

Sea Level Rise Simulations of the Chassahowitzka River-Part Five

for

**Southwest Florida Water Management District
Under PO 07PO0001577**

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Table of Contents

1	Introduction	1
2	Scenarios of Rise in Water Level.....	1
3	Salinity Habitat Criteria	2
3.1	Current Sea Level Condition	2
3.1.1	Total Water Volume.....	3
3.1.2	Bottom Area	4
3.1.3	Shoreline Length	5
3.1.4	Isohaline RK Location	6
3.2	2.0 Inch SLR and Flow Reduction	7
3.2.1	Total Volume	7
3.2.2	Bottom Area	8
3.2.3	Shoreline Length	9
3.2.4	Isohaline RK Location	10
3.3	3.4 inch SLR and flow reduction	11
3.3.1	Total Volume	11
3.3.2	Bottom Area	12
3.3.3	Shoreline Length	13
3.3.4	Isohaline RK Location	14
3.4	7.7 inch SLR and flow reduction	15
3.4.1	Total Volume	15
3.4.2	Bottom Area	16
3.4.3	Shoreline length	17
3.4.4	Isohaline RK location.....	18
4	AUC Analysis.....	18
5	15% Loss Flow Reduction Estimates	24
6	Conclusions and Limitations	26
7	References	28

Appendix A – Scope of Work

Appendix B – Complete Model Plots

List of Tables

Table 1	Normalized Area under the CDF Curve (AUC)	23
Table 2	AUC and flow reduction trend relation.	25
Table 3	Flow Reductions based on a 15% loss of volume, area or shoreline length for the salinity ranges.....	26

List of Figures

Figure 1	Volumetric analysis CDF's: Current sea level.....	3
Figure 2	Bottom area analysis CDF's: Current sea level.	4
Figure 3	Shoreline length analysis CDF's: Current sea level.....	5
Figure 4	Isohaline location analysis CDF's: Current sea level.	6
Figure 5	Volumetric analysis CDF's: SLR 2.0 inches	7
Figure 6	Bottom area analysis CDF's: SLR 2.0 inches.....	8
Figure 7	Shoreline length analysis CDF's: SLR 2.0 inches.	9
Figure 8	Isohaline location analysis CDF's: SLR 2.0 inches.....	10
Figure 9	Volumetric analysis CDF's: SLR 3.4 inches	11
Figure 10	Bottom area analysis CDF's: SLR 3.4 inches.....	12
Figure 11	Shoreline length analysis CDF's: SLR 3.4 inches.	13
Figure 12	Isohaline location analysis CDF's: SLR 3.4 inches.....	14
Figure 13	Volumetric analysis CDF's: SLR 7.7 inches	15
Figure 14	Bottom area analysis CDF's: SLR 7.7 inches.....	16
Figure 15	Shoreline length analysis CDF's: SLR 7.7 inches.	17
Figure 16	Isohaline location analysis CDF's: SLR 7.7 inches.....	18
Figure 17	Summary of volume AUC analysis.	19
Figure 18	Summary of bottom area AUC analysis.....	20
Figure 19	Summary of shoreline length AUC analysis	21
Figure 20	Summary of isohaline location AUC analysis	22

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 Five

which is pre-qualified under PO 07PO0001577-5. See Appendix A for the detailed Scope of Work.

2 Scenarios of Rise in Water Level

Sea level rise is one of the potential impacts caused by climate change in South Florida. Sea level rise may change the salinity in the coastal bay, the intrusion into river system, and consequently, the natural habitat in the area. The District has chosen to evaluate a range of sea level rise (SLR) scenarios for several of the Springs Coast estuaries including the Chassahowitzka River. The basic approach was to assign a range of sea level rises and flow reduction. An EFDC hydrodynamic model was developed for the initial Minimum Flows and Levels (MFL) work (DSLLC 2009) which simulated the period of 2004-2006. This model was chosen as the baseline condition to evaluate the impact of sea level rise and flow reduction on the salinity habitat of the Chassahowitzka river system.

SLR scenarios for 2030 are taken from a) extrapolation of regional historic records (2.0 inch), b) USACOE¹ recommended NRC modified Curve I (3.4 inches) and c) USACOE recommended NRC modified Curve III (7.7 inches). The water levels at the seawater boundary condition were adjusted from the baseline model and a reduction in the fresh water spring discharges was included to establish the following 16 scenarios:

- Baseline sea level and flow condition
- Current sea level using base flows reduced 5%
- Current sea level using base flows reduced 10%
- Current sea level using base flows reduced 15%

- 2.0 inch SLR using baseline flows conditions
- 2.0 inch SLR using baseline flows reduced 5%
- 2.0 inch SLR using baseline flows reduced 10%
- 2.0 inch SLR using baseline flows reduced 15%

- 3.4 inch SLR using baseline flow conditions
- 3.4 inch SLR using baseline flows reduced 5%

¹ USACOE Sea Level Rise Circular No. 1165-2-211.



- 3.4 inch SLR using baseline flows reduced 10%
- 3.4 inch SLR using baseline flows reduced 15%

- 7.7 inch SLR using baseline flow conditions
- 7.7 inch SLR using baseline flows reduced 5%
- 7.7 inch SLR using baseline flows reduced 10%
- 7.7 inch SLR using baseline flows reduced 15%

The impacts of the SLR and flow reduction on salinity habitat were analyzed based on calculated results.

3 Salinity Habitat Criteria

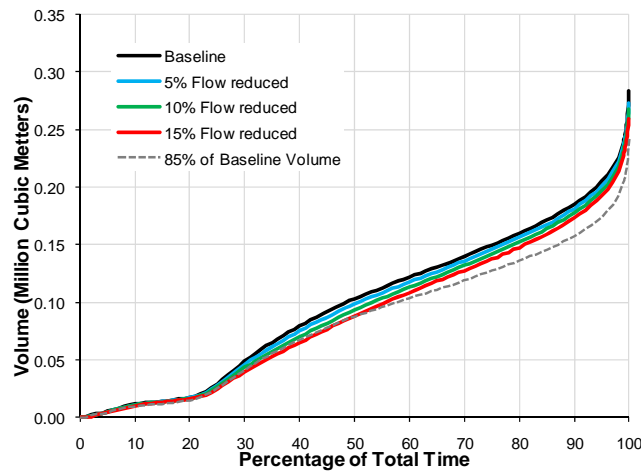
Similar to the approach described in the Section 7 of the main report (DSLLC 2009), for each of the scenarios listed above, the water volume, bottom area, shoreline length, and isohaline river kilometer (RK) locations were computed for the conditions where the depth-averaged salinities were below 2 ppt, 5 ppt, 10 ppt, and 15 ppt. For these analyses, the scenarios were grouped based on the current and projected sea level rises at the ocean boundary for the Chassahowitzka System. Within each sea level condition group, the spring discharges were varied from no reduction (i.e. "Baseline") to a 15% reduction, in 5% increments. These data were then used to build the Cumulative Distribution Functions (CDF's) for assessments of the available habitat criteria.

3.1 Current Sea Level Condition

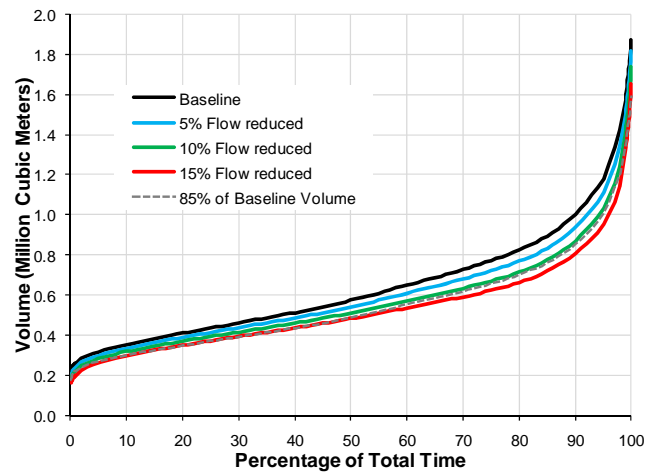
Under the current sea level conditions, CDF plots of the total volume, bottom area, shoreline length, and isohaline RK location of the water for the various salinity ranges were computed and are shown in Figures **Figure 1** to 4. As the spring flow decreases, the respective salinity habitat criteria is also reduced. The 0-15 ppt salinity range criteria is the least affected habitat.



