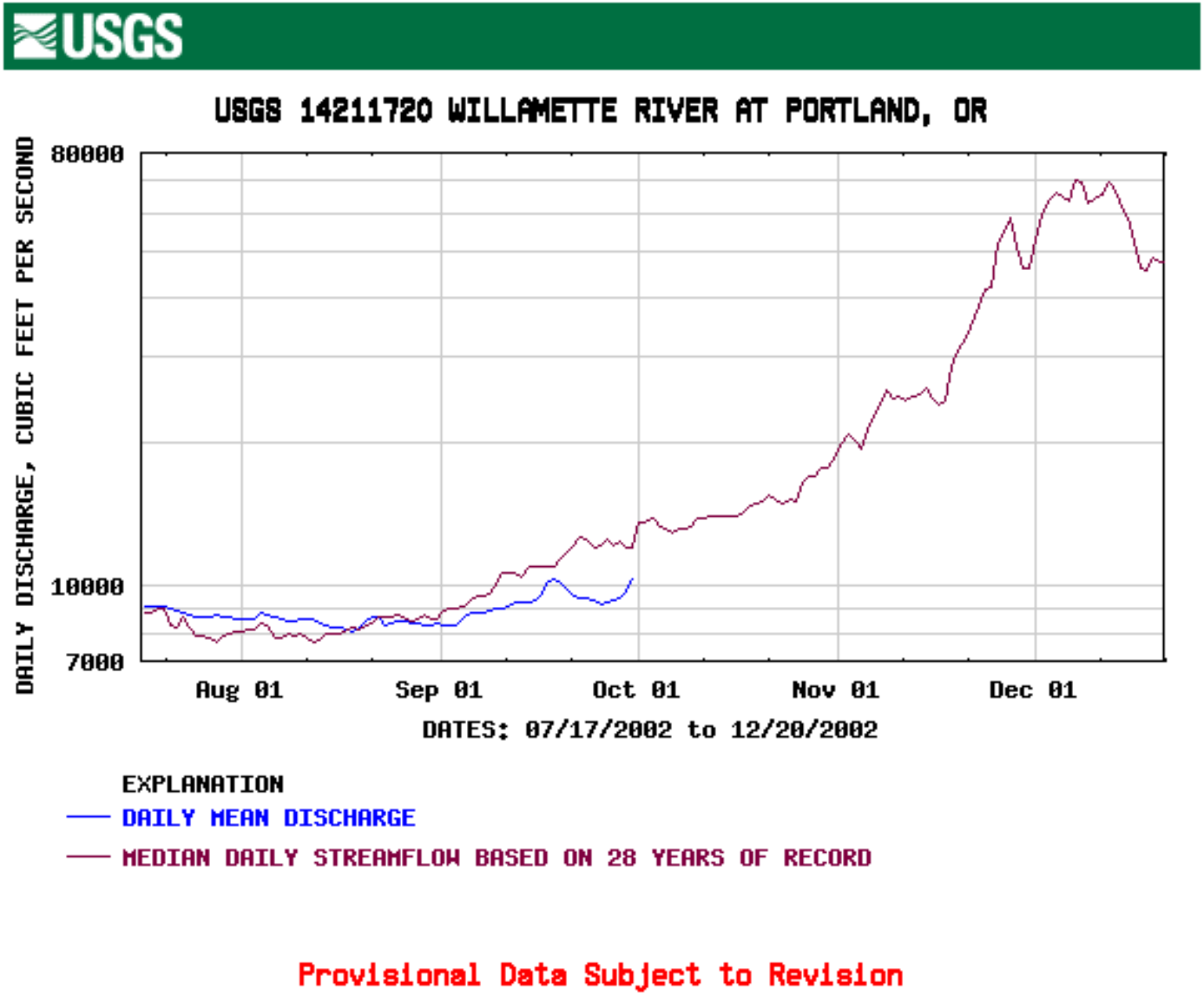

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Figure 3
Daily Discharge of the Willamette River at Portland, Oregon–July 17 to December 20, 2002
Round 1A Portland Harbor RI/FS

