Sea Level Rise Simulations of the Chassahowitzka River

for

Southwest Florida Water Management District
Under PO 07PO0001577

June 21, 2011

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Note - The term 'baseline' as used in this report refers to daily discharge as reported by the USGS.

1   Introduction

This memorandum summarizes the expansion of work issued under RFQ015-06 for the Chassahowitzka River System:

Additional Numeric Model Simulations of the Chassahowitzka River – Part Four

which is pre-qualified under PO 07PO0001577. See Appendix A for the detailed Scope of Work.

2   Scenarios of Rise in Water Level

The District has chosen to evaluate a range of sea level rise scenarios for several of the Springs Coast estuaries including the Chassahowitzka River. Sea level rise is one impact of climate change and is of particular interest for the Chassahowitzka River. The basic approach was to assign a range of sea level rises and compare these to a baseline (BSL). The model developed in the initial Minimum Flows and Levels (MFL) work (DSLLC 2009) simulated the period of 2004-2006. This period was chosen as the baseline condition to evaluate the impact of sea level rise on the salinity regime. :

The water levels at the sea water boundary condition were adjusted from the baseline model with, and without the proposed MFL reduction in the fresh water spring discharges to establish following six scenarios:

- Two-inch sea level rise on baseline flow conditions

- Two-inch sea level rise on proposed MFL condition

- Six-inch sea level rise on baseline flow conditions

- Six-inch sea level rise on proposed MFL condition

- Twelve-inch sea level rise on baseline flow conditions

- Twelve-inch sea level rise on proposed MFL condition

The MFL conditions are defined as an 11% maximum flow withdrawal from the system.

3   Salinity Habitat Criteria

Similar to the approach described in the Section 7 of the main report (DSLLC 2009), for each of the scenarios listed above, the results of volume, area, shoreline length and isohaline locations of

water having depth averaged salinity below 2 ppt, 5 ppt, 10 ppt and 15 ppt were extracted for analysis.

3.1   Total Water Volume

CDF plots of the total volume of the water for the various salinity ranges are presented in Figure 1**Error! Reference source not found.** under BSL flow condition and in Figure 2 under MFL flow condition. It can be seen from these plots that the volume of water in the lower salinity ranges decreases with increasing sea level rise, while the volume of water in the higher salinity ranges increases with increasing sea level rise.
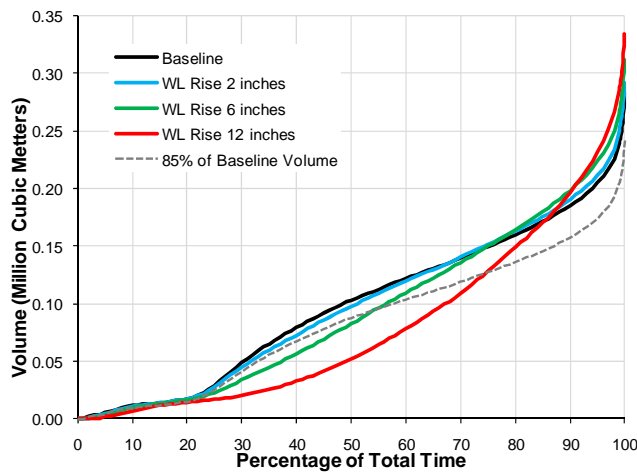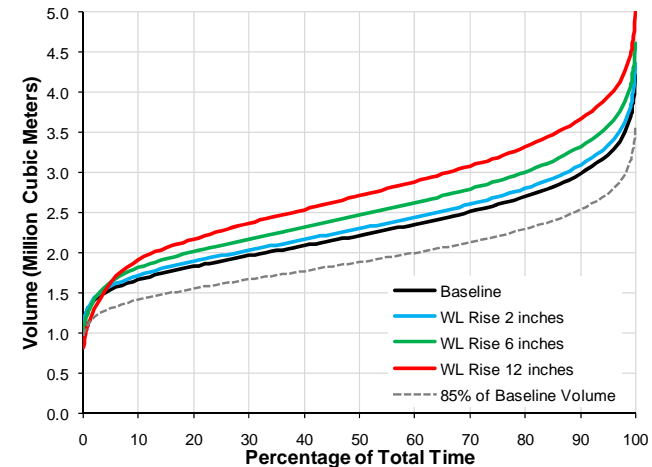

(a) Salinity range 0 to 2 ppt
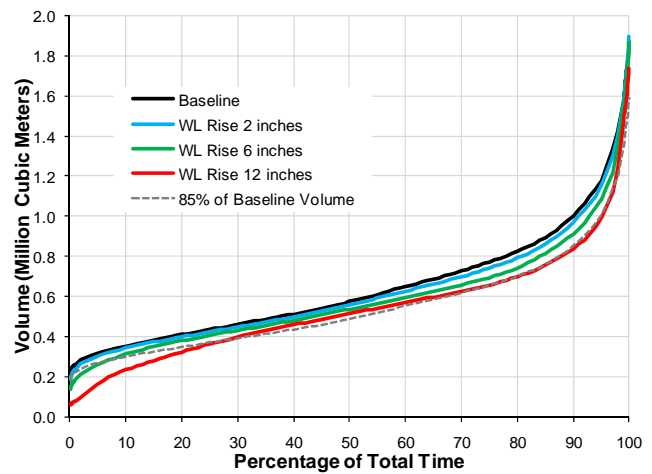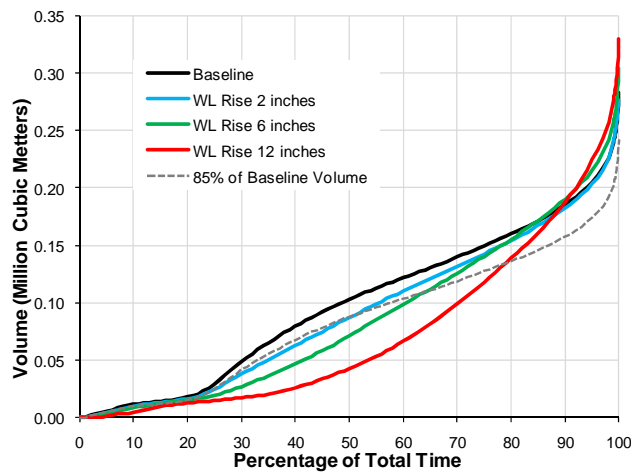
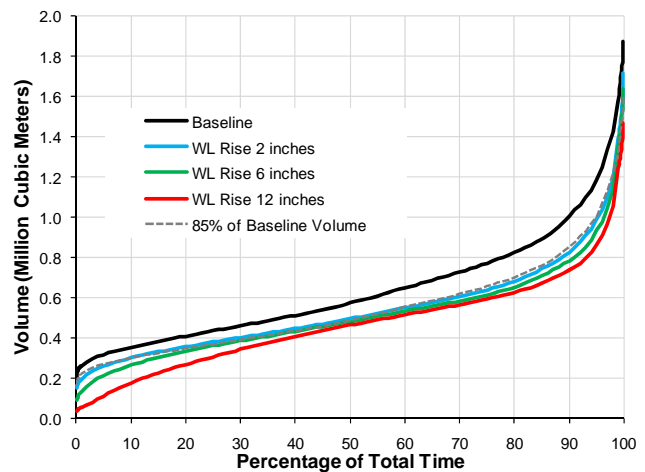**(b) Salinity range 0 to 5 ppt**
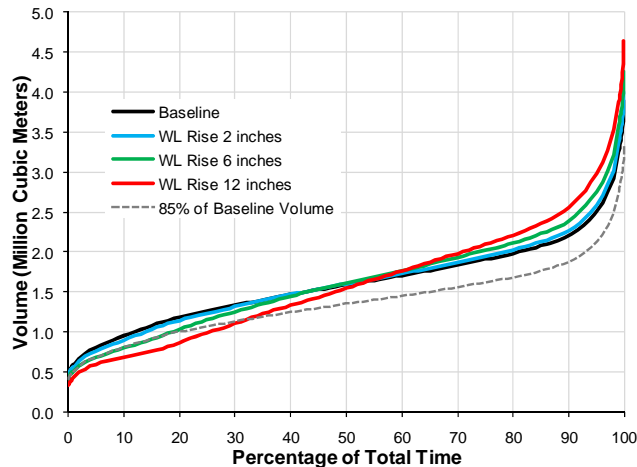
(c) Salinity range 0 to 10 ppt

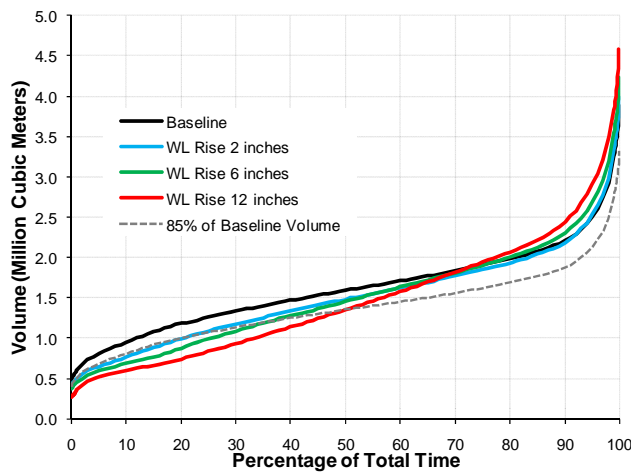**(d) Salinity range 0 to 15 ppt**

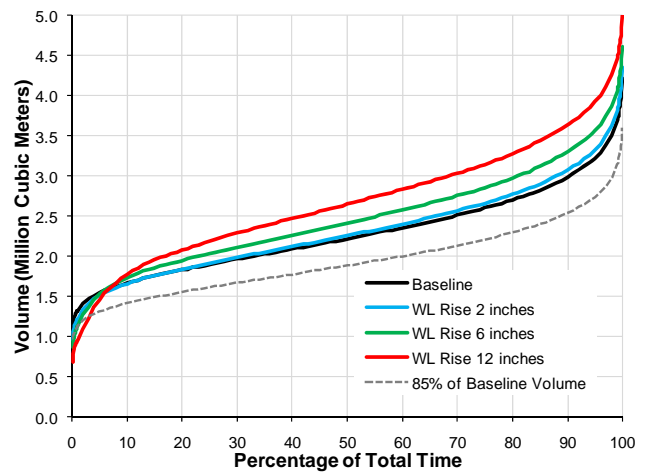**Figure 1 Volumetric analysis CDF's: BSL flow condition**

(a) Salinity range 0 to 2 ppt

(b) Salinity range 0 to 5 ppt

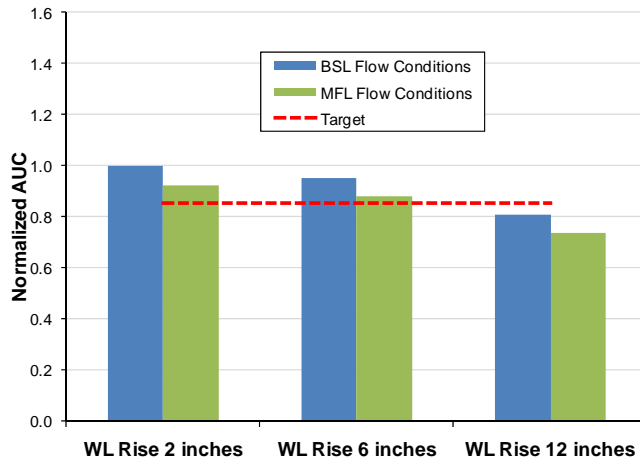**(c) Salinity range 0 to 10 ppt**

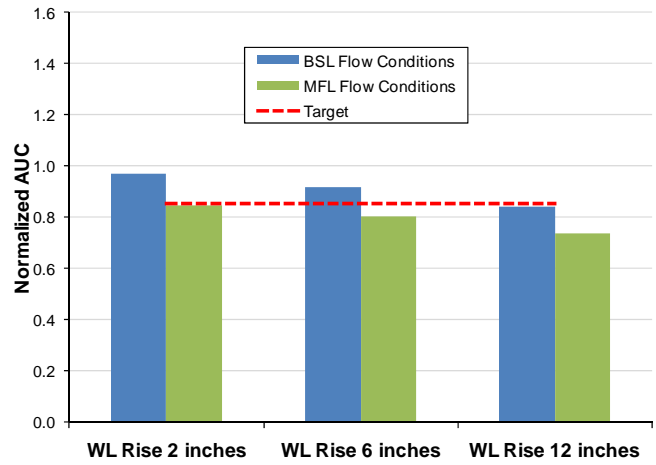**(d) Salinity range 0 to 15 ppt**

Figure 2 Volumetric analysis CDF's: MFL flow condition.