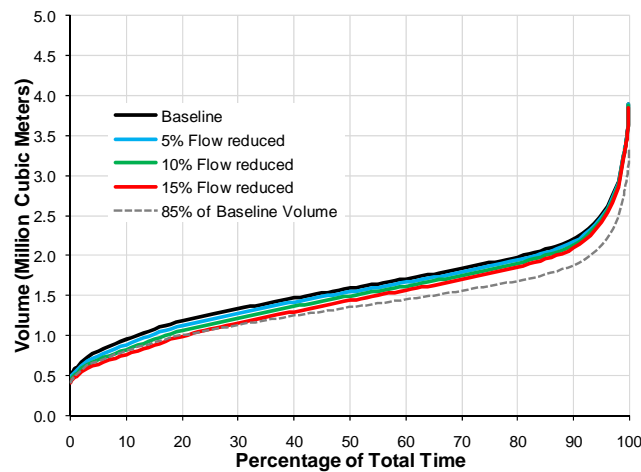
3.1.1 Total Water Volume



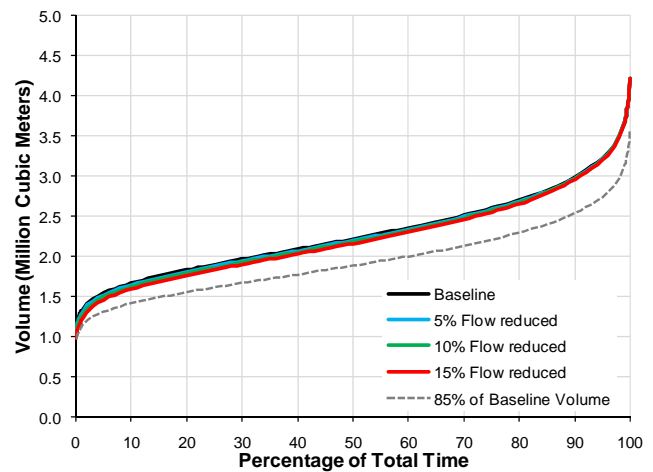
(a) Salinity range 0 to 2 ppt



(b) Salinity range 0 to 5 ppt



(c) Salinity range 0 to 10 ppt

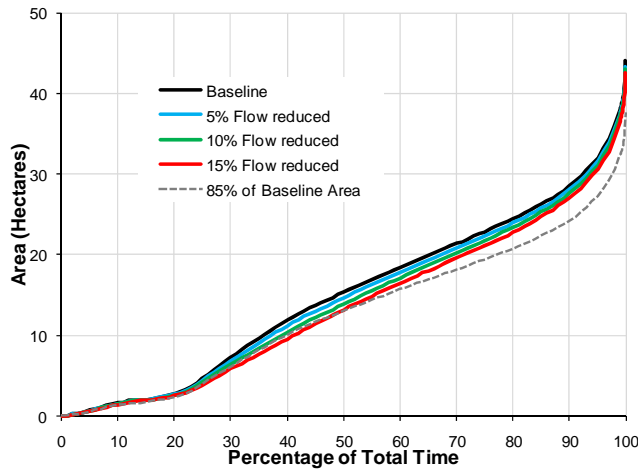


(d) Salinity range 0 to 15 ppt

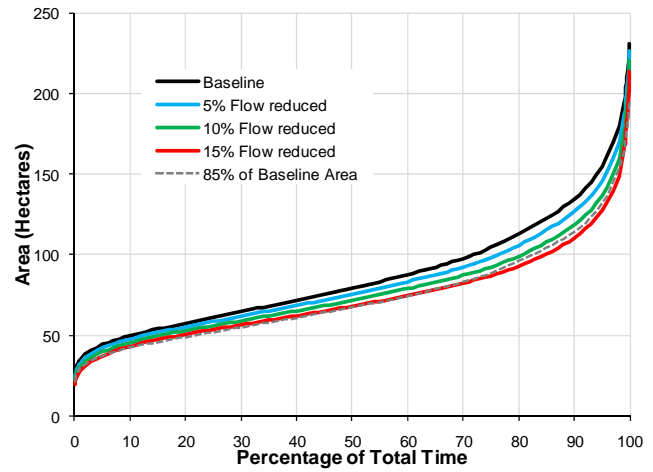
Figure 1 Volumetric analysis CDF's: Current sea level



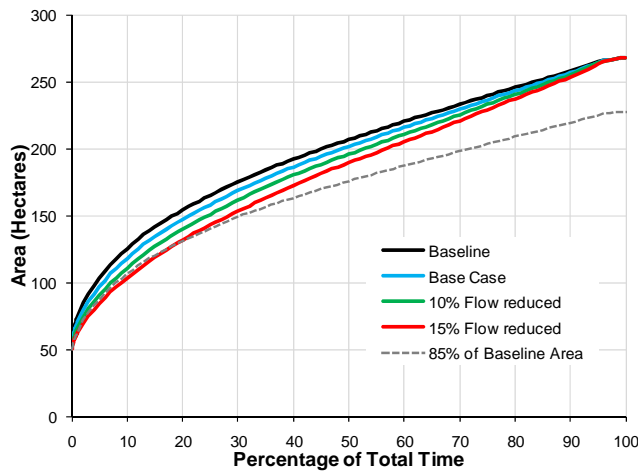
3.1.2 Bottom Area



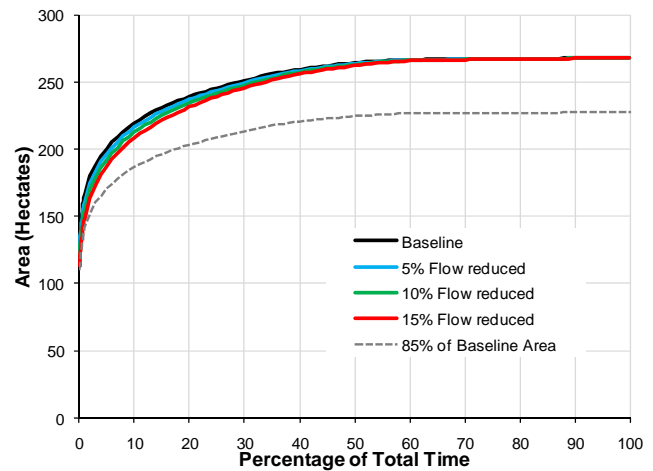
(a) Salinity range 0 to 2 ppt



(b) Salinity range 0 to 5 ppt



(c) Salinity range 0 to 10 ppt

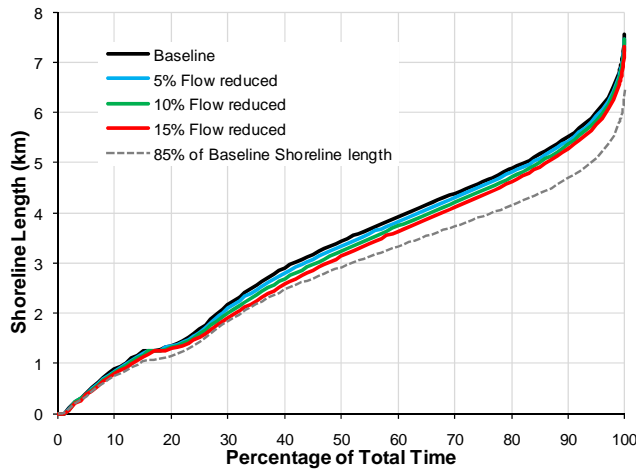


(d) Salinity range 0 to 15 ppt

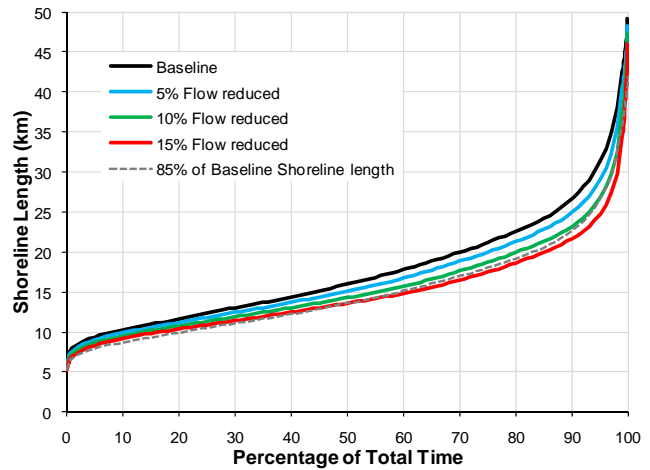
Figure 2 Bottom area analysis CDF's: Current sea level.



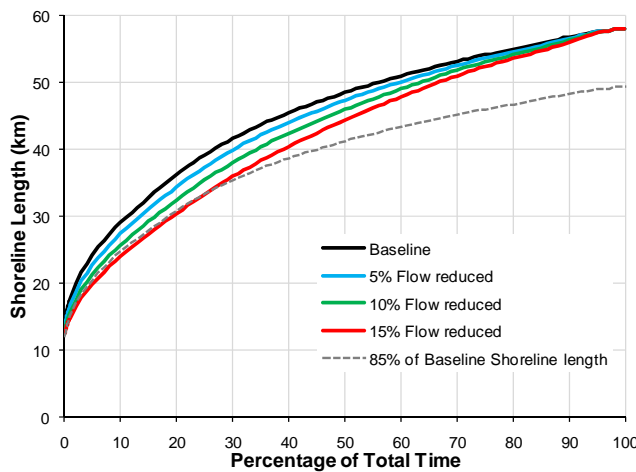
3.1.3 Shoreline Length



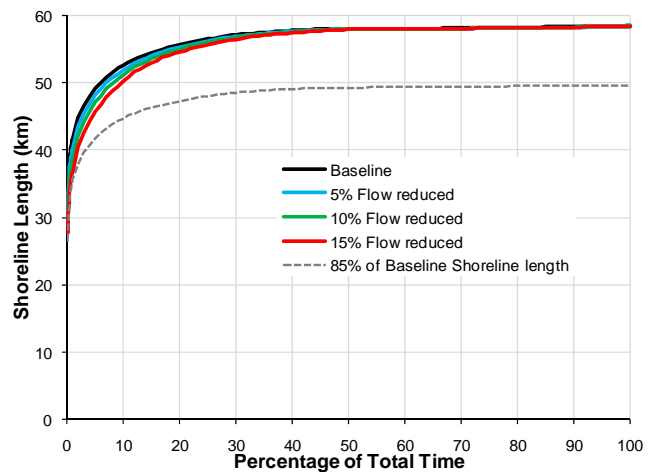
(a) Salinity range 0 to 2 ppt



(b) Salinity range 0 to 5 ppt



(c) Salinity range 0 to 10 ppt



(d) Salinity range 0 to 15 ppt

Figure 3 Shoreline length analysis CDF's: Current sea level.