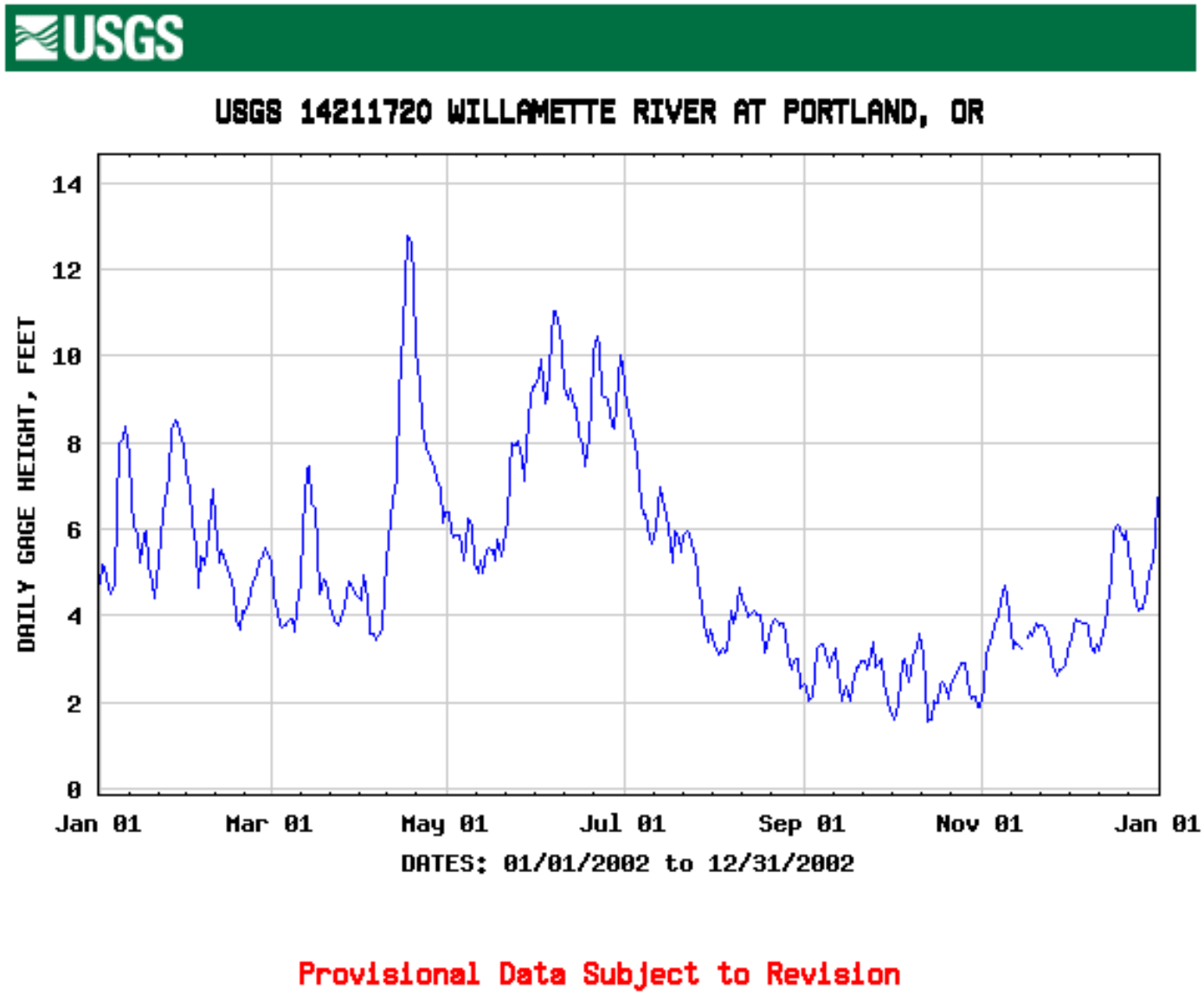

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Figure 4
Daily Gauge Height of the Willamette River at Portland, Oregon—Year 2002
Round 1A Portland Harbor RI/FS