Figure 3 provides the total volume normalized area curve under CDF (AUC) for all salinity criteria. The "Target" line shown on Figures 3 (a) to (d) represents the MFL allowable impact of a 15% loss in volume. While not strictly applicable for this sea level rise analysis, this level provides one type of metric to assist in comparing the salinity increases due to the rise in sea level. AUC's whose values are above the target lines shown in Figure 3   meet the 15% target.
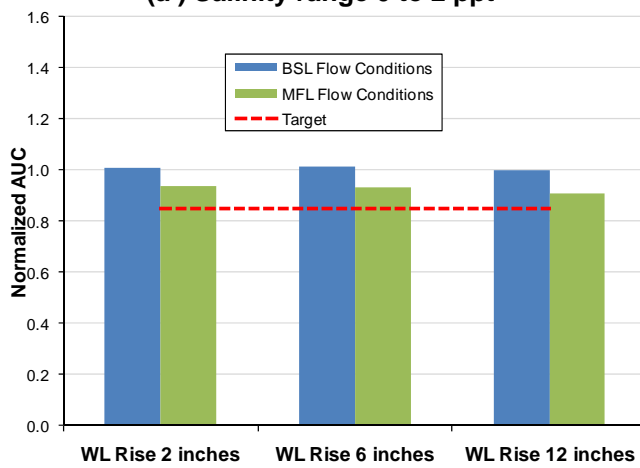
Under both BSL and MFL flow conditions, the loss of 0-2 ppt and 0-5 ppt salinity range water volume shows an increasing trend with rising sea water level. The loss of water volume is higher than the 15% target in the 12 inch scenario but meets the target in the cases of the 6 and 2 inch rises.
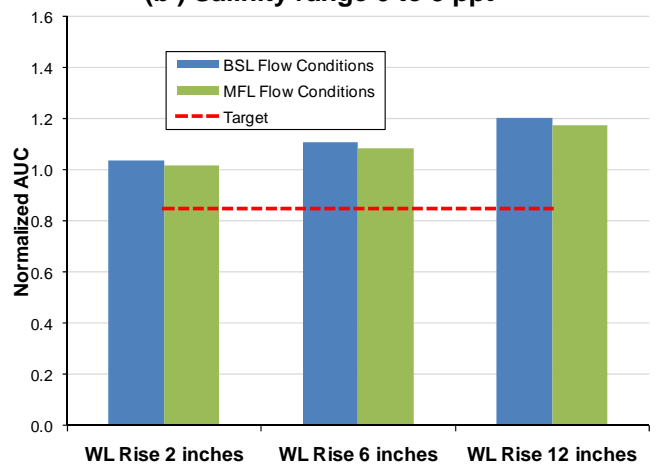
Figure 3 Summary of volume AUC analysis.

3.2   Bottom Area

Figure 4 and Figure 5 provide the CDF's of the bottom areas for the BSL and MFL flow conditions. Each figure shows the salinity ranges for each of the three sea level rise scenarios. It can be seen from these CDF's that the baseline case always has greater bottom surface area than each of the sea level rise scenarios for all salinity ranges. The AUC analysis of the bottom surface areas in Figure 6 shows that the bottom area is significantly affected by the sea water rise problem. The situation is worse under MFL flow condition. AUC's whose values are above the target lines shown in Figure 6 meet the 15% target.

(a) Salinity range 0 to 2 ppt

(b) Salinity range 0 to 5 ppt

(c) Salinity range 0 to 10 ppt
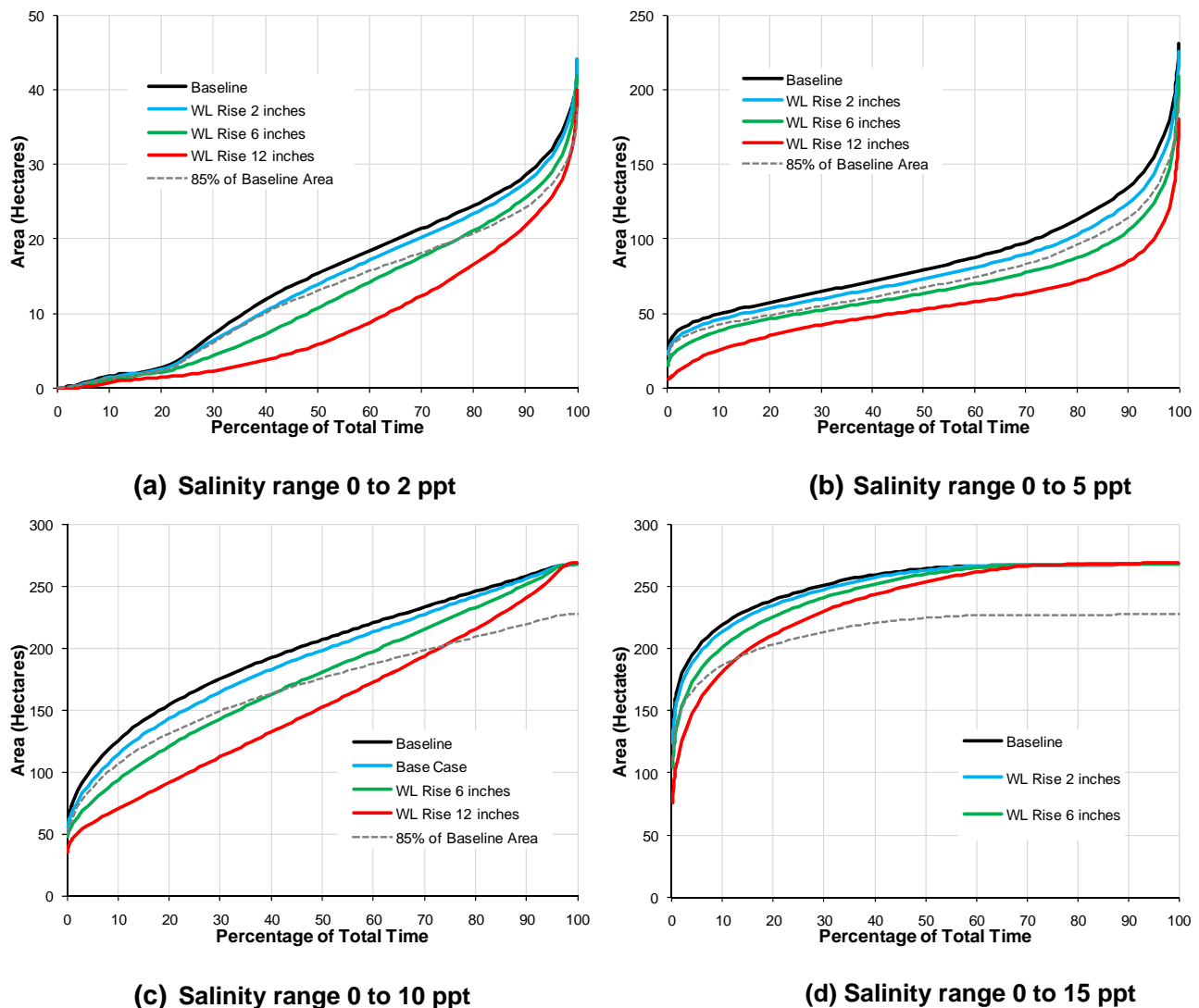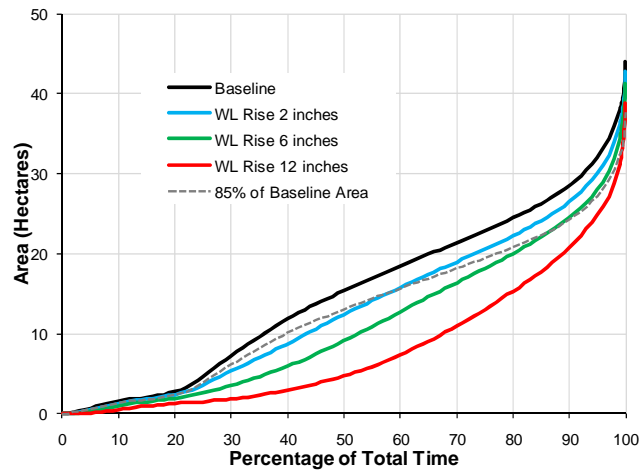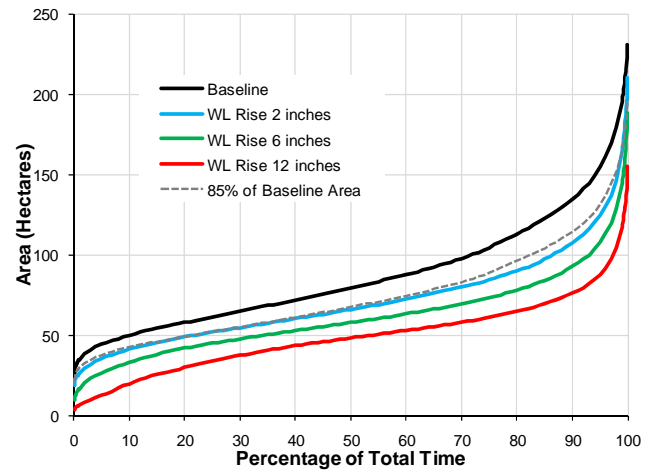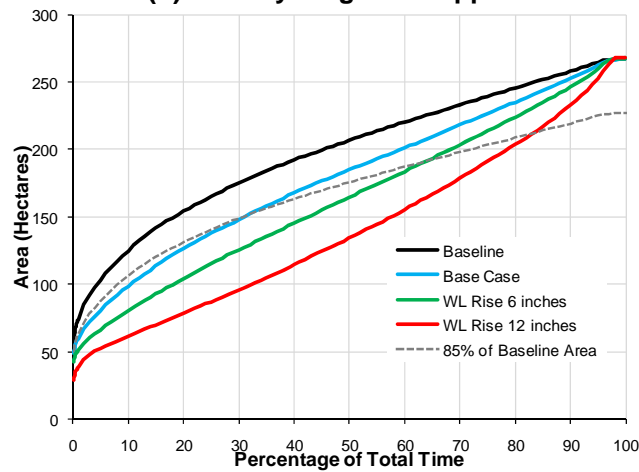
(d) Salinity range 0 to 15 ppt

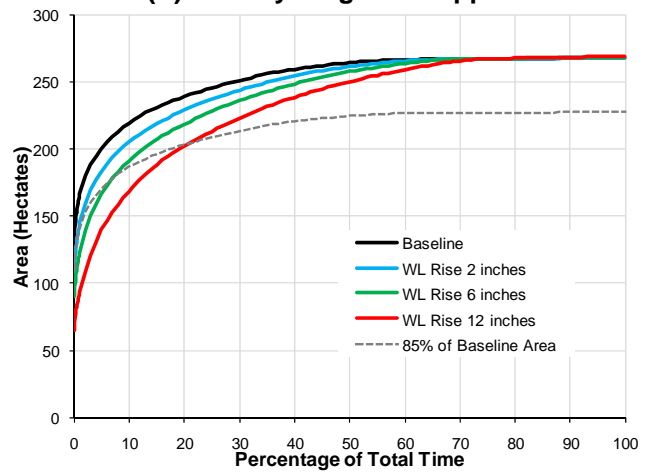**Figure 4 Bottom area analysis CDF's: BSL flow condition.**

(a) Salinity range 0 to 2 ppt

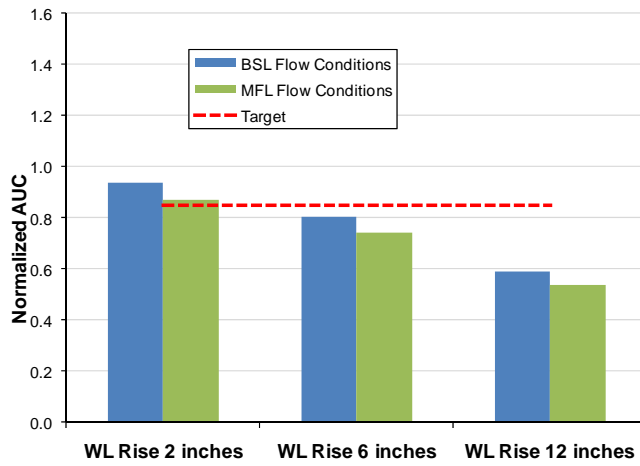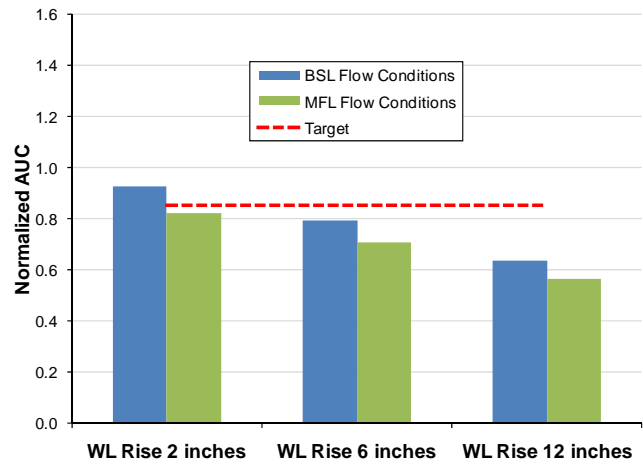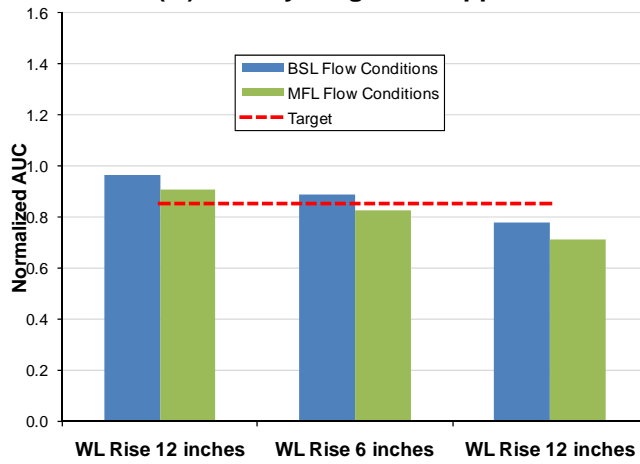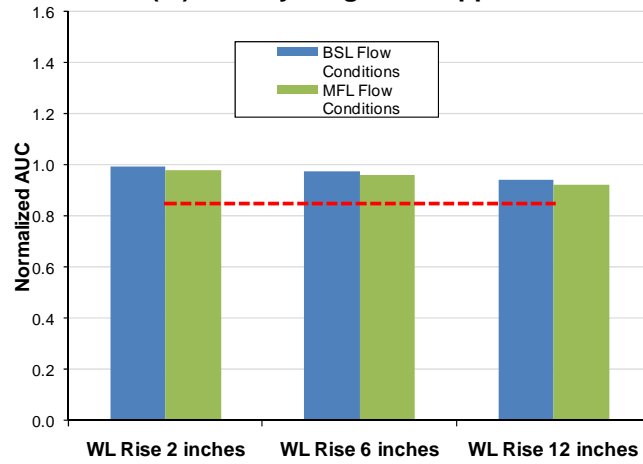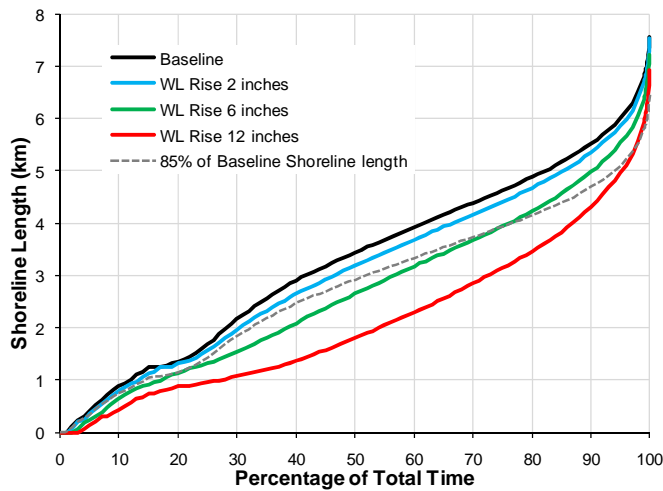(b) Salinity range 0 to 5 ppt