3.1.4 Isohaline RK Location

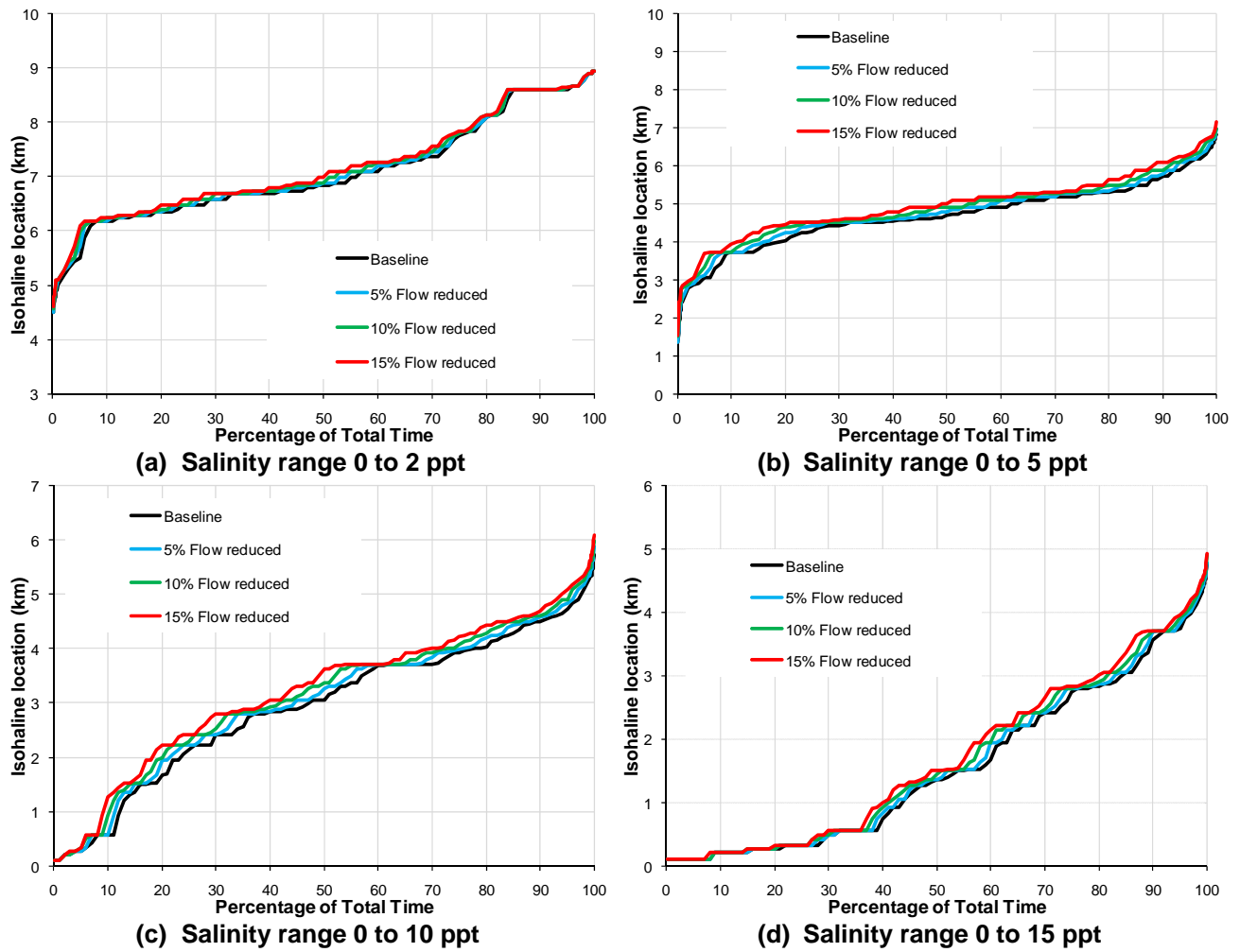


Figure 4 Isohaline location analysis CDF's: Current sea level.



3.2 2.0 Inch SLR and Flow Reduction

The CDF curves for the case of the 2.0 inch SLR for the various habit criteria are shown in Figure 5 to Figure 8. As with the base flow case, as the spring flow decreases, the respective salinity habit criteria is also reduced. Compared to the current sea level cases, the 2 inch SLR has a weak but noticeable impact on the salinity habitats.