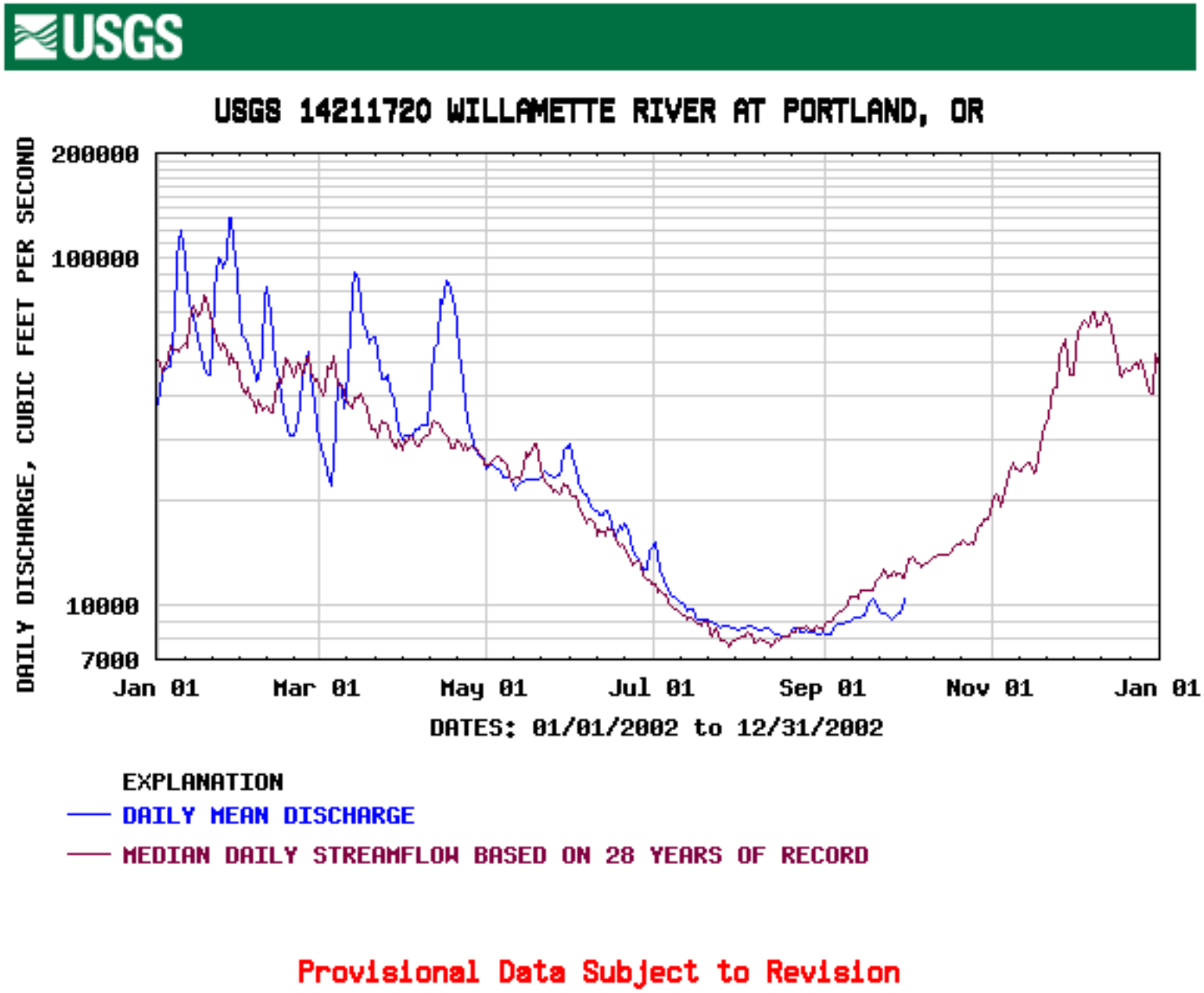

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Figure 5
Daily Discharge of the Willamette River at Portland, Oregon—Year 2002
Round 1A Portland Harbor RI/FS