(c) Salinity range 0 to 10 ppt

(d) Salinity range 0 to 15 ppt

Figure 5 Bottom area analysis CDF's: MFL flow condition.

**Figure 6 Summary of bottom area AUC analysis**
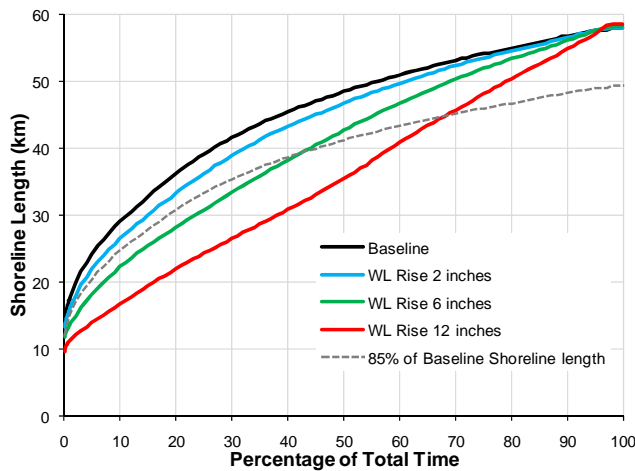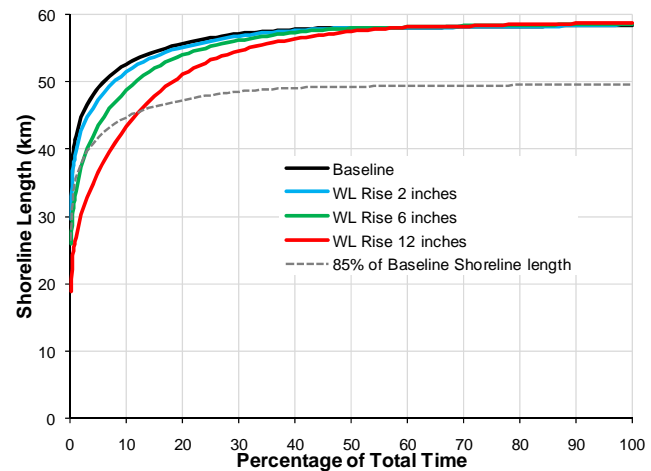
3.3   Shoreline length

The situation with shoreline length for each scenario is similar to the bottom area results. Figure 7
S and Figure 8 and provide the CDF under BSL and MFL flow conditions respectively. The AUC in
Figure 9 also indicates the loss of shoreline length due to the sea water levels rising for all
scenarios. AUC's whose values are above the target lines shown in Figure 9 meet the 15% target.

(a) Salinity range 0 to 2 ppt
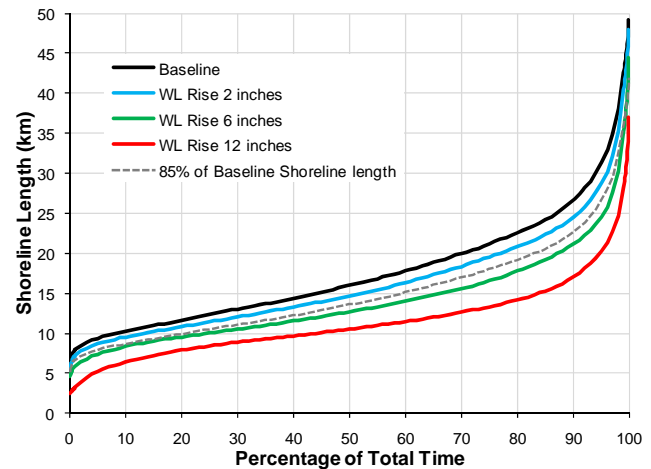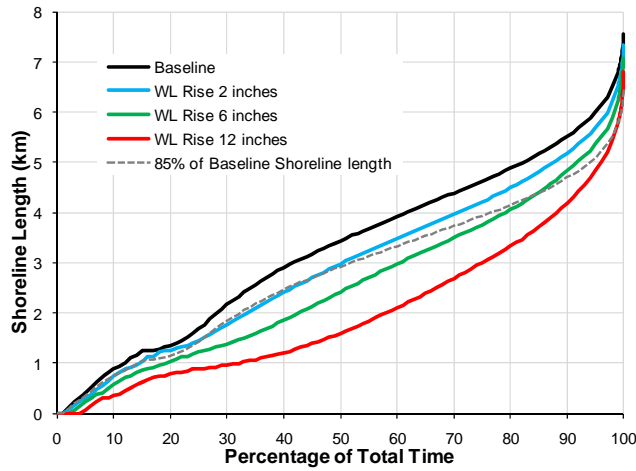
(b) Salinity range 0 to 5 ppt

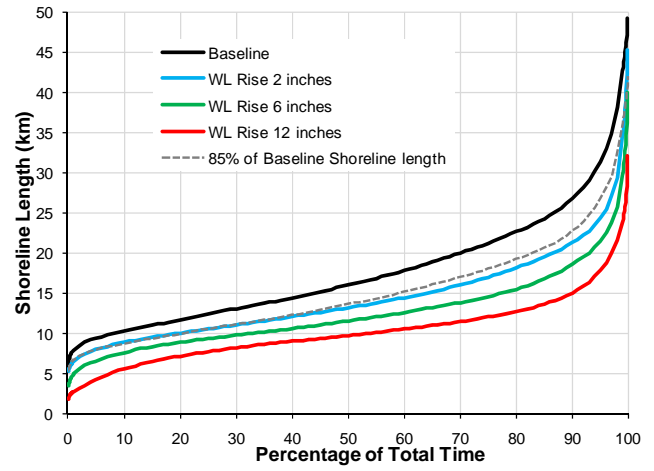**(c) Salinity range 0 to 10 ppt**

(d) Salinity range 0 to 15 ppt

Figure 7 Shoreline length analysis CDF's: BSL flow condition.

Figure 8 Shoreline length analysis CDF's: MFL flow condition.
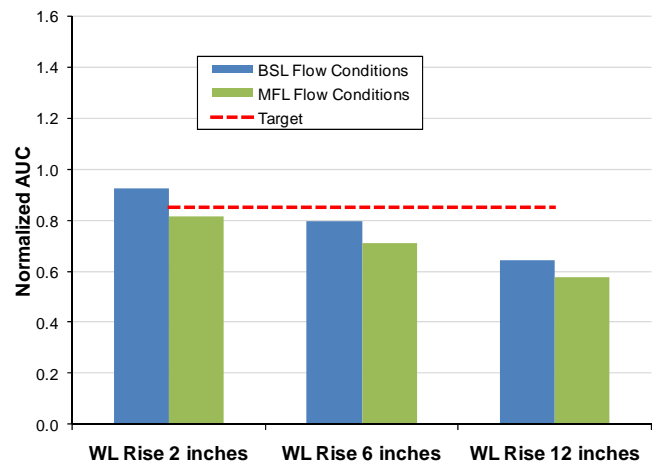
Figure 9 Summary of shoreline length AUC analysis

3.4   Isohaline RK location

Figure 10 and Figure 11 show the isohaline analysis CDF's for the BSL and MFL flow condition. As sea water level rises, the isohaline location moves upstream. Because the RK is starting from the river mouth, the RK value increases as the isohaline location moves upstream.

The AUC in Figure 12 indicates that isohaline location of the water for all salinity criteria is moving upstream with sea water level rise.