3.2.1 Total Volume

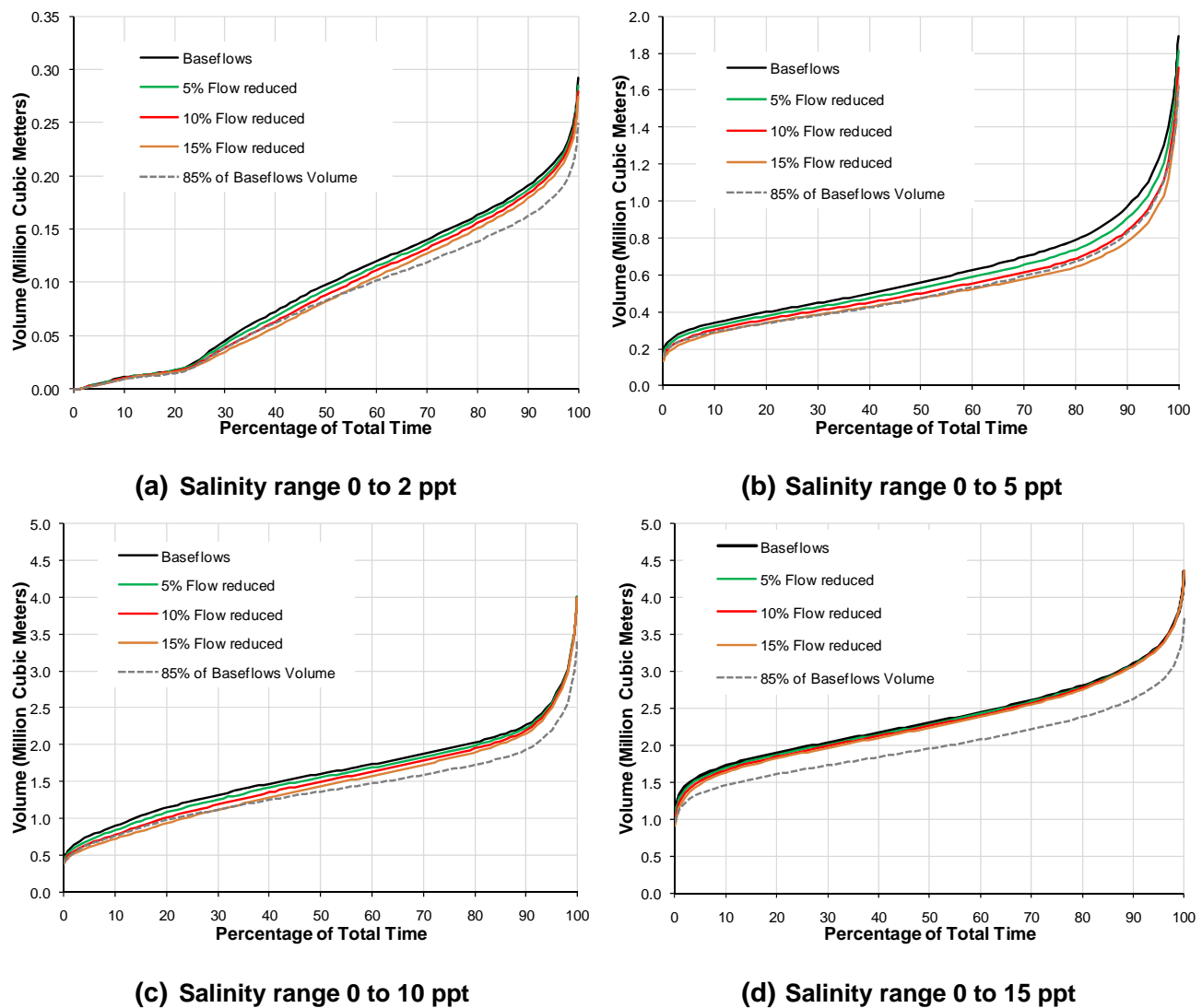


Figure 5 Volumetric analysis CDF's: SLR 2.0 inches



3.2.2 Bottom Area

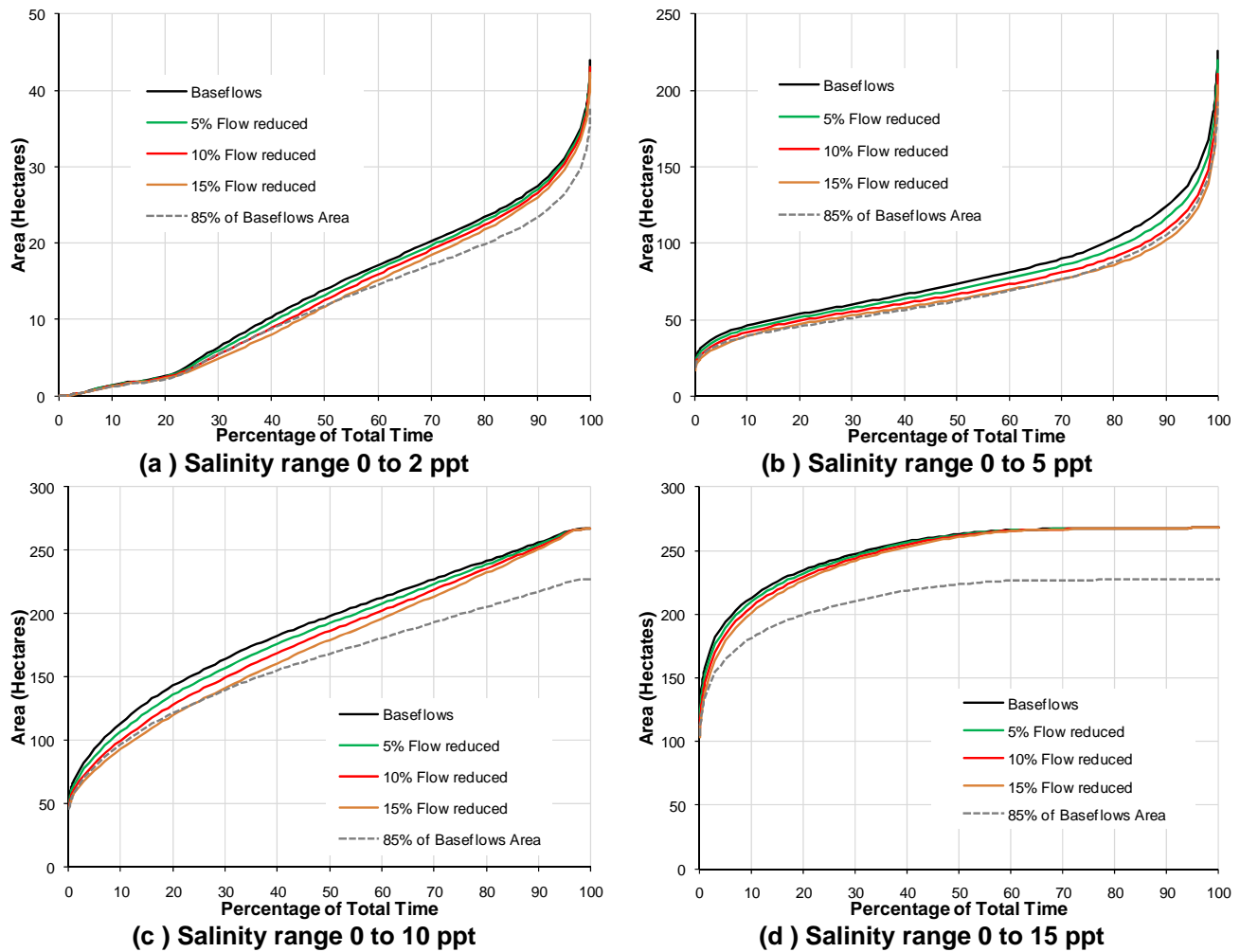
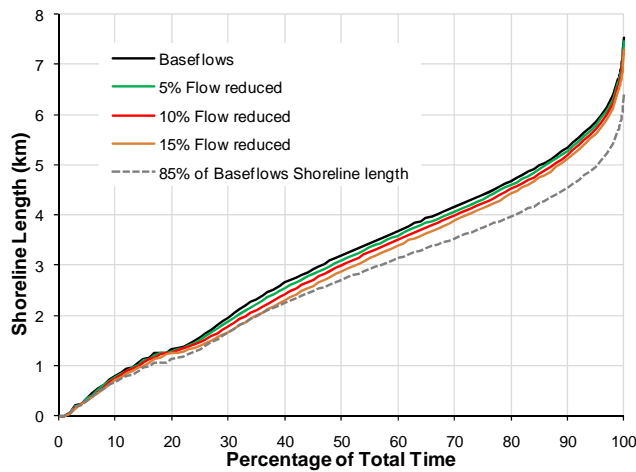


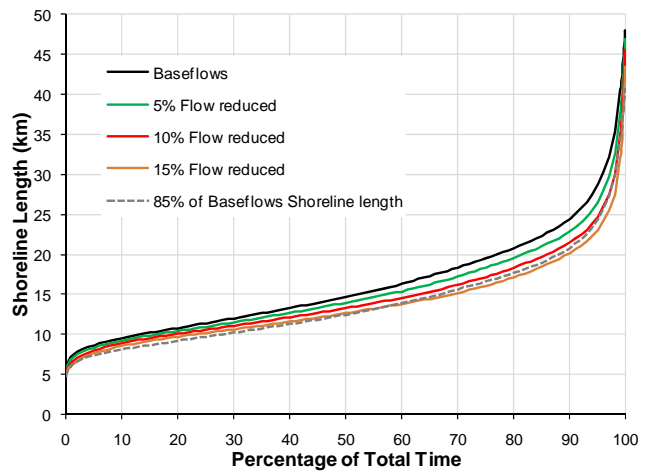
Figure 6 Bottom area analysis CDF's: SLR 2.0 inches.



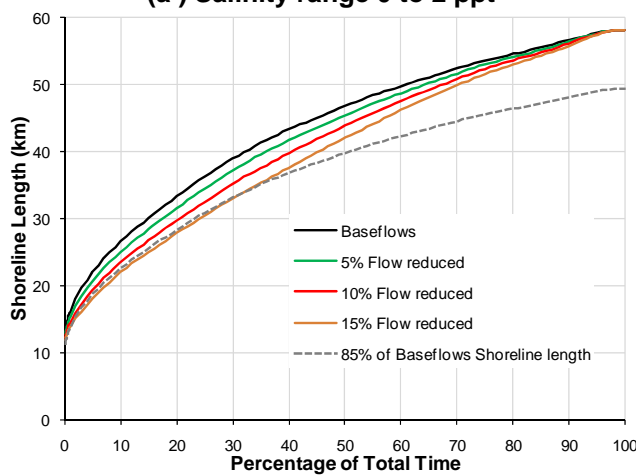
3.2.3 Shoreline Length



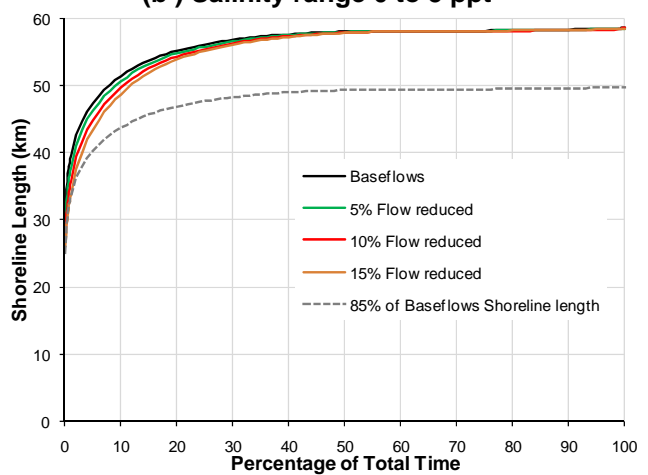
(a) Salinity range 0 to 2 ppt



(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: SLR 2.0 inches.