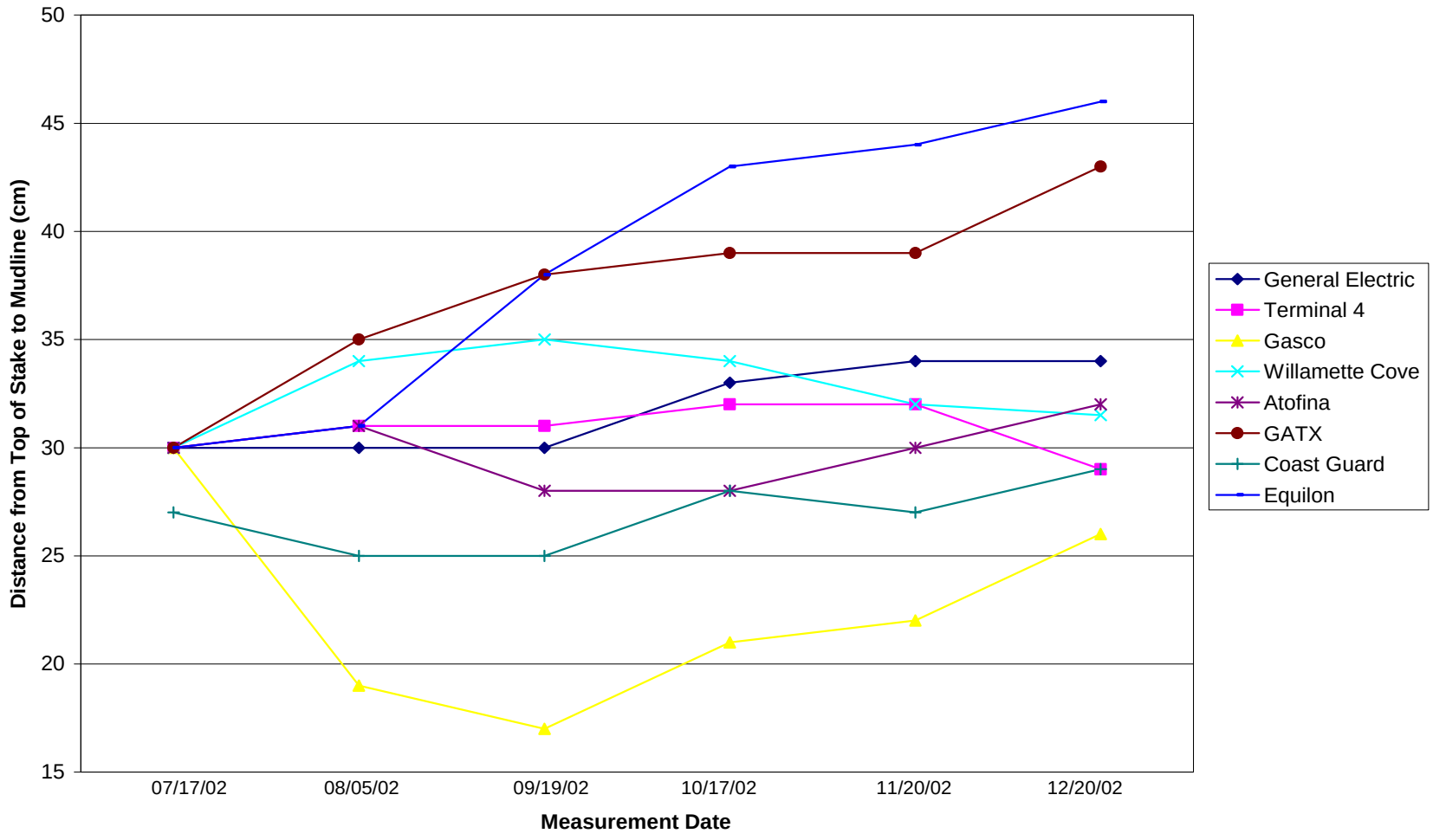

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Figure 6