(a) Salinity range 0 to 2 ppt

(b) Salinity range 0 to 5 ppt

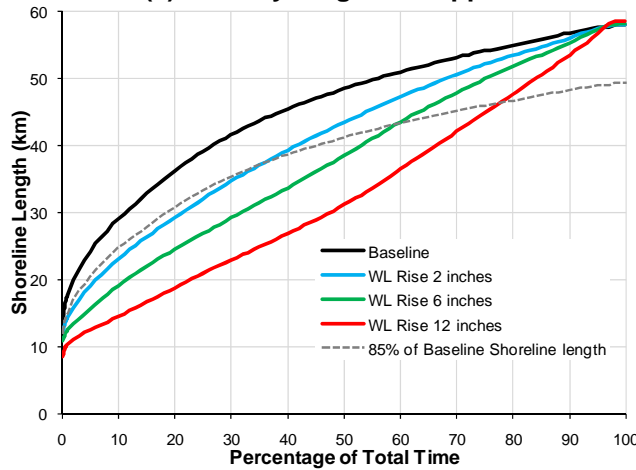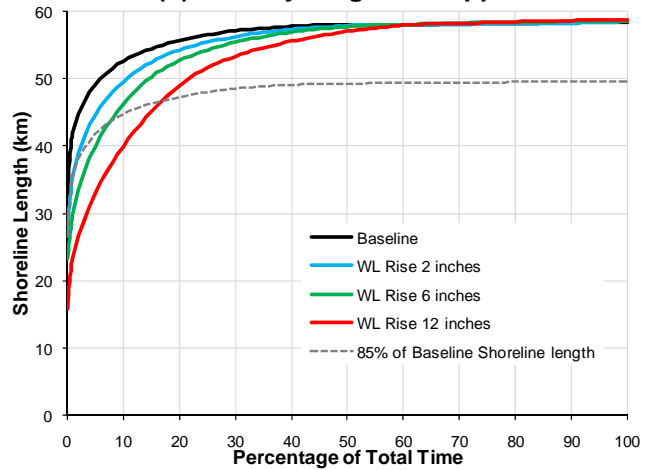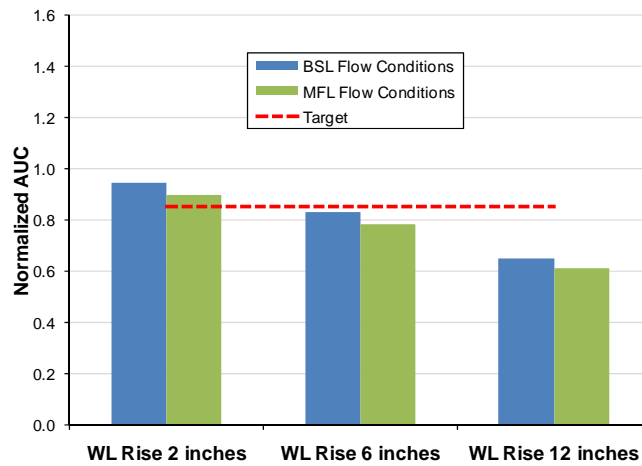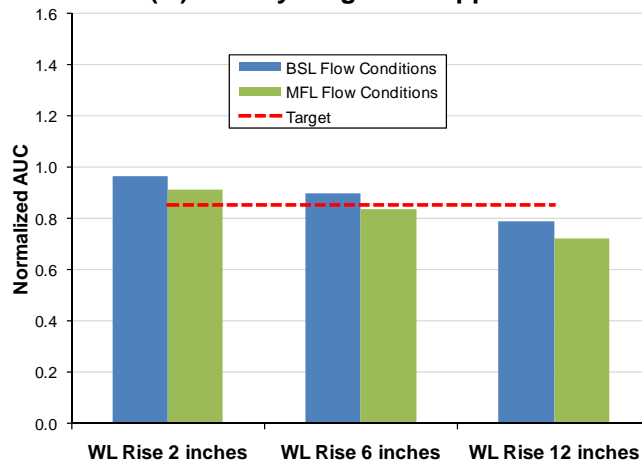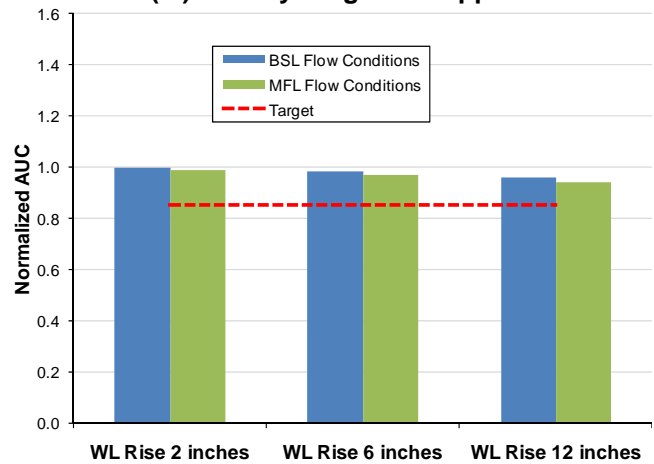**(c) Salinity range 0 to 10 ppt**
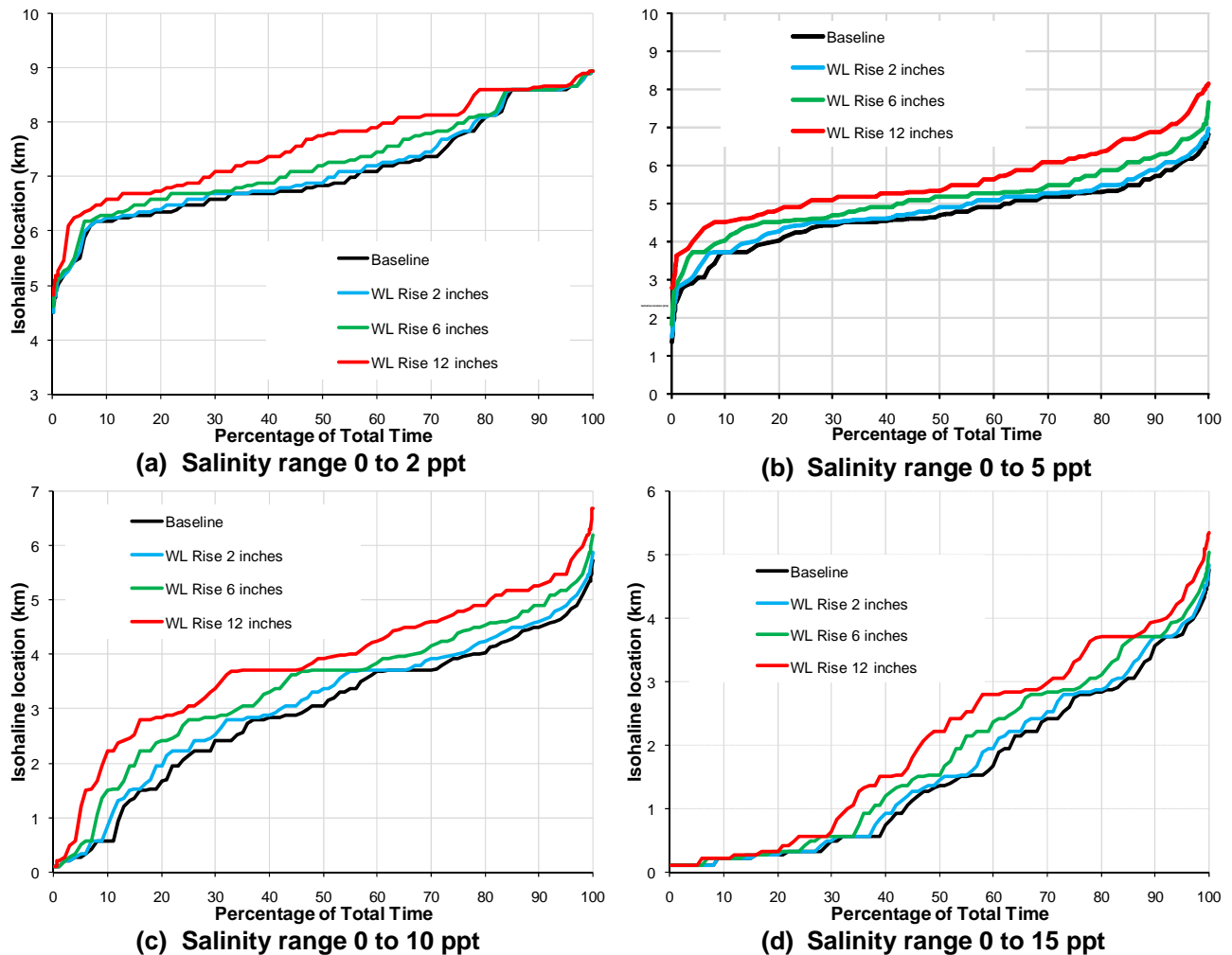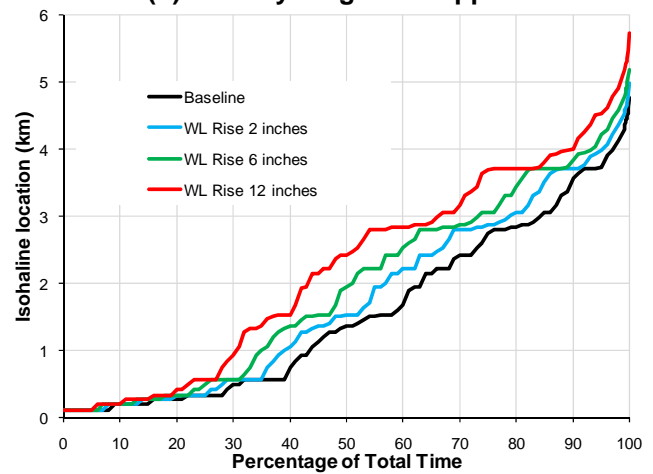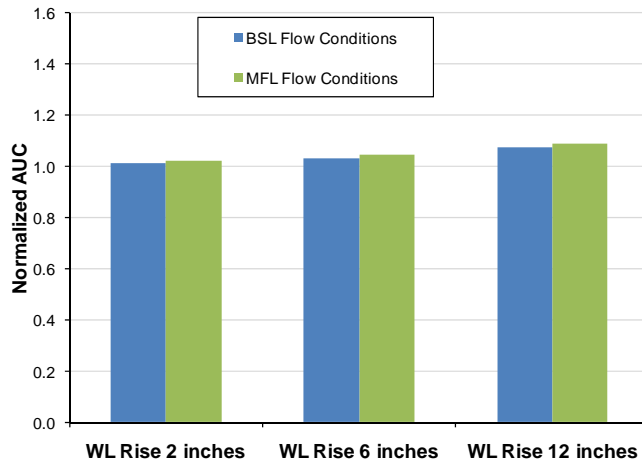
(d) Salinity range 0 to 15 ppt

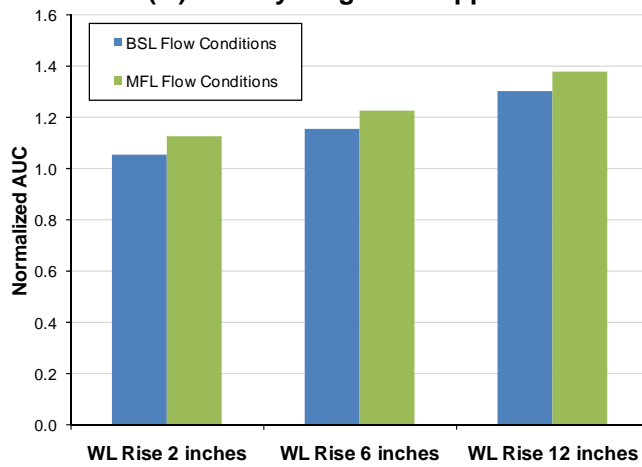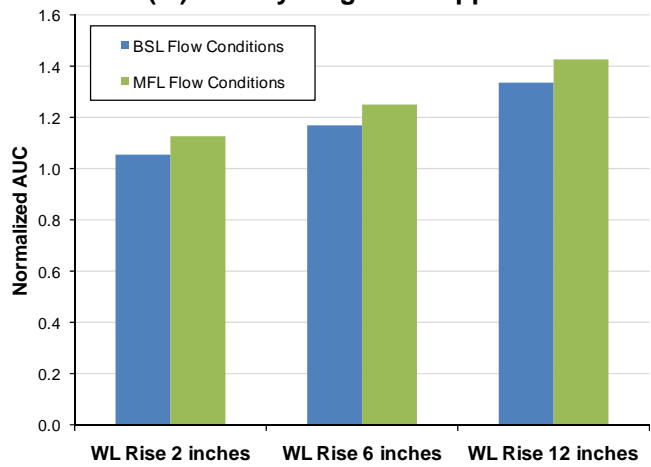**Figure 10   Isohaline location analysis CDF's: BSL flow condition.**
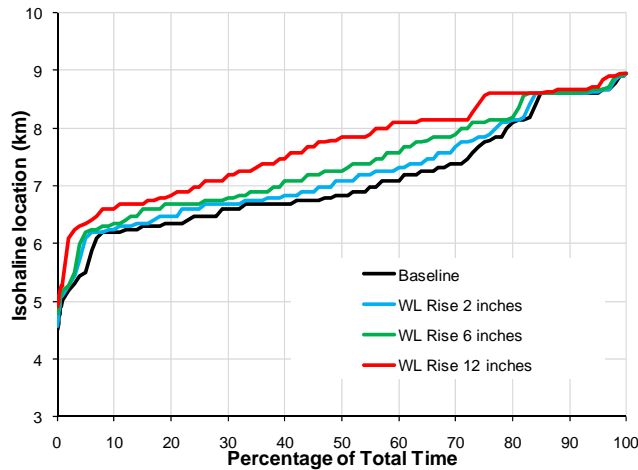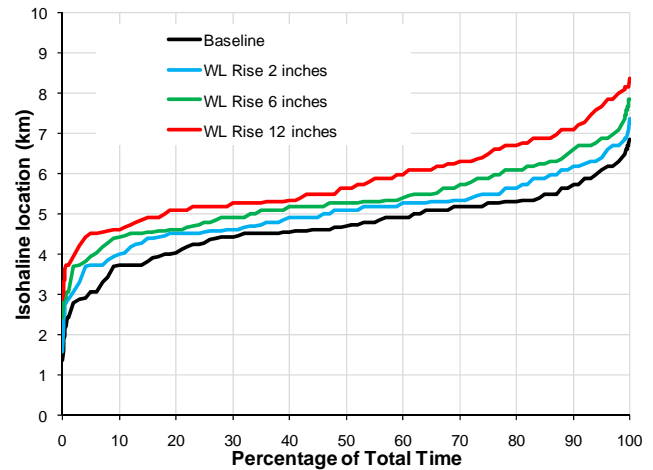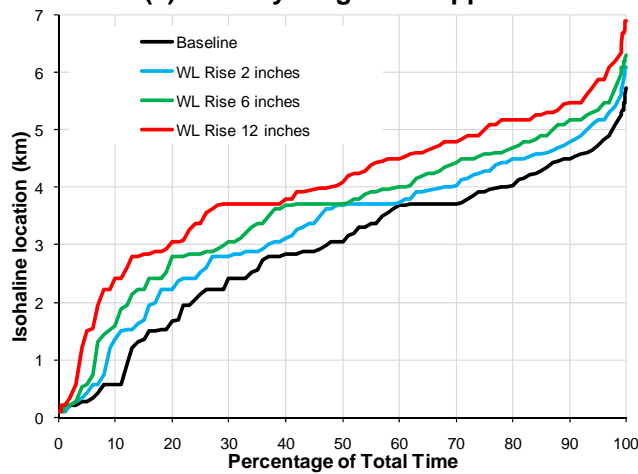
Figure 11 Isohaline location analysis CDF's: MFL flow condition.
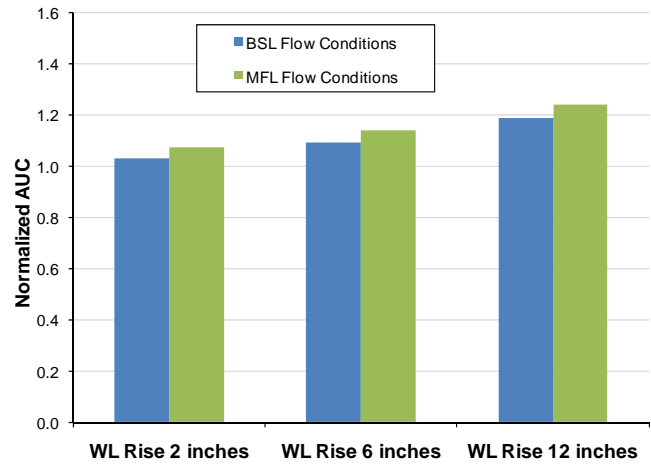
Figure 12 Summary of isohaline location AUC analysis

4   Summary of Outcomes

Table 1 summarizes the AUC ratio for all calculated scenarios. In general, additional losses in volume, area and shoreline length of the water with salinity in a range of 0-2 and 0-5 ppt occurred with every sea water level rise scenario. For the salinity ranges of 0-10 and 0-15 ppt the volumes may increase as indicated in the table, with AUC greater than one. The time series plots of all cases are provided in Appendix B attached to this report.