3.2.4 Isohaline RK Location

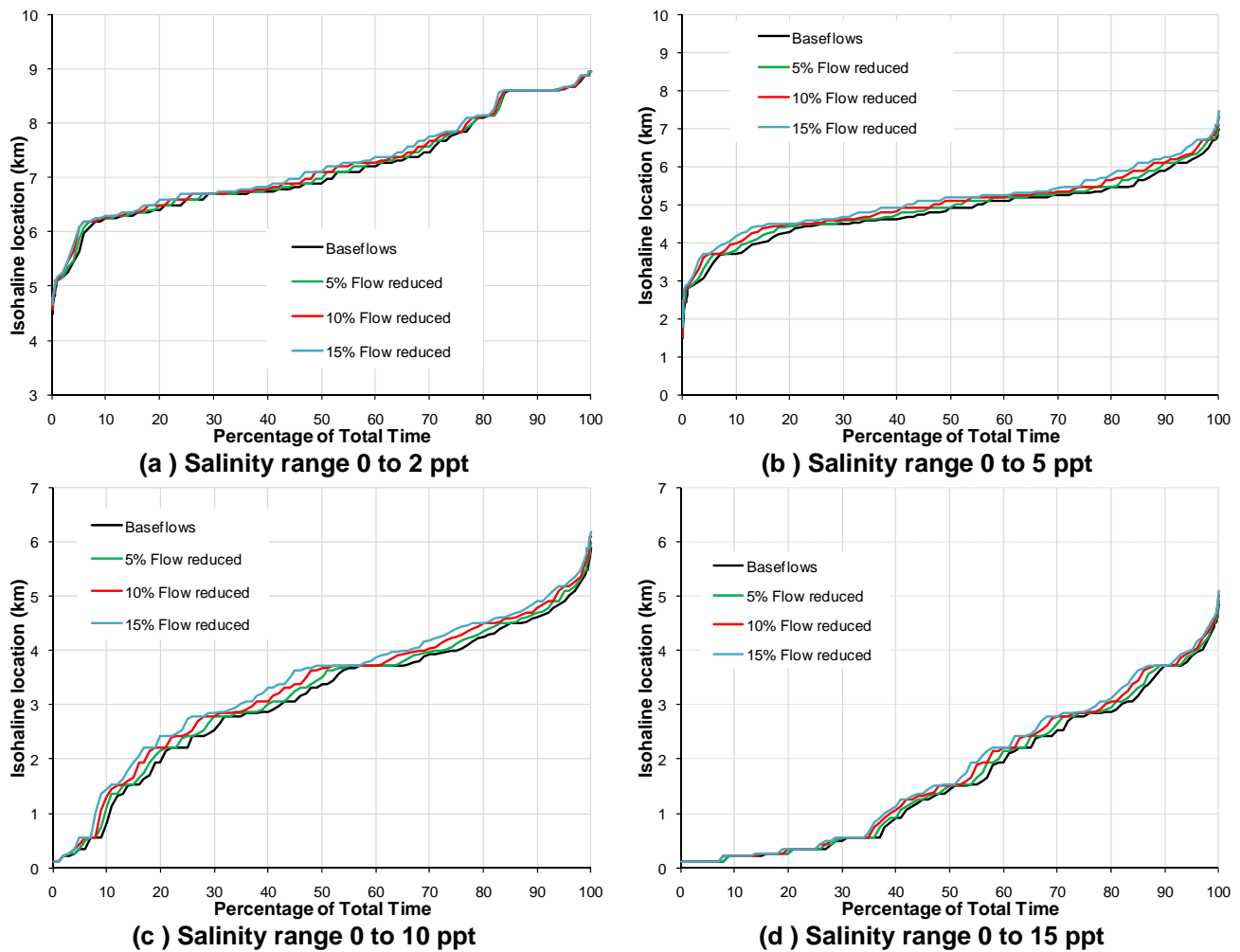


Figure 8 Isohaline location analysis CDF's: SLR 2.0 inches.



3.3 3.4 inch SLR and flow reduction

The CDF curves for the case of the 3.4 inch SLR for the various habit criteria are shown in Figure 9 to Figure 12. Under this SLR condition, the low salinity (0-2 and 0-5 ppt) habitat criteria metrics are significantly reduced, as compared with the baseline case. The volume of water with low concentration salinities is significantly reduced while the volume of water of 0-15 ppt is increased. The increase of the high salinity water is in part due to the increase of total volume of water as well as more sea water intrusion into the system under the higher sea level.