Sediment Stake Measurements—Low Stakes

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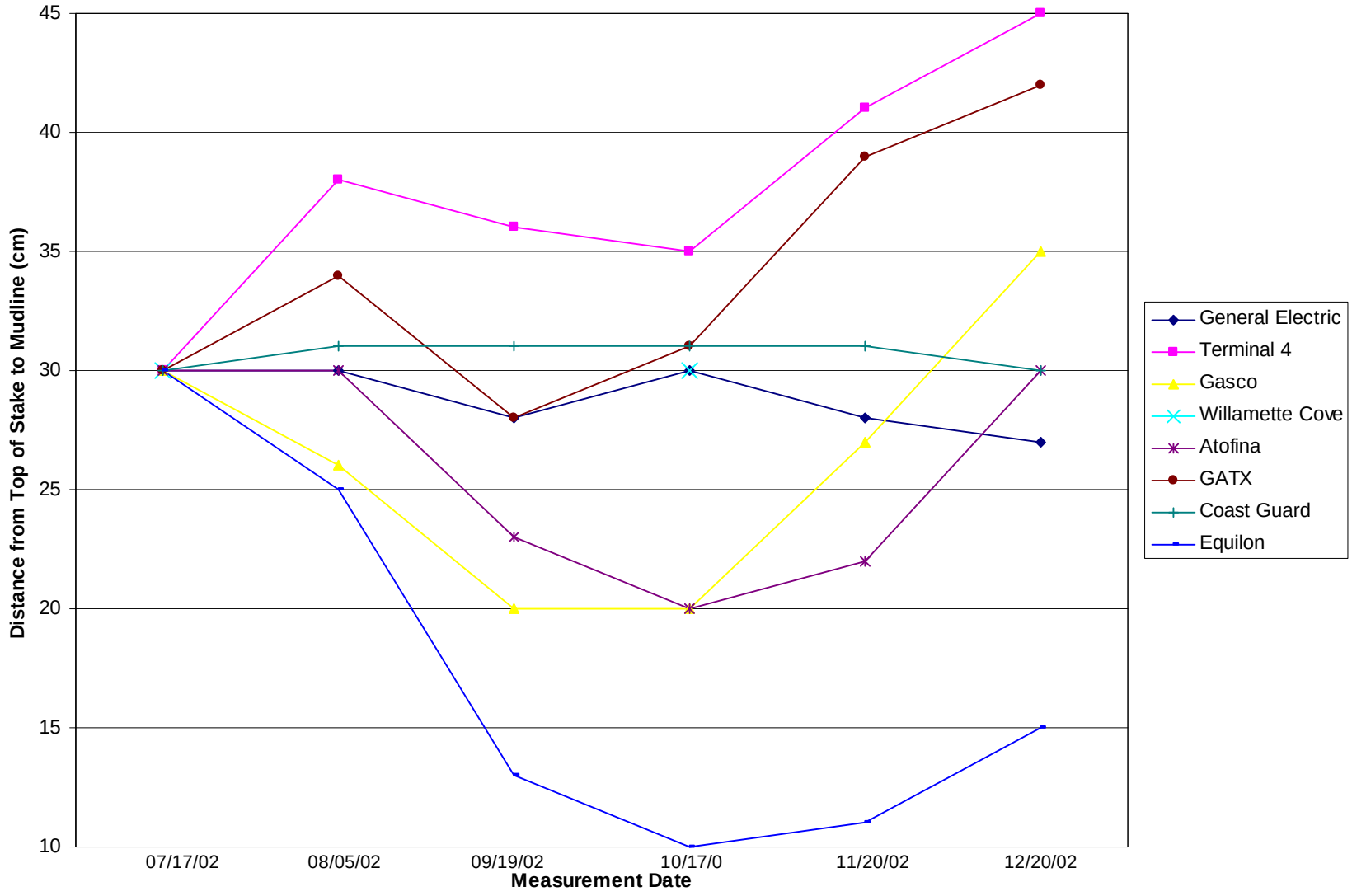