Table 1 Normalized Area under the CDF Curve (AUC)

Salinity Range (ppt)	Normalized Area Under the CDF Curve (AUC)					
	2 Inch Sea Level Rise		6 Inch Sea Level Rise		12 Inch Sea Level Rise	
	BSL	MFL	BSL	MFL	BSL	MFL
Volume						
0 to 2	0.995	0.923	0.951	0.876	0.808	0.737
0 to 5	0.969	0.845	0.916	0.803	0.838	0.734
0 to 10	1.006	0.936	1.012	0.932	1.001	0.910
0 to 15	1.036	1.016	1.106	1.082	1.205	1.173
Bottom Area						
0 to 2	0.939	0.873	0.806	0.743	0.592	0.536
0 to 5	0.923	0.819	0.793	0.706	0.634	0.562
0 to 10	0.963	0.906	0.887	0.826	0.774	0.710
0 to 15	0.992	0.980	0.974	0.959	0.943	0.924
Shoreline Length						
0 to 2	0.946	0.897	0.829	0.782	0.649	0.609
0 to 5	0.923	0.816	0.796	0.709	0.645	0.578
0 to 10	0.965	0.909	0.895	0.833	0.787	0.722
0 to 15	0.994	0.984	0.982	0.970	0.956	0.939
Isohaline Location						
0 to 2	1.008	1.019	1.029	1.042	1.072	1.085
0 to 5	1.031	1.074	1.091	1.137	1.188	1.238
0 to 10	1.054	1.125	1.155	1.227	1.303	1.376
0 to 15	1.054	1.126	1.170	1.249	1.335	1.424

5   Conclusions and Limitations

The impact on the salinity regime in the Chassahowitzka River System due to a rise in sea water level has been analyzed. The results indicate that the habitat availability in the system (in term of volume, area, shoreline length and isohaline location) is reduced with water level rise.

The analysis conducted here was subject to the following limitations:

- With the rise in sea water level, the water at the open sea boundary condition of the model in the natural environment may be more saline. The salinity at the sea boundary was assumed to be the same level as for the baseline model.

- The model domain covers only the currently wetted area in the system, thus excluding the adjacent low lying grounds. These low lying regions would likely be flooded in the case of sea water rise, potentially significantly increasing the wetted area and shoreline length. Volumes, on the other hand, would only be significantly increased if the magnitude of the sea level rise was significant. The potential change in wetted area would have an impact on the hydrodynamic and salinity regimes.

6   References

Dynamic Solutions, LLC, April, 2009, *Impacts of Withdrawals on the Chassahowitzka River System* for Southwest Florida Water Management District Under PO 07PO0001577. (http://www.swfwmd.state.fl.us/projects/mfl/reports/Chass_Appendices-section13.pdf)

Appendix A – Scope of Work

Scope of Work 07PO0001577
Additional Numeric Model Simulations of the Chassahowitzka River – Part Four

(Note – This work is an expansion of work issued under RFQ015-06 minimum flows pre-qualifications as PO 07PO0001577.)

Purpose

The District has chosen to evaluate a range of sea level rise scenarios for several of the springs coast estuaries including the Chassahowitzka River. Previously, Dynamic Solutions LLC (CONSULTANT) developed a hydrodynamic model under a 2006 pre-qualified minimum flow and level master agreement with the DISTRICT. This work order expands on the initial work, incorporating an evaluation of a two-inch, six-inch and twelve-inch rise in sea level. This work order also expands on the post-processing and presentation of the results.

Scope of Work

Task 1– Simulate the change in salinity and stage for the following scenarios using the baseline conditions previously established for 1995 –1999:

- a)   Two-inch sea level rise on baseline flow conditions
- b)   Two-inch sea level rise on proposed MFL conditions.
       (MFL conditions are defined as an 11% maximum withdrawal.)
- c)   Six-inch sea level rise on baseline flow conditions
- d)   Six-inch sea level rise on proposed MFL conditions
- e)   Twelve-inch sea level rise on baseline flow conditions
- f)   Twelve-inch sea level rise on proposed MFL conditions
- g)   Results of above simulations shall be briefly described in a letter report.

Task 2. Post process the results into standardized Excel spreadsheet for:

- a)   Daily volume, area and shoreline length at, or below salinity of 2 ppt, 5 ppt, 10 ppt and 15 ppt at baseline and all Task 1 simulations above. In addition, the daily location of the 2, 5, 10 and 15 ppt isohaline for all simulations in Task 1 shall be calculated. District will provide example of output required.

- b)   Post process existing baseline and 11 percent reduction scenarios for 2, 10 and 15 ppt daily average isohaline locations.

Schedule.
The CONSULTANT shall complete Tasks 1 and 2 and submit all deliverables no later than June 30, 2011.
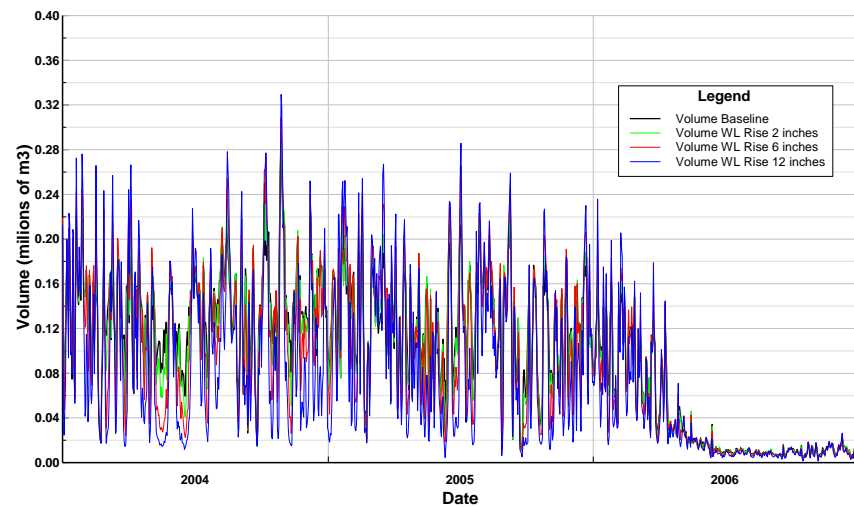
Appendix B – Time Series Plots

Figure B1 Daily volume of water: salinity range 0-2ppt, BSL flow conditions.
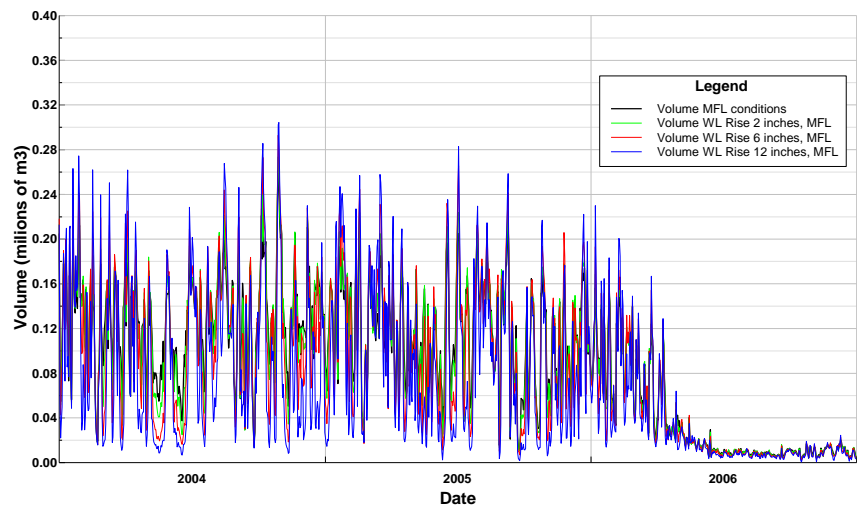

Figure B2 Daily volume of water: salinity range 0-2ppt, MFL flow conditions.
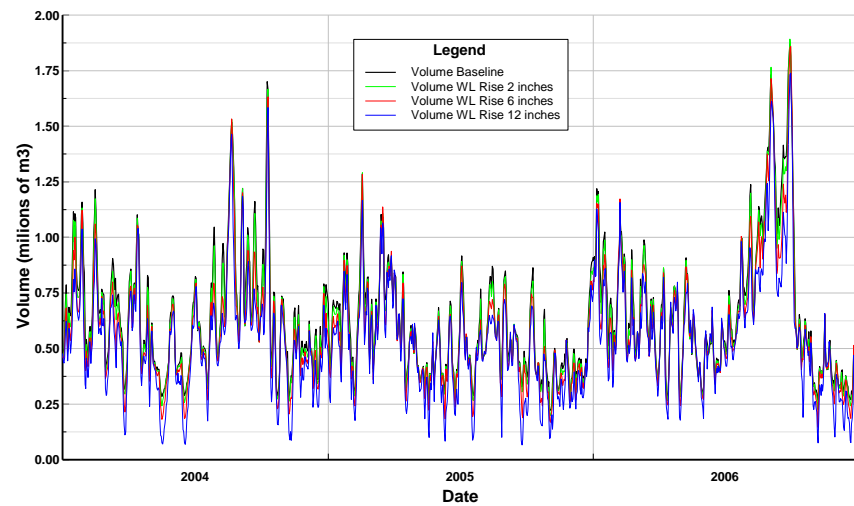

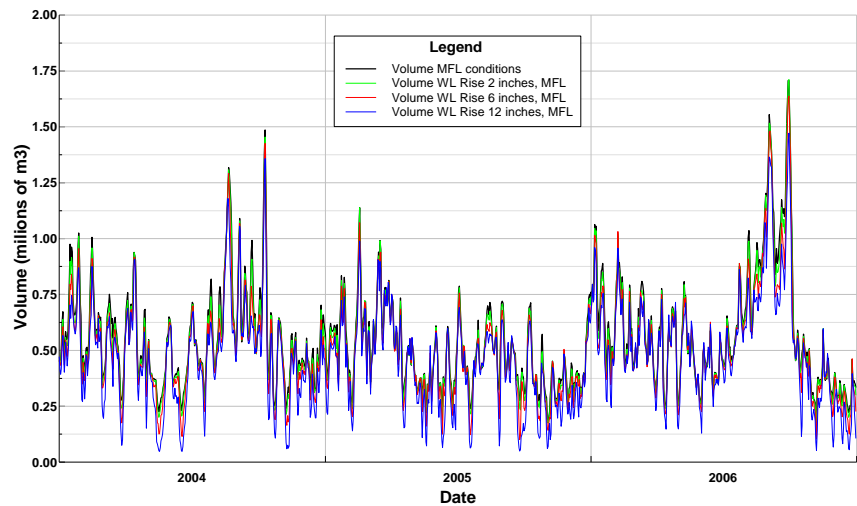Figure B3 Daily volume of water: salinity range 0-5ppt, BSL flow conditions.