3.3.1 Total Volume

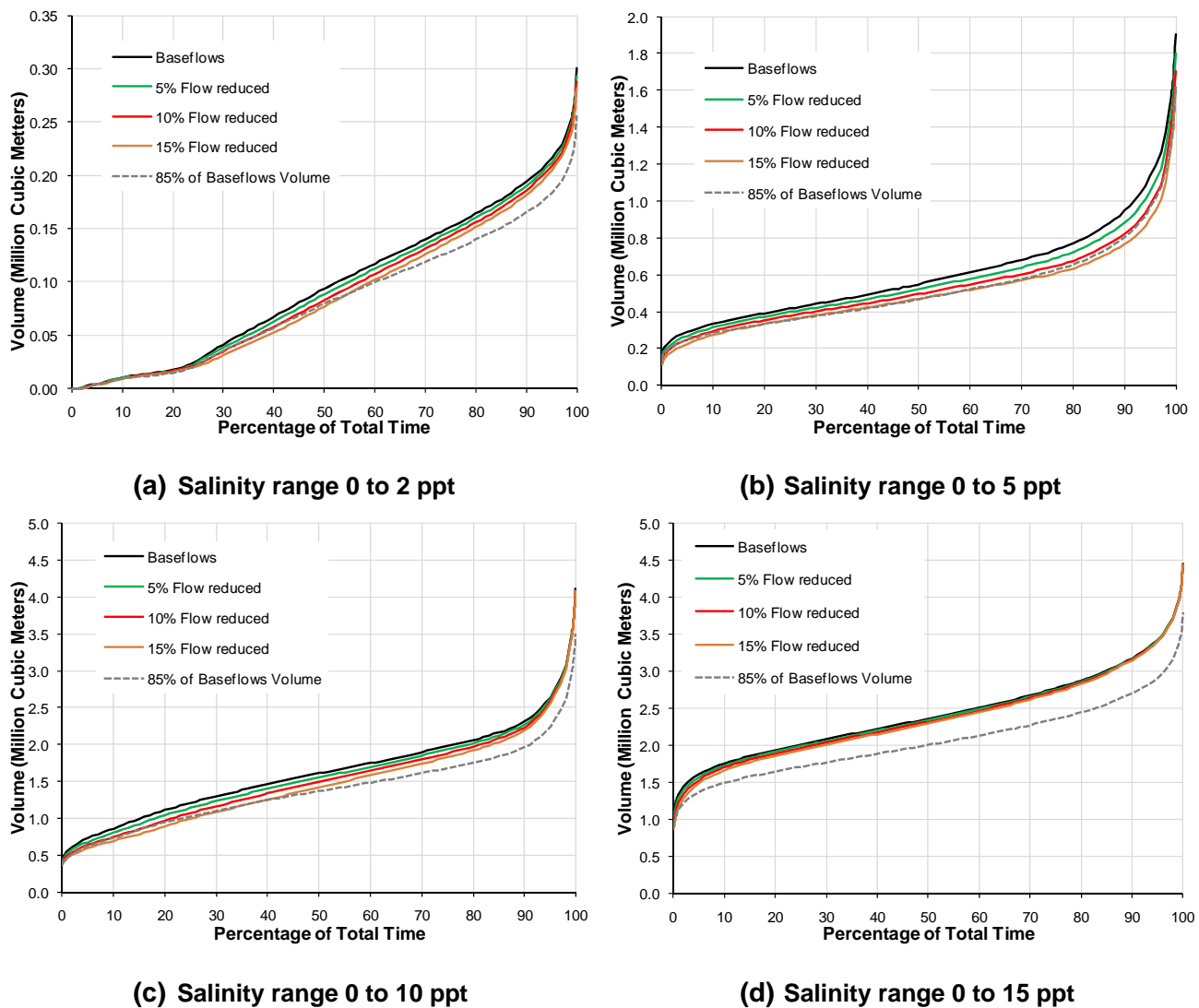


Figure 9 Volumetric analysis CDF's: SLR 3.4 inches



3.3.2 Bottom Area

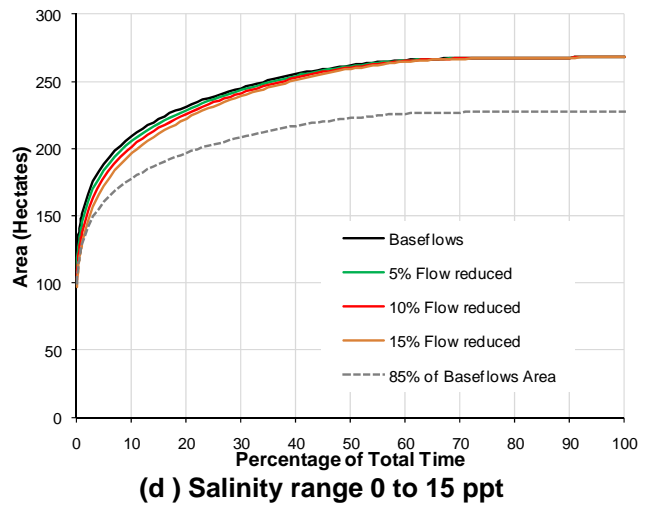
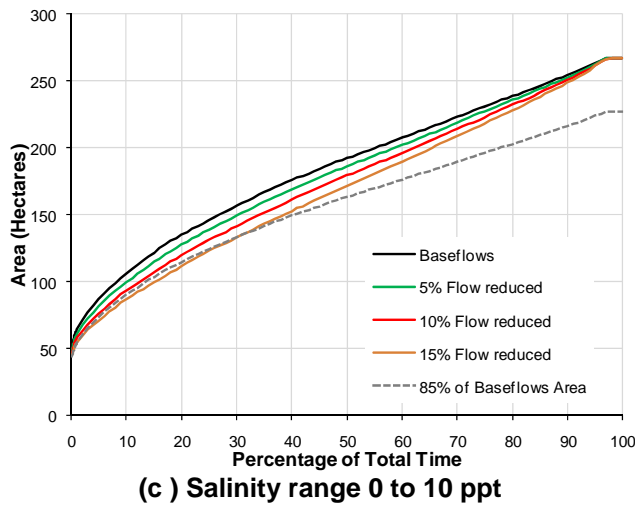
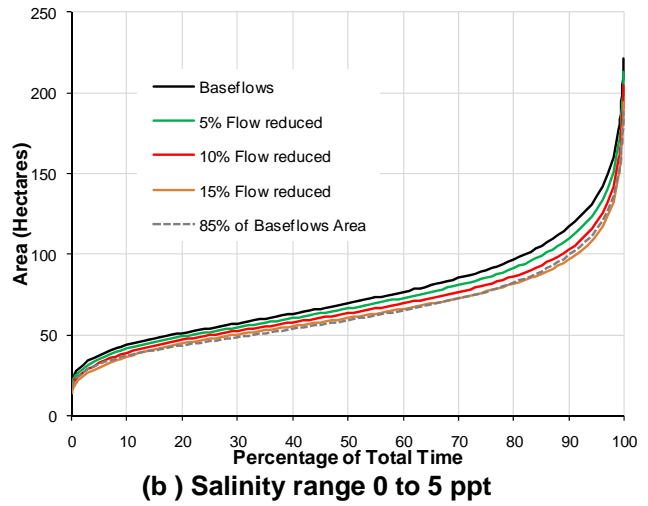
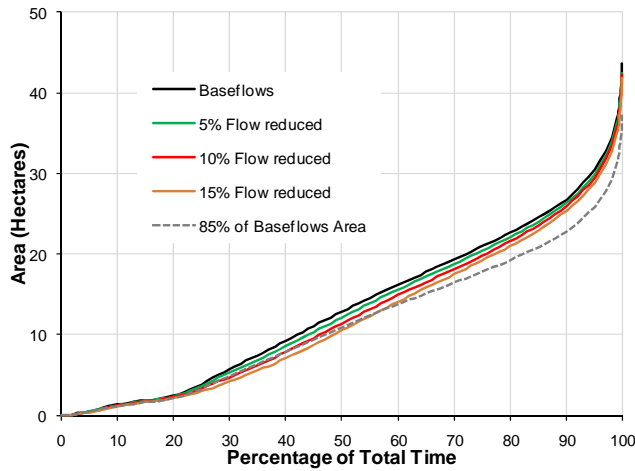


Figure 10 Bottom area analysis CDF's: SLR 3.4 inches.



3.3.3 Shoreline Length

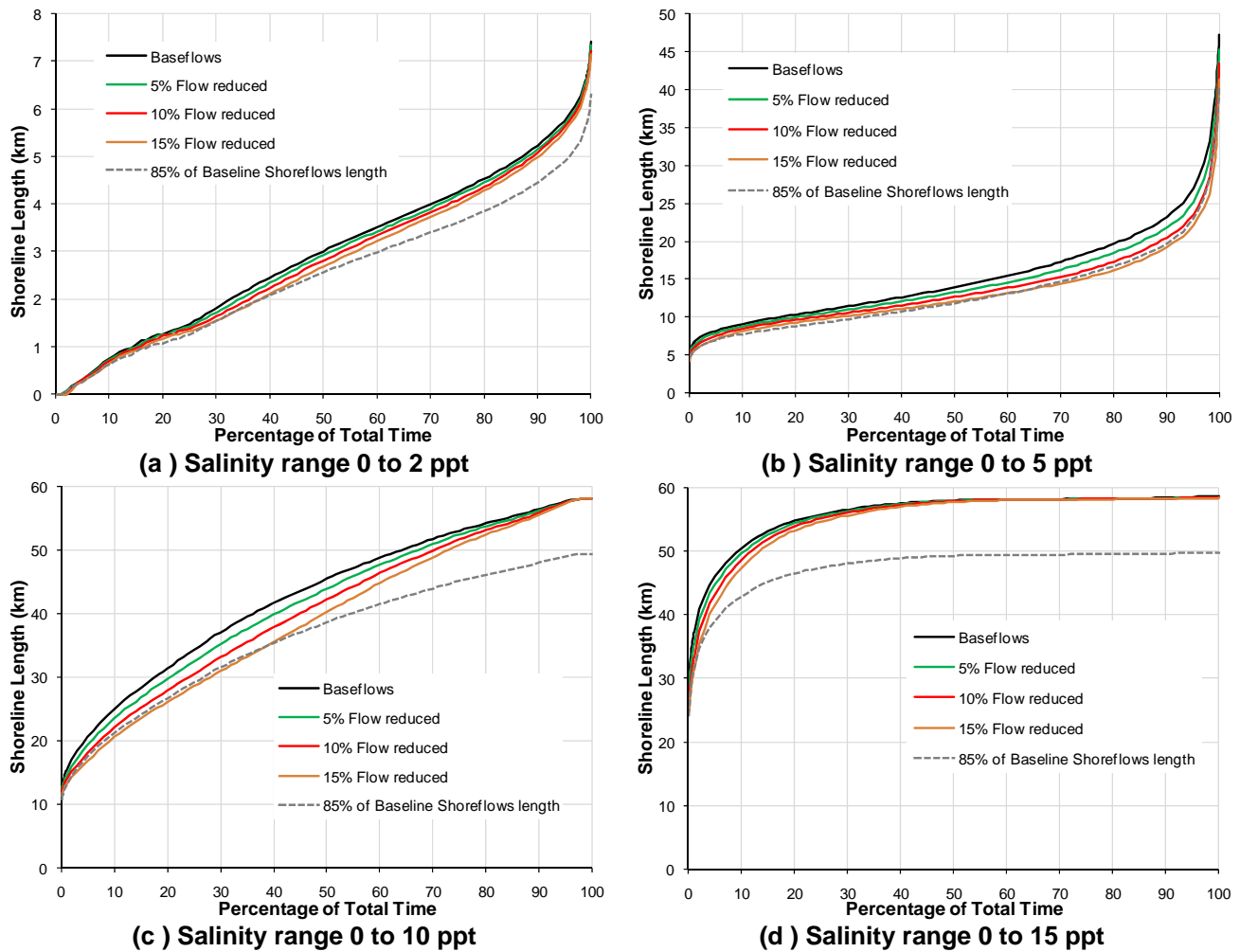


Figure 11 Shoreline length analysis CDF's: SLR 3.4 inches.



3.3.4 Isohaline RK Location

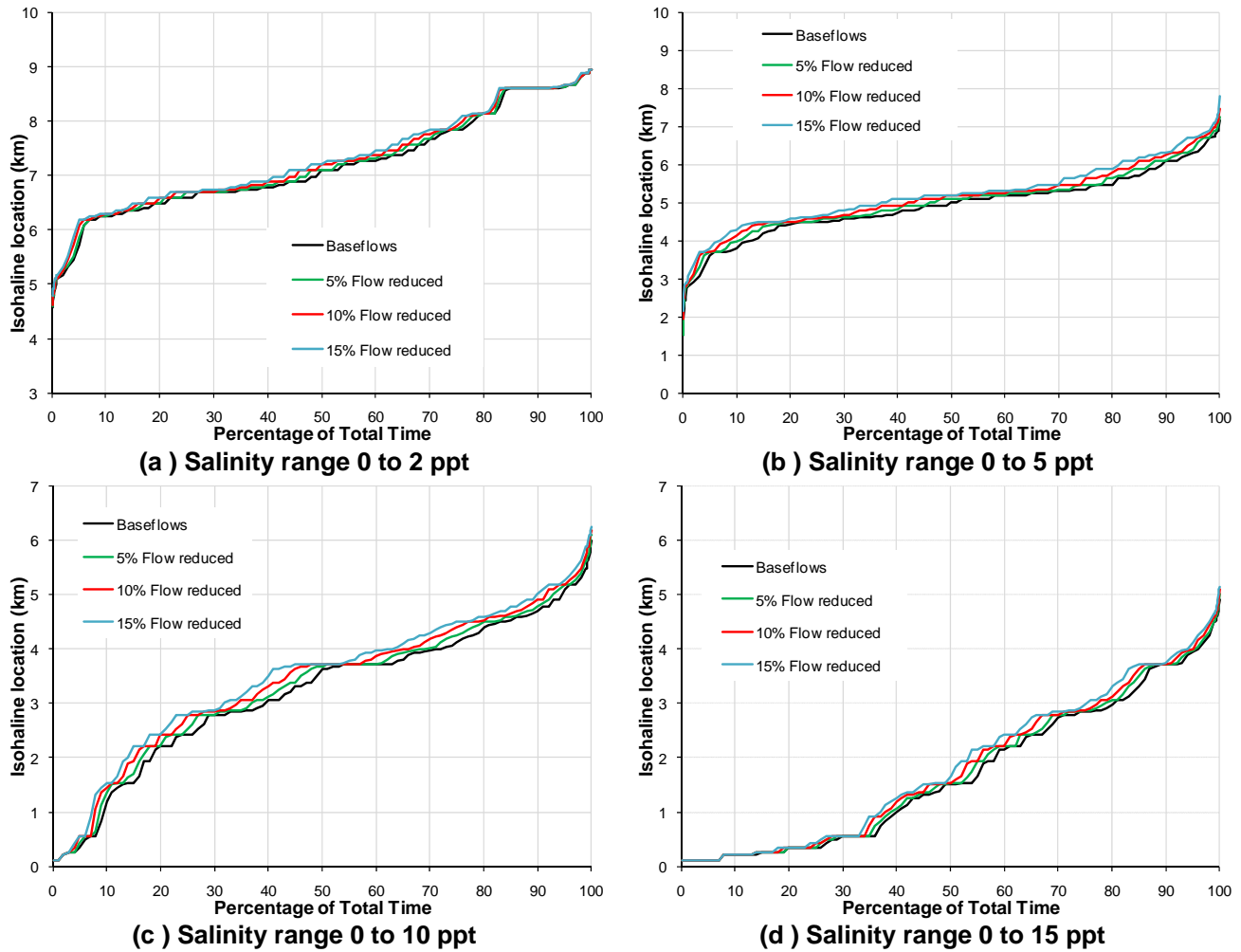


Figure 12 Isohaline location analysis CDF's: SLR 3.4 inches.