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Figure 7

Sediment Stake Measurements—Medium Stakes

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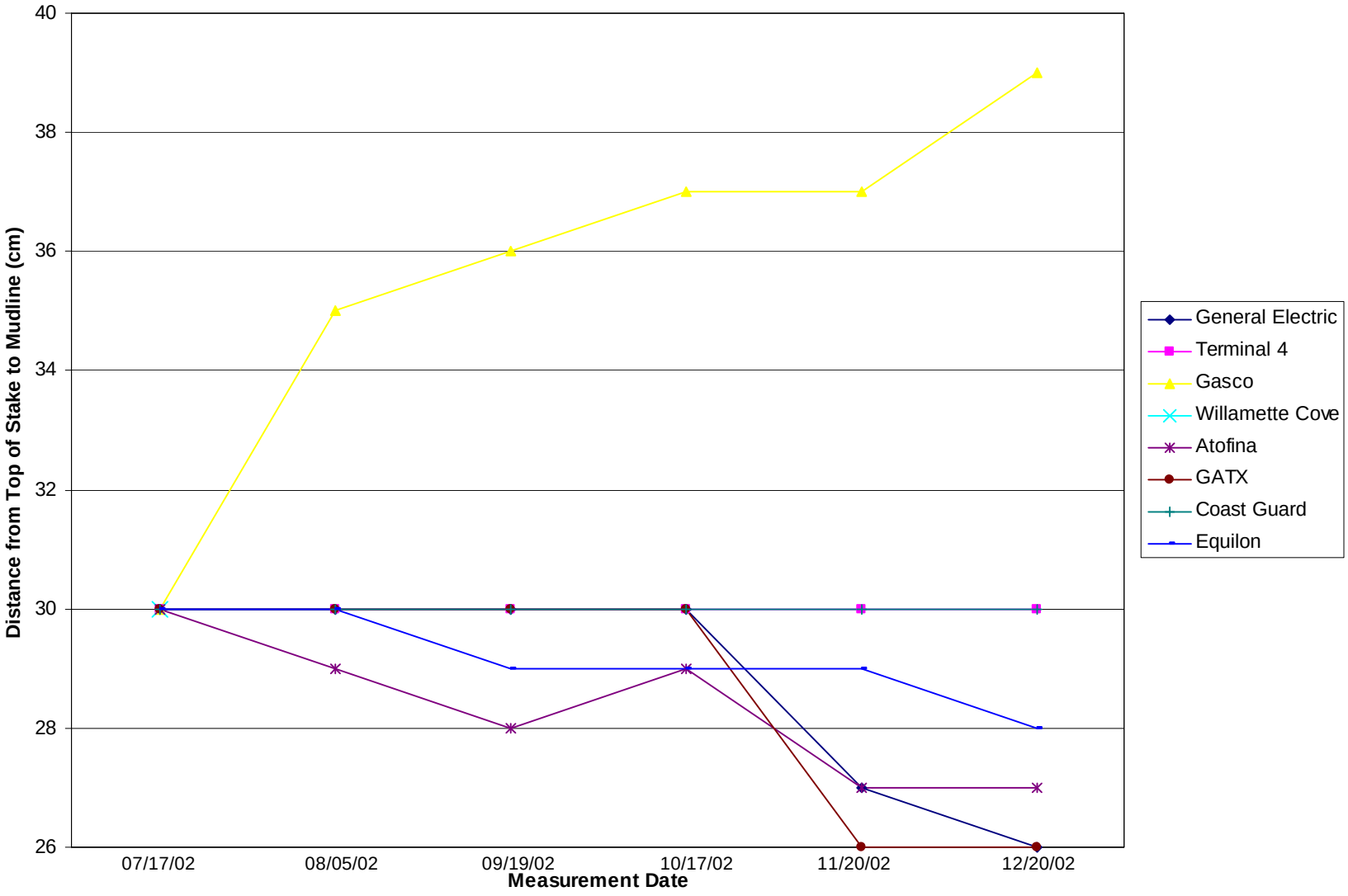