Figure B4 Daily volume of water: salinity range 0-5ppt, MFL flow conditions.
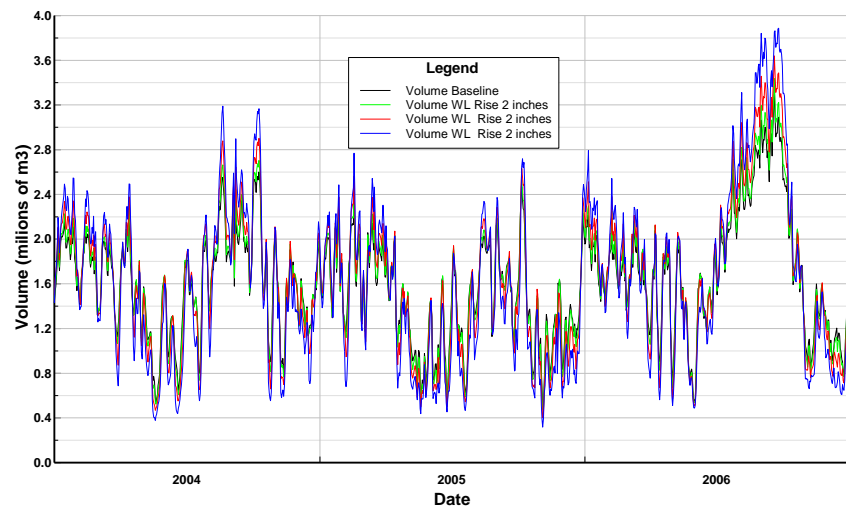
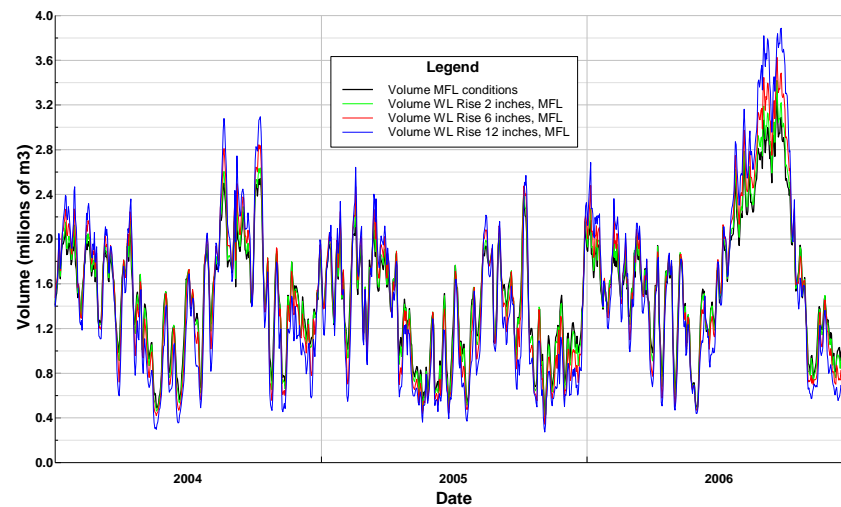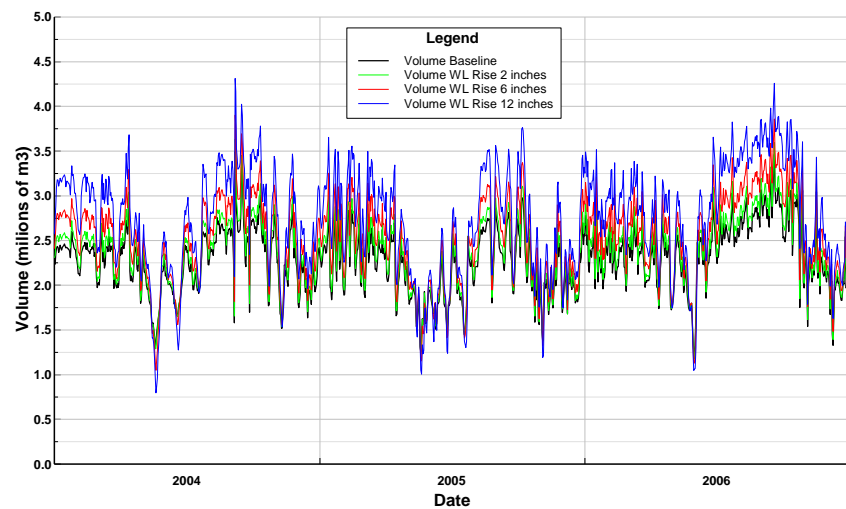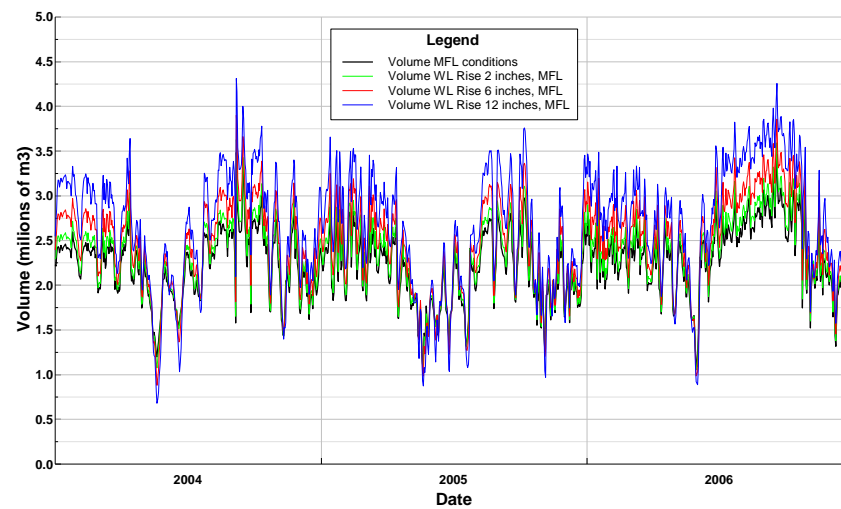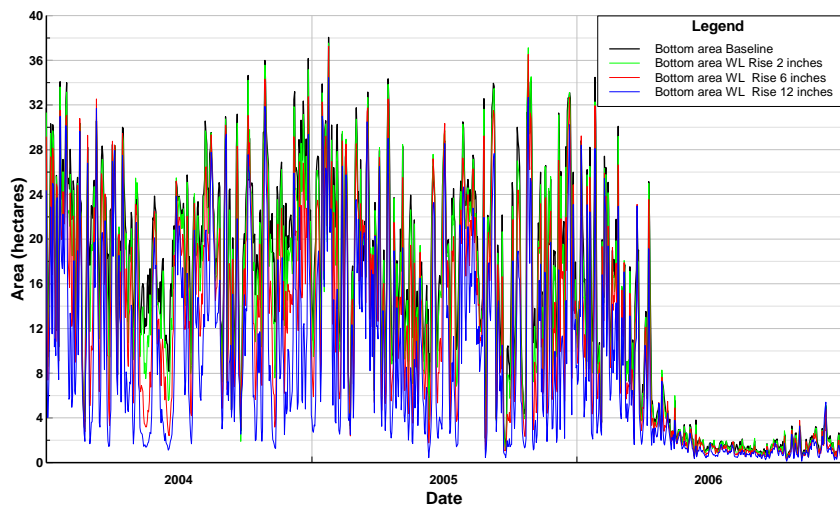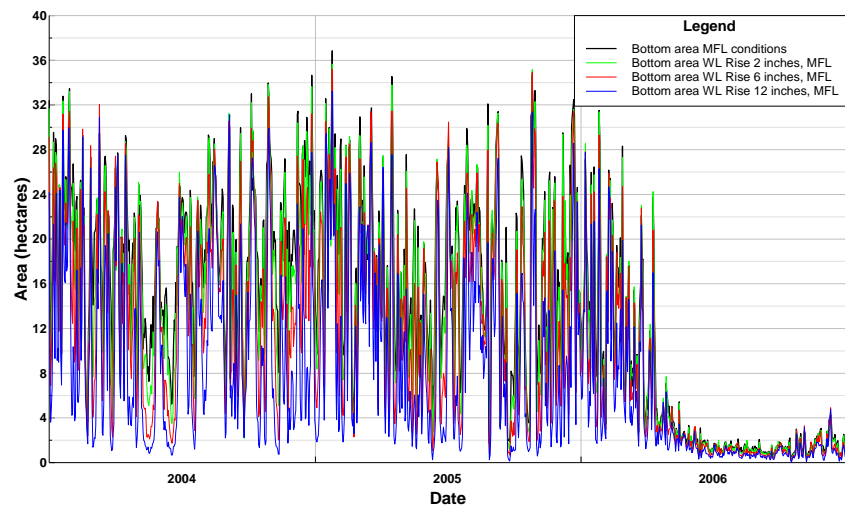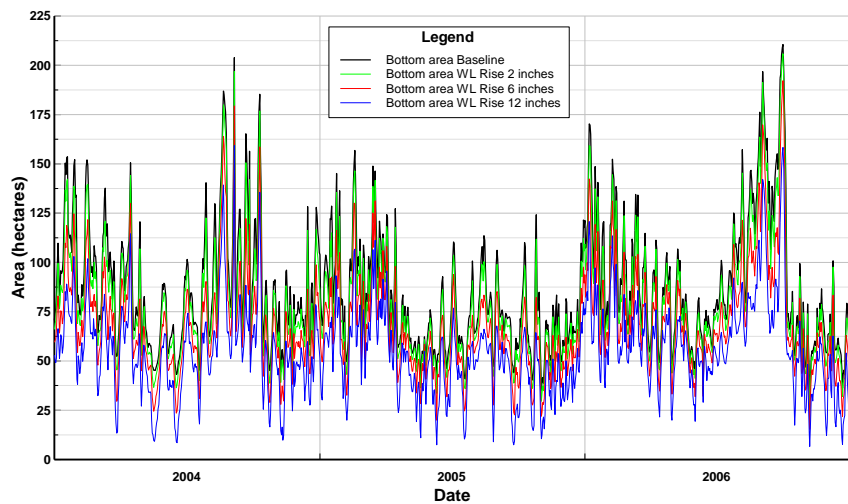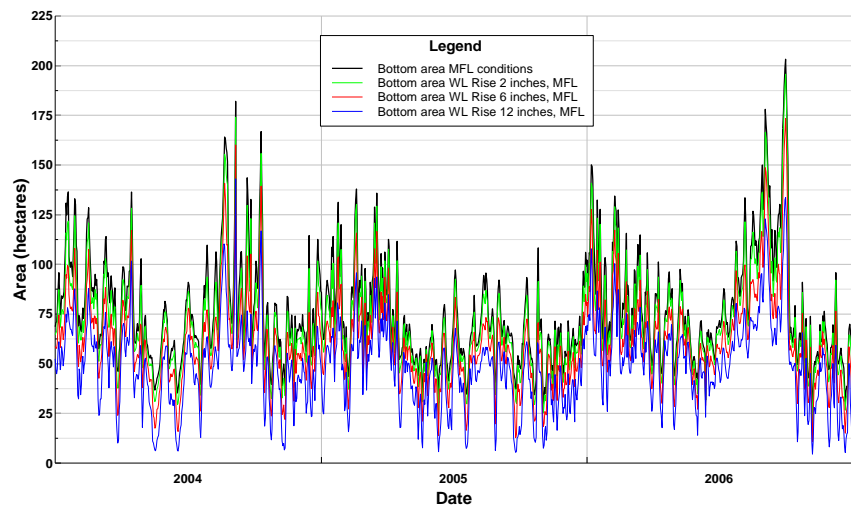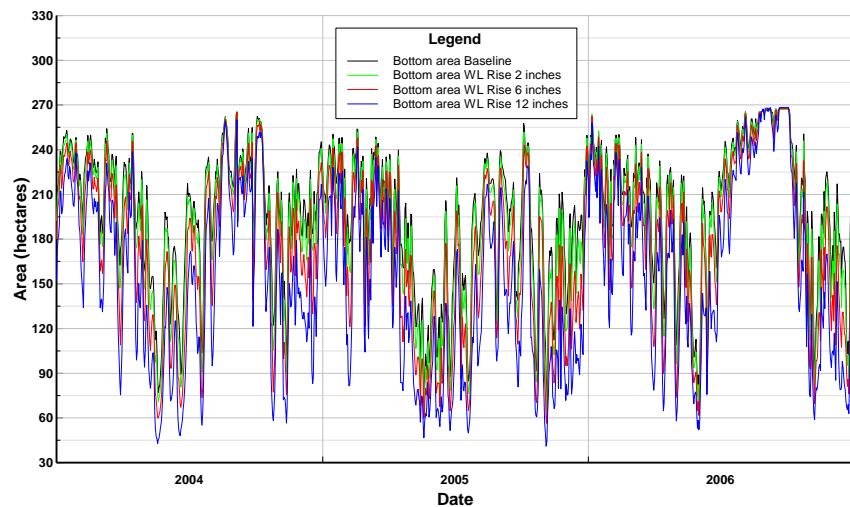Figure B5 Daily volume of water: salinity range 0-10ppt, BSL flow conditions.

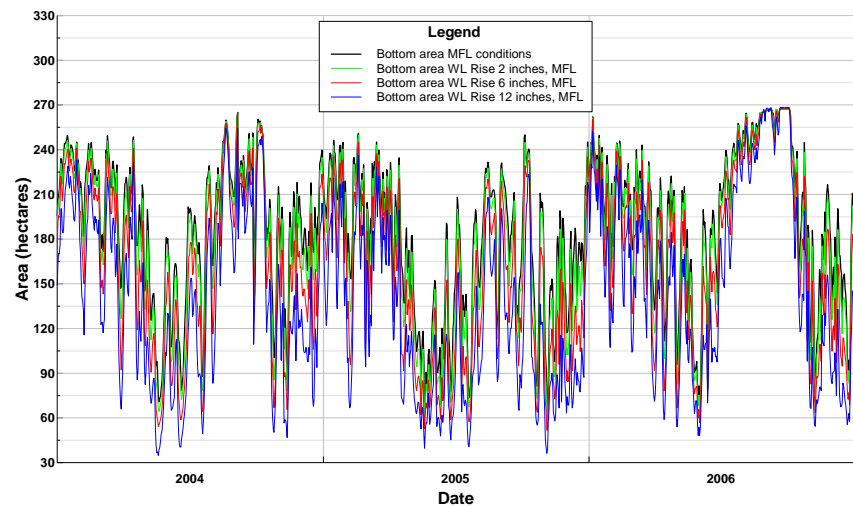Figure B6 Daily volume of water: salinity range 0-10ppt, MFL flow conditions.

Figure B7 Daily volume of water: salinity range 0-15ppt, BSL flow conditions.

Figure B8 Daily volume of water: salinity range 0-15ppt, MFL flow conditions.

Figure B9 Daily Bottom area of water: salinity range 0-2ppt, BSL flow conditions.

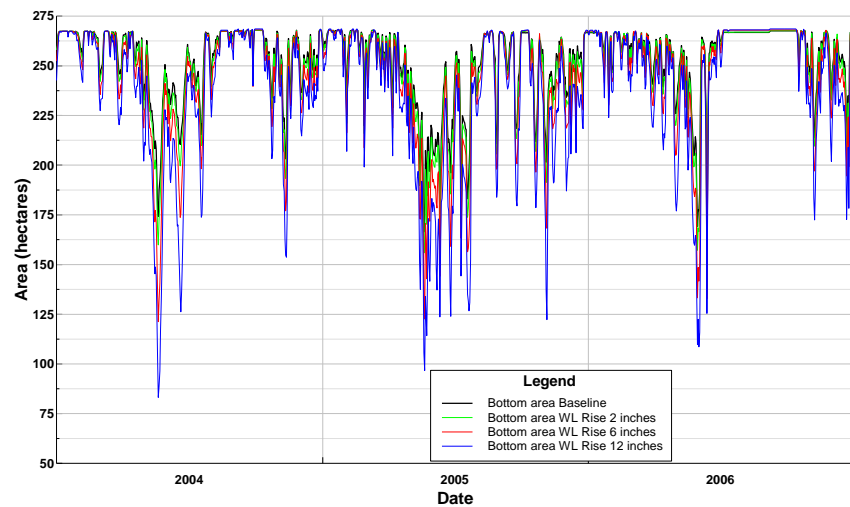Figure B10 Daily Bottom area of water: salinity range 0-2ppt, MFL flow conditions.