3.4 7.7 inch SLR and flow reduction

The CDF curves for the case of the 7.7 inch SLR for the various habit criteria are shown in Figure 13 to Figure 16. Examination of these figures reveals that the habitat criteria of salinity less than 2 ppt or 5 ppt is significantly reduced compared with the baseline case.

3.4.1 Total Volume

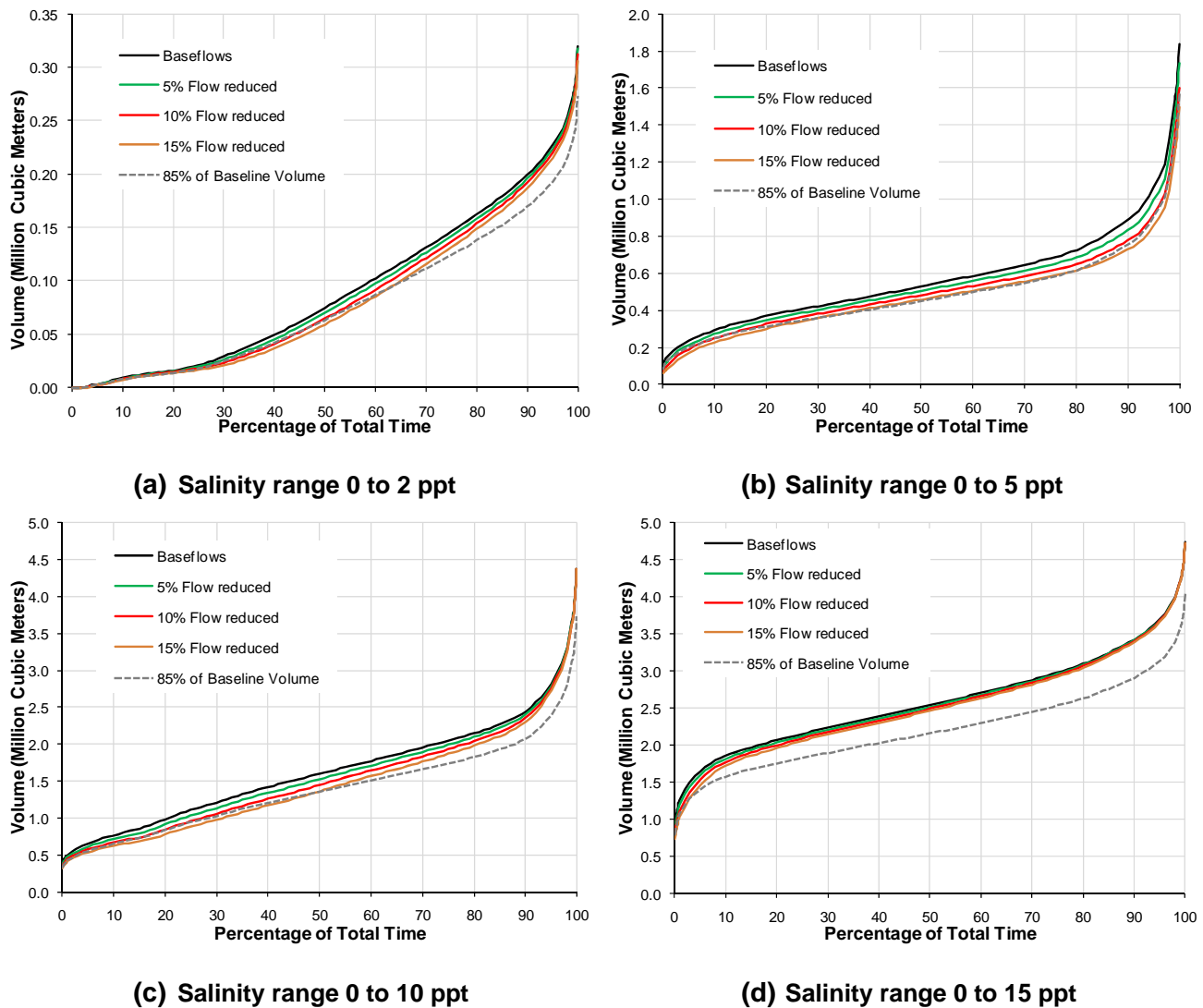


Figure 13 Volumetric analysis CDF's: SLR 7.7 inches



3.4.2 Bottom Area

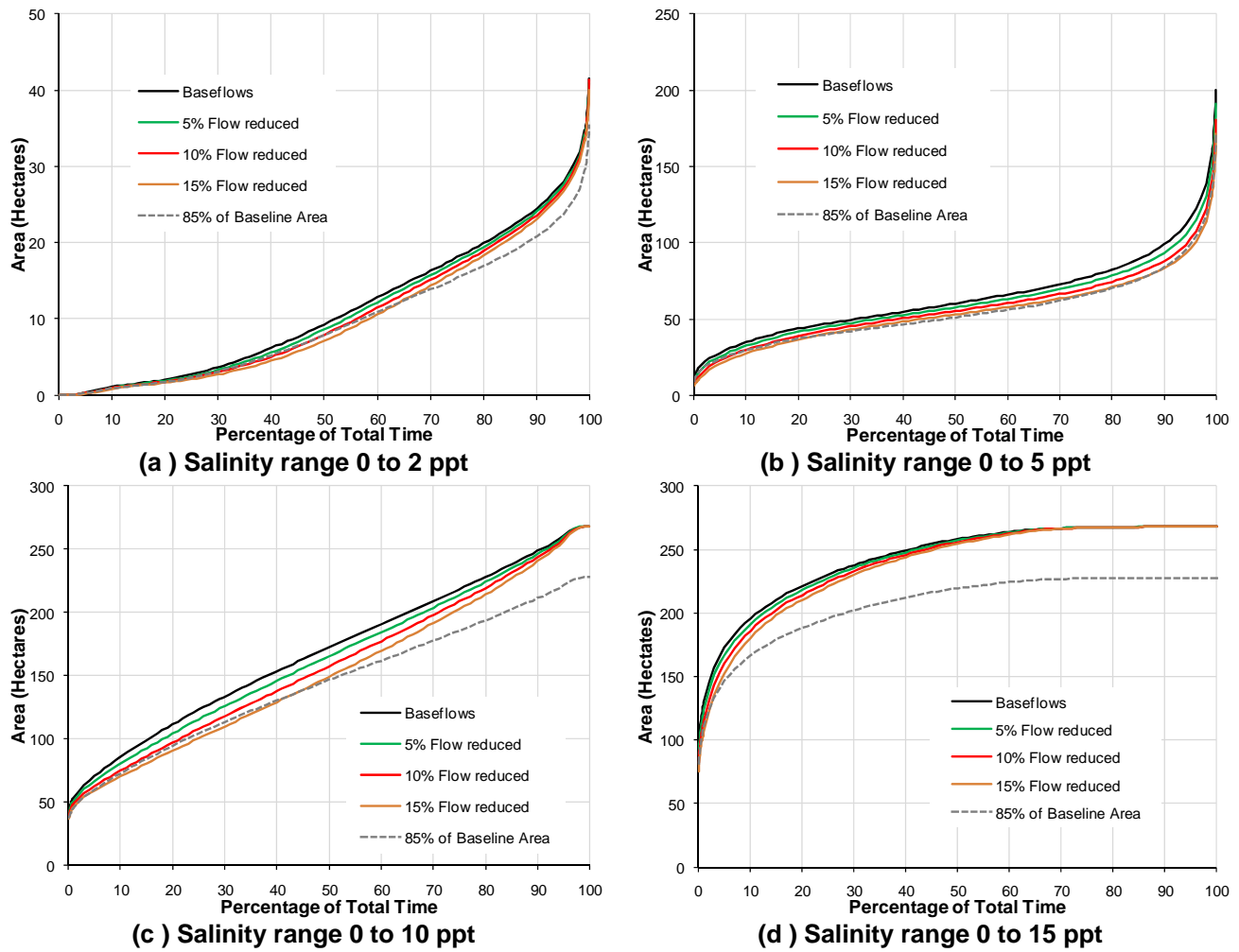


Figure 14 Bottom area analysis CDF's: SLR 7.7 inches.