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Figure 8
Sediment Stake Measurements—High Stakes
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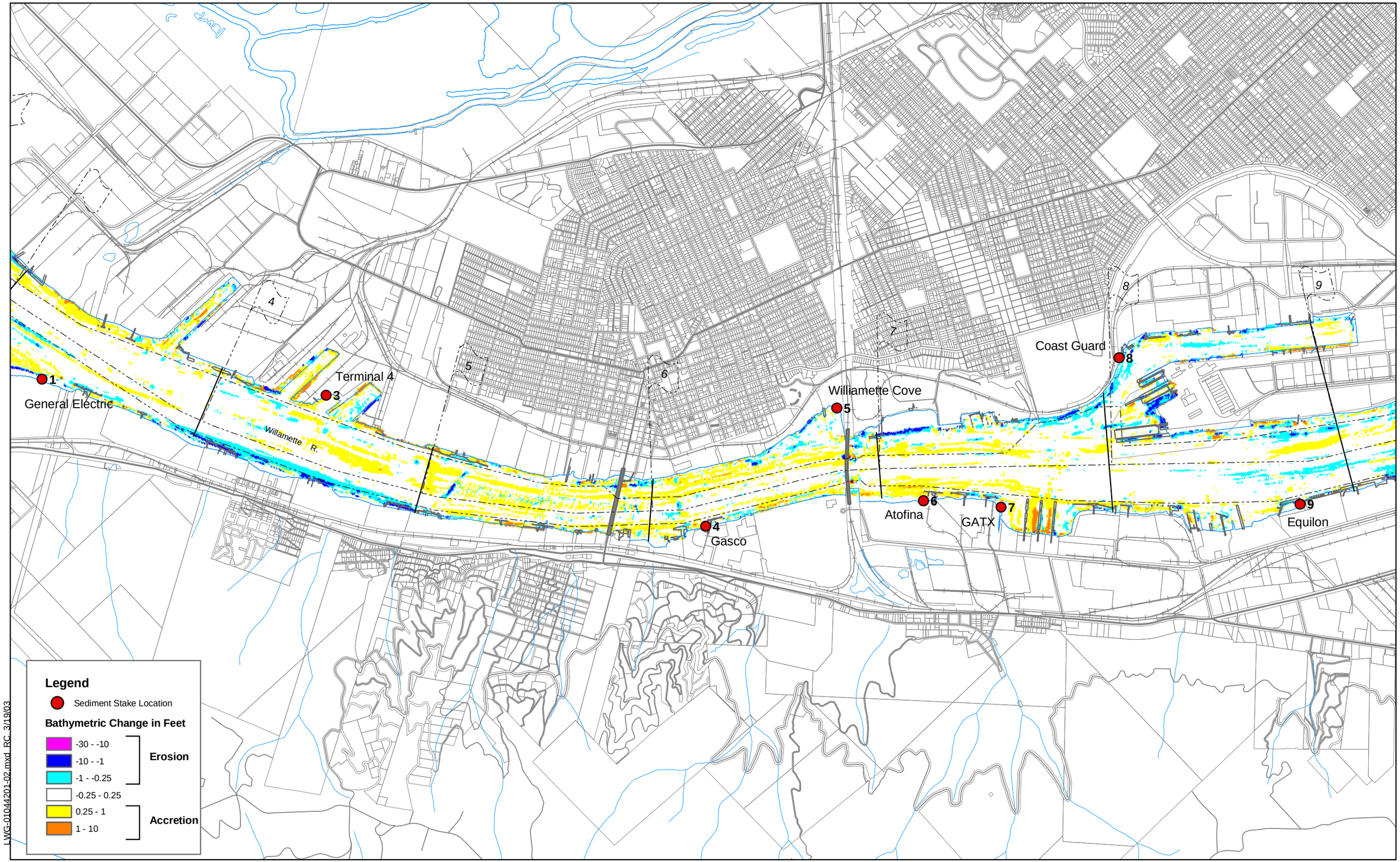

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Figure 9
Bathymetric Changes Determined From Surveys Performed in December 2001 and July 2002
Round 1A Portland Harbor RI/FS

APPENDIX A

PHOTOS

Location 1
General Electric Offshore View

Location 3
Terminal 4 Offshore View

Location 3
Terminal 4 Onshore View

Location 4
Gasco Offshore View

Location 4
Gasco Onshore View

Location 5
Willamette Cove Offshore View

Location 5
Willamette Cove Onshore View

Location 6
Atofina Offshore View

Location 6
Atofina Onshore View

Location 7
GATX Offshore View

Location 7
GATX Onshore View

Location 8
Coast Guard Offshore View

Location 8
Coast Guard Onshore View

Location 9
Equilon Offshore View

Location 9
Equilon Onshore View