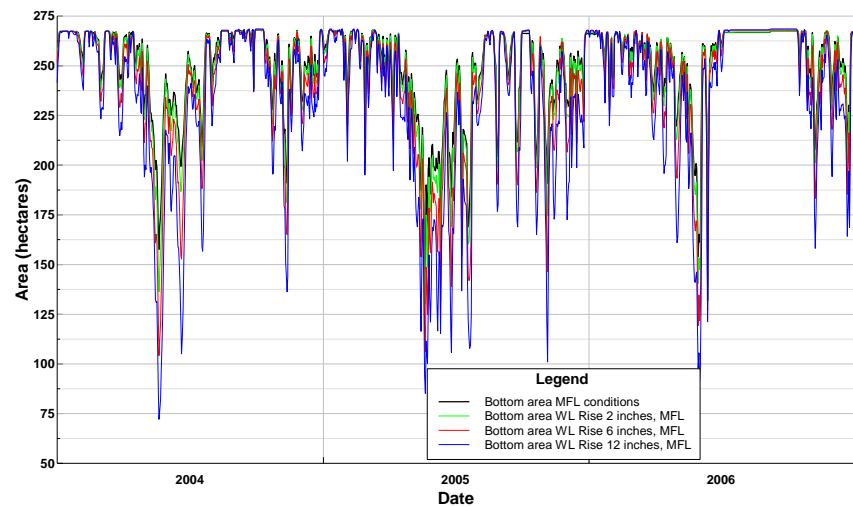Figure B11 Daily Bottom area of water: salinity range 0-5ppt, BSL flow conditions.

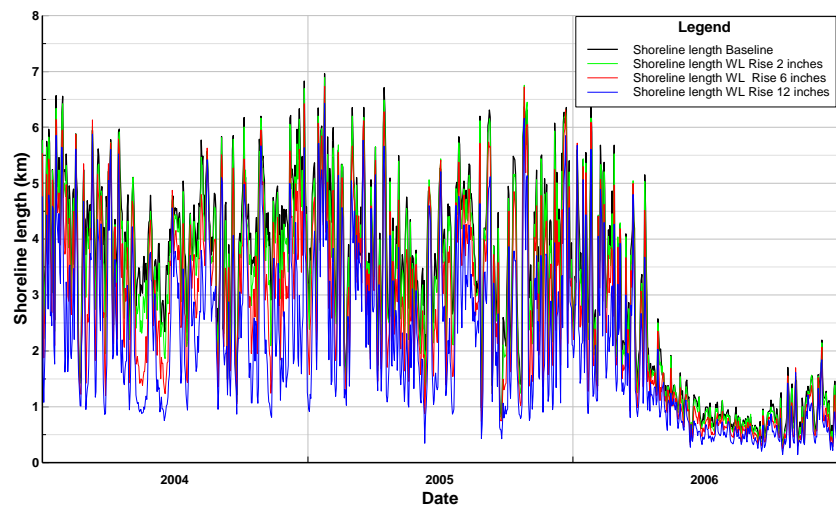Figure B12 Daily Bottom area of water: salinity range 0-5ppt, MFL flow conditions.

Figure B13 Daily Bottom area of water: salinity range 0-10ppt, BSL flow conditions.

Figure B14 Daily Bottom area of water: salinity range 0-10ppt, MFL flow conditions.

Figure B15 Daily Bottom area of water: salinity range 0-15ppt, BSL flow conditions.

Figure B16 Daily Bottom area of water: salinity range 0-15ppt, MFL flow conditions.

Figure B17 Daily shoreline length of water: salinity range 0-2ppt, BSL flow conditions.
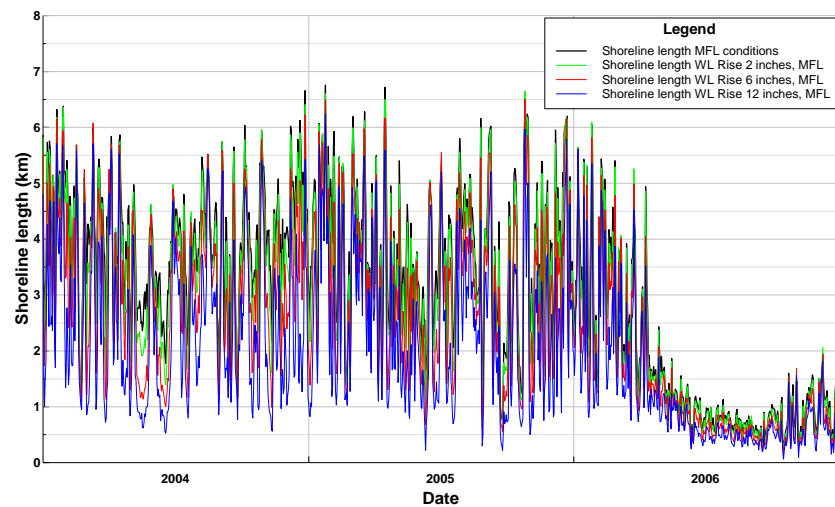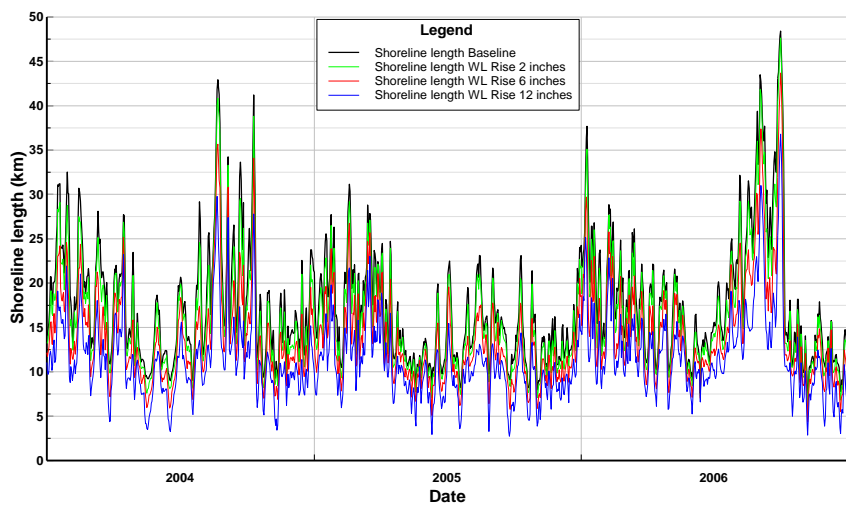

Figure B18 Daily shoreline length of water: salinity range 0-2ppt, MFL flow conditions.

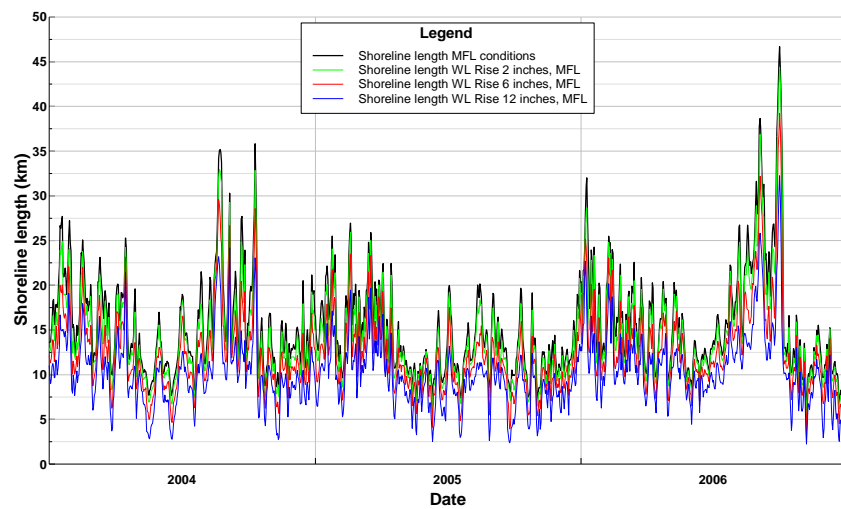Figure B19 Daily shoreline length of water: salinity range 0-5ppt, BSL flow conditions.

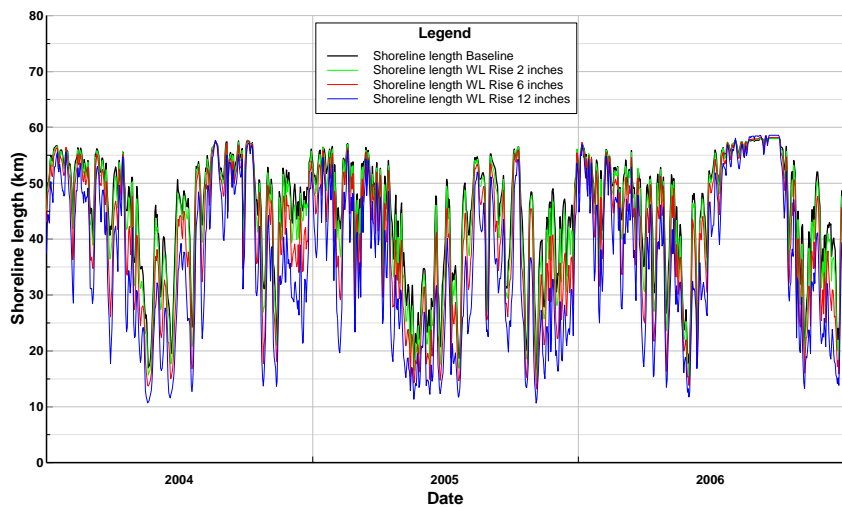Figure B20 Daily shoreline length of water: salinity range 0-5ppt, MFL flow conditions.

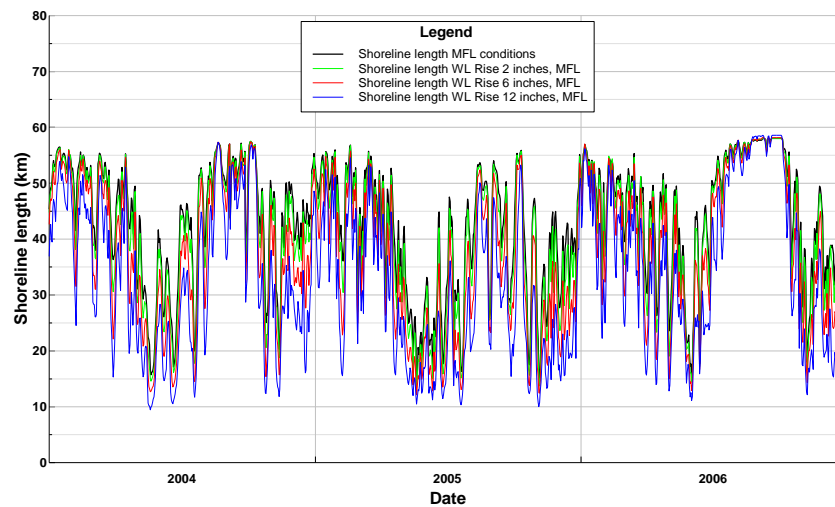Figure B21 Daily shoreline length of water: salinity range 0-10ppt, BSL flow conditions.

Figure B22 Daily shoreline length of water: salinity range 0-10ppt, MFL flow conditions.
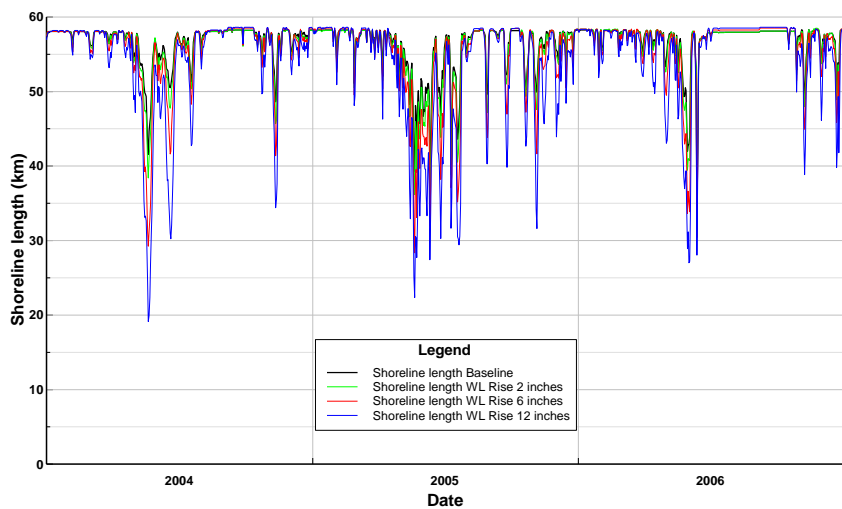

Figure B23 Daily shoreline length of water: salinity range 0-15ppt, BSL flow conditions.
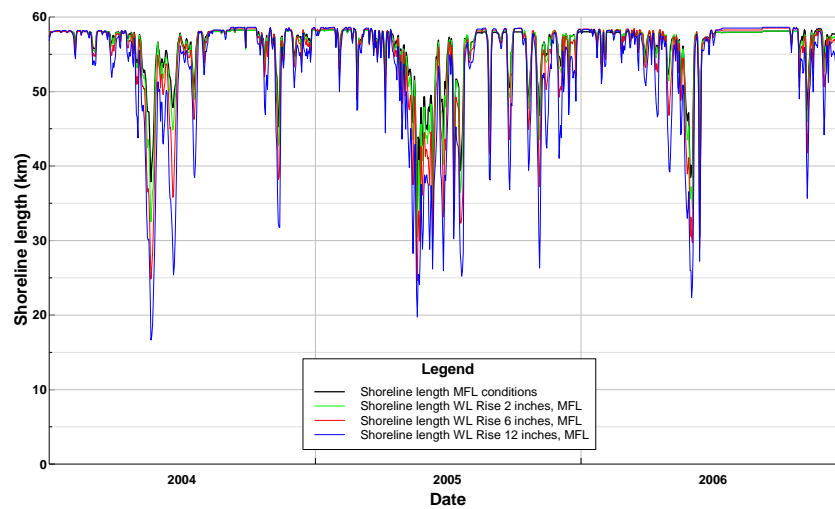

Figure B24 Daily shoreline length of water: salinity range 0-15ppt, MFL flow conditions.
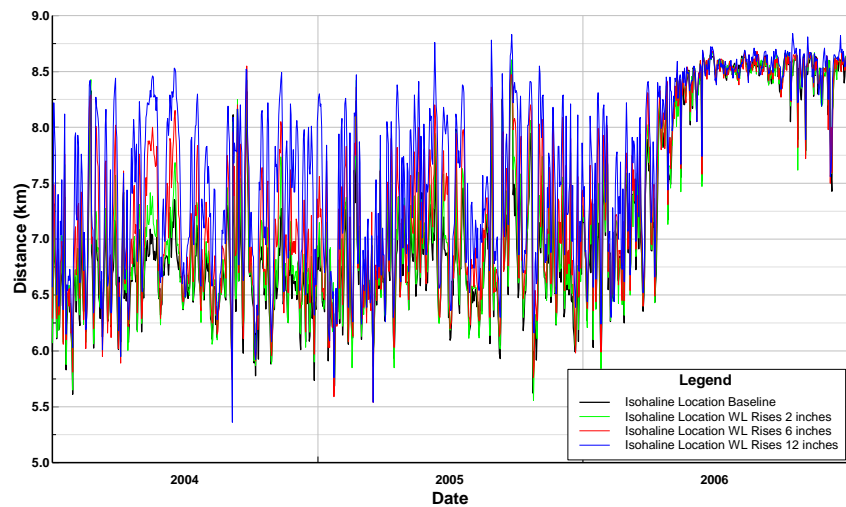
Figure B25 Daily isohaline location of water: salinity range 0-2ppt, BSL flow conditions.
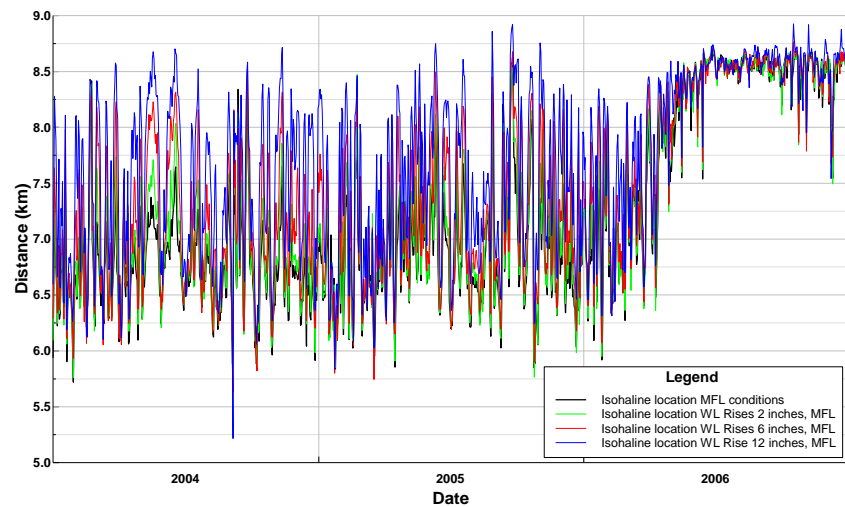

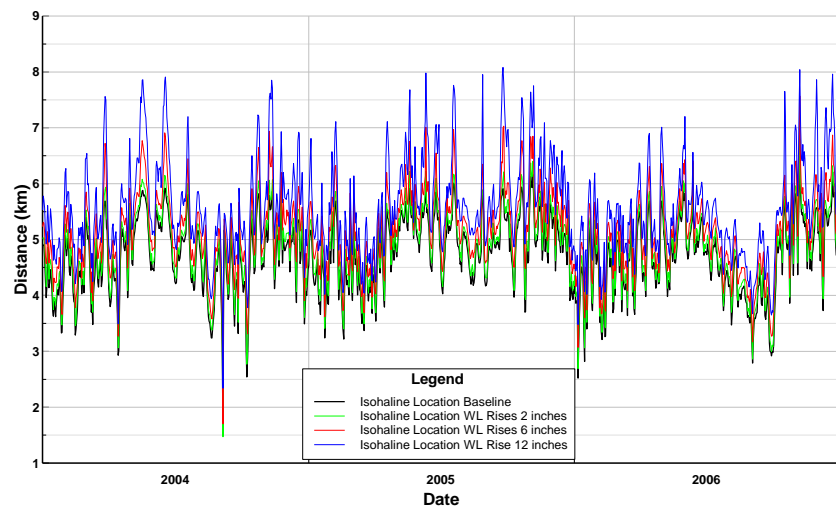Figure B26 Daily isohaline location of water: salinity range 0-2ppt, MFL flow conditions.

Figure B27 Daily isohaline location of water: salinity range 0-5ppt, BSL flow conditions.
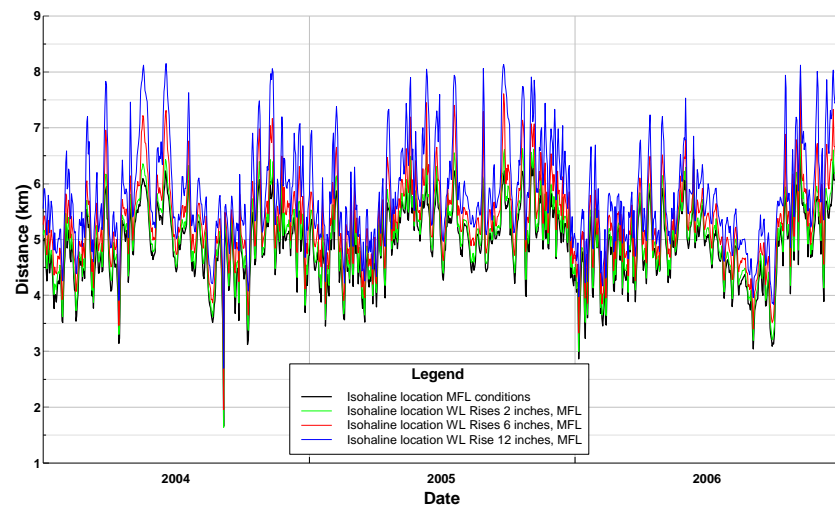

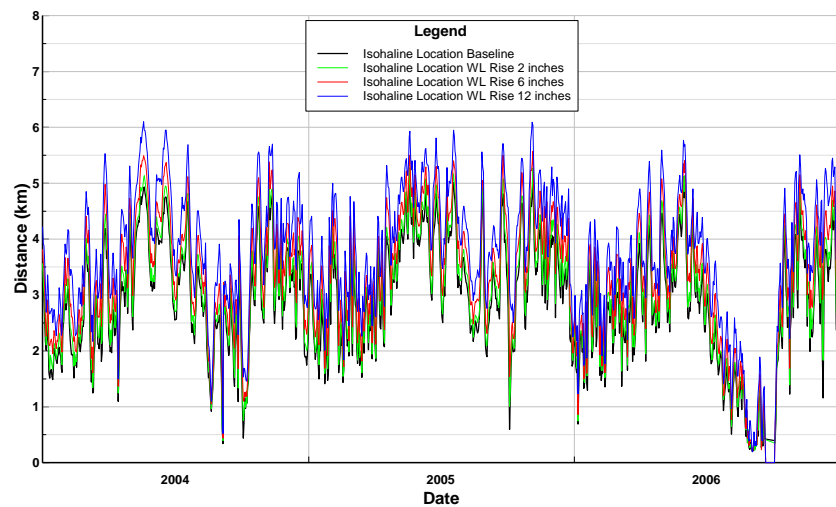Figure B28 Daily isohaline location of water: salinity range 0-5ppt, MFL flow conditions.

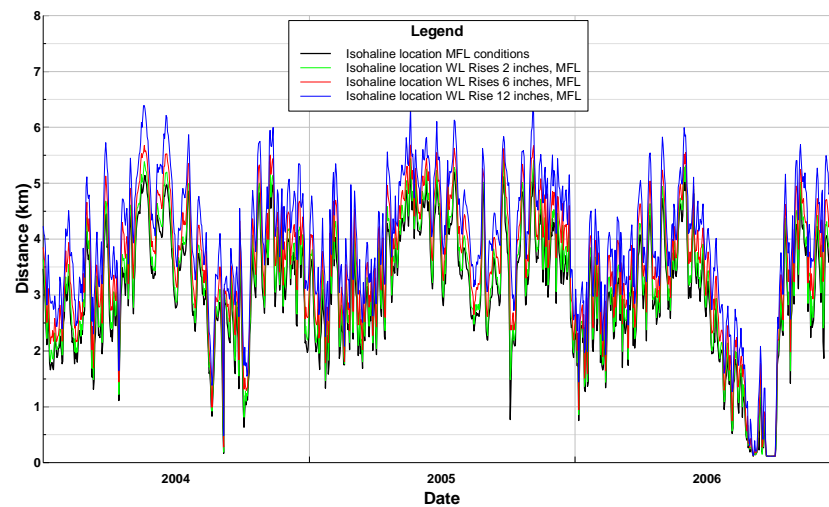Figure B29 Daily isohaline location of water: salinity range 0-10ppt, BSL flow conditions.

Figure B30 Daily isohaline location of water: salinity range 0-10ppt, MFL flow conditions.
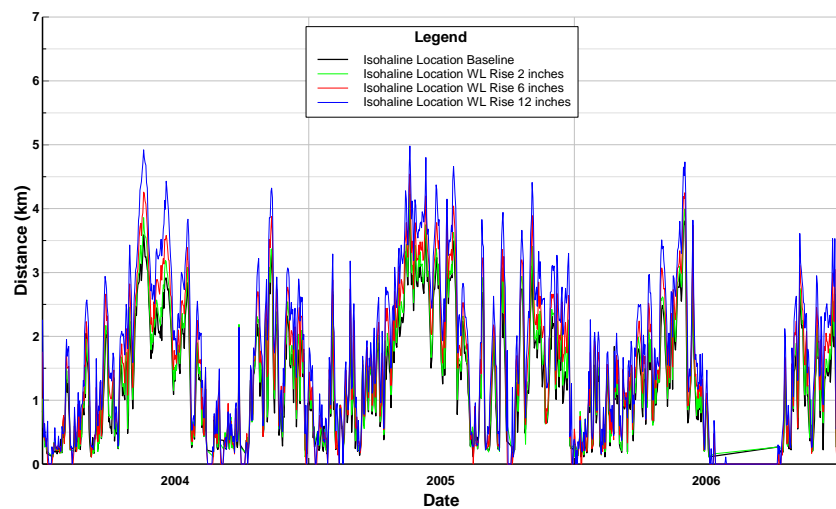

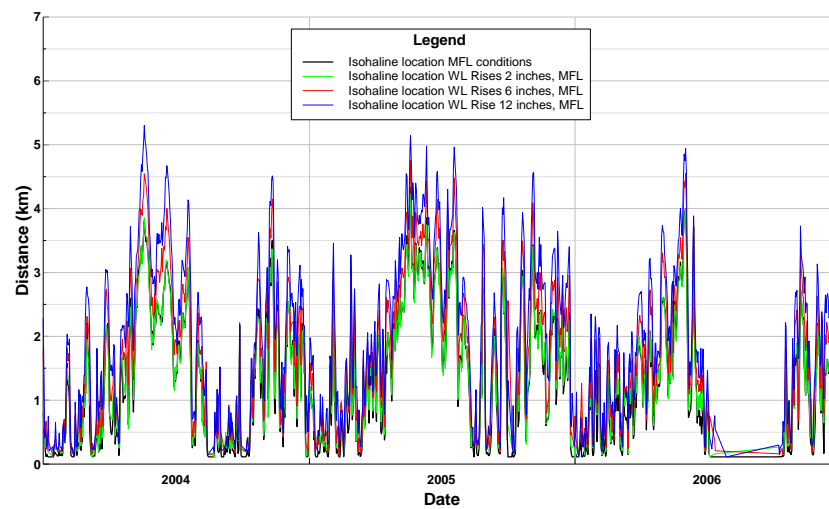Figure B31 Daily isohaline location of water: salinity range 0-15ppt, BSL flow conditions.

Figure B32 Daily isohaline location of water: salinity range 0-15ppt, MFL flow conditions.