3.4.3 Shoreline length

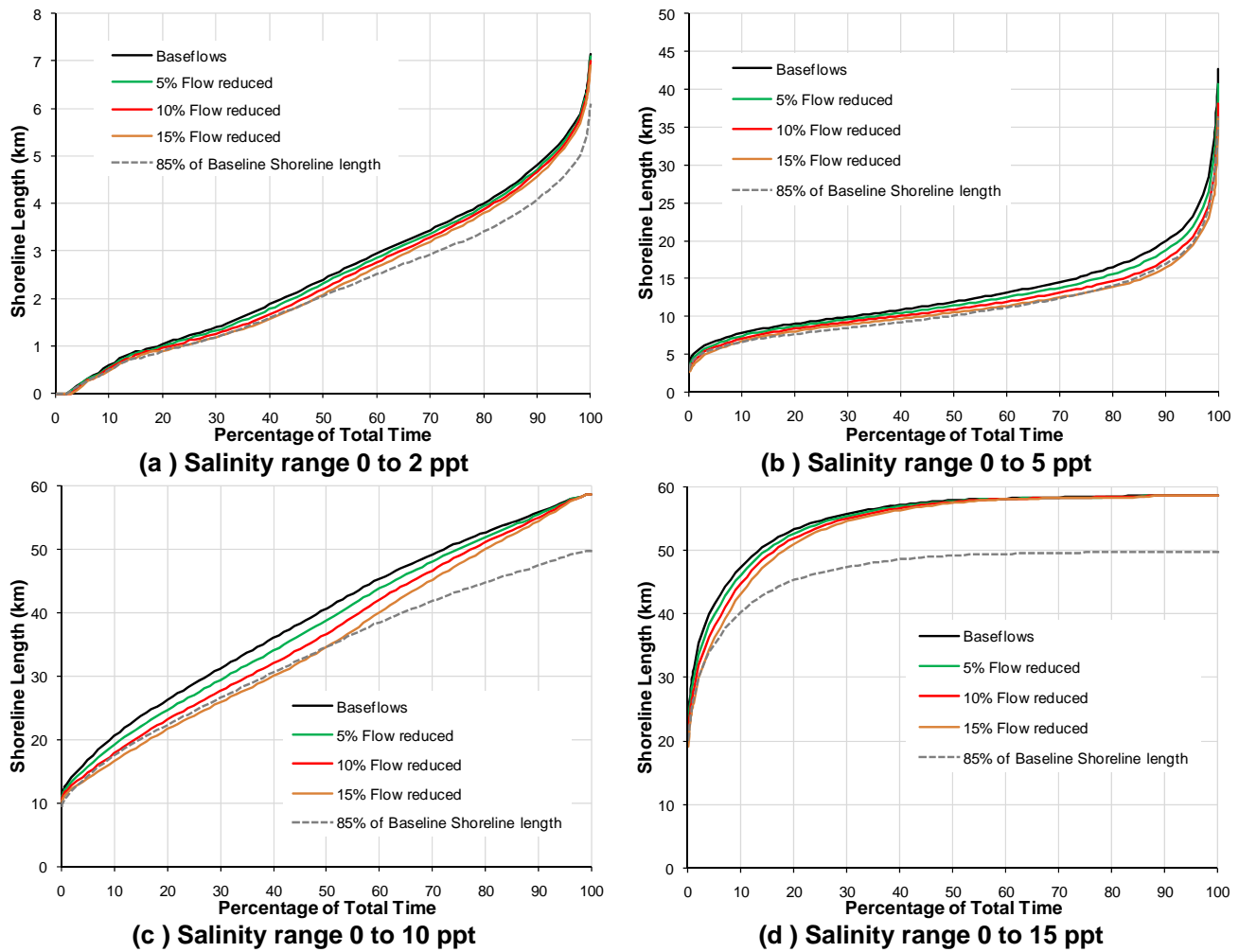


Figure 15 Shoreline length analysis CDF's: SLR 7.7 inches.



3.4.4 Isohaline RK location

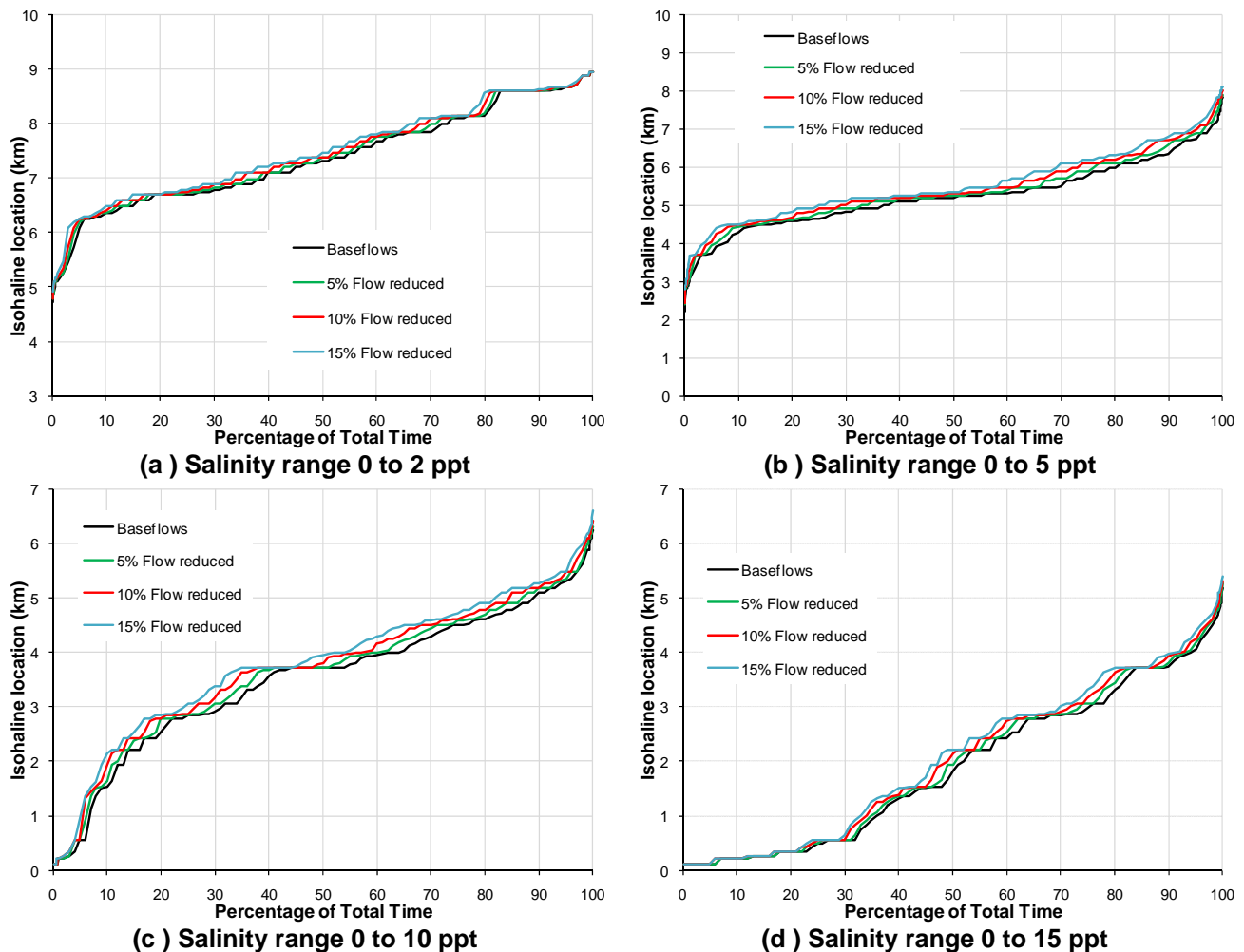


Figure 16 Isohaline location analysis CDF's: SLR 7.7 inches.

4 AUC Analysis

Figure 17 to Figure 20 provides the normalized area under the curve (AUC) for the CDF's presented in the previous section for all salinity criteria. The "Target" line shown on these figures represents the MFL allowable impact of a 15% loss in habitat criteria. 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 these figures meet the 15% target.

The total volume AUC in Figure 17 indicates that the habitat criteria for water with salinity in the range of 0-2 ppt or 0-5 ppt are significantly reduced by SLR and the reduction of flow. The water



with salinity in the range 0-10 ppt appears to be less sensitive to changes sea level and flow, while the volume of the 0-15 ppt water is increased with SLR and the flow reduction.

The AUC of the bottom area and shoreline in Figure 18 and Figure 19 indicate a similar situation. Bottom area was significantly reduced with SLR and flow reduction in the case of low concentration salinities 0-2, 0-5, or 0-10 ppt. However, it was less sensitive in the case of 0-15 ppt.

The isohaline location of the 0-2 ppt water appears to be less sensitive to changes in sea level and flow (Figure 20a). For the more saline 0-5 ppt, 0-10 ppt, and 0-15 ppt water, the AUC shows the isohaline location moving upstream as a result of the flow reduction and SLR.

A summary of the AUC for each of the habitat criteria and scenarios of sea level and flow condition is provided in Table 1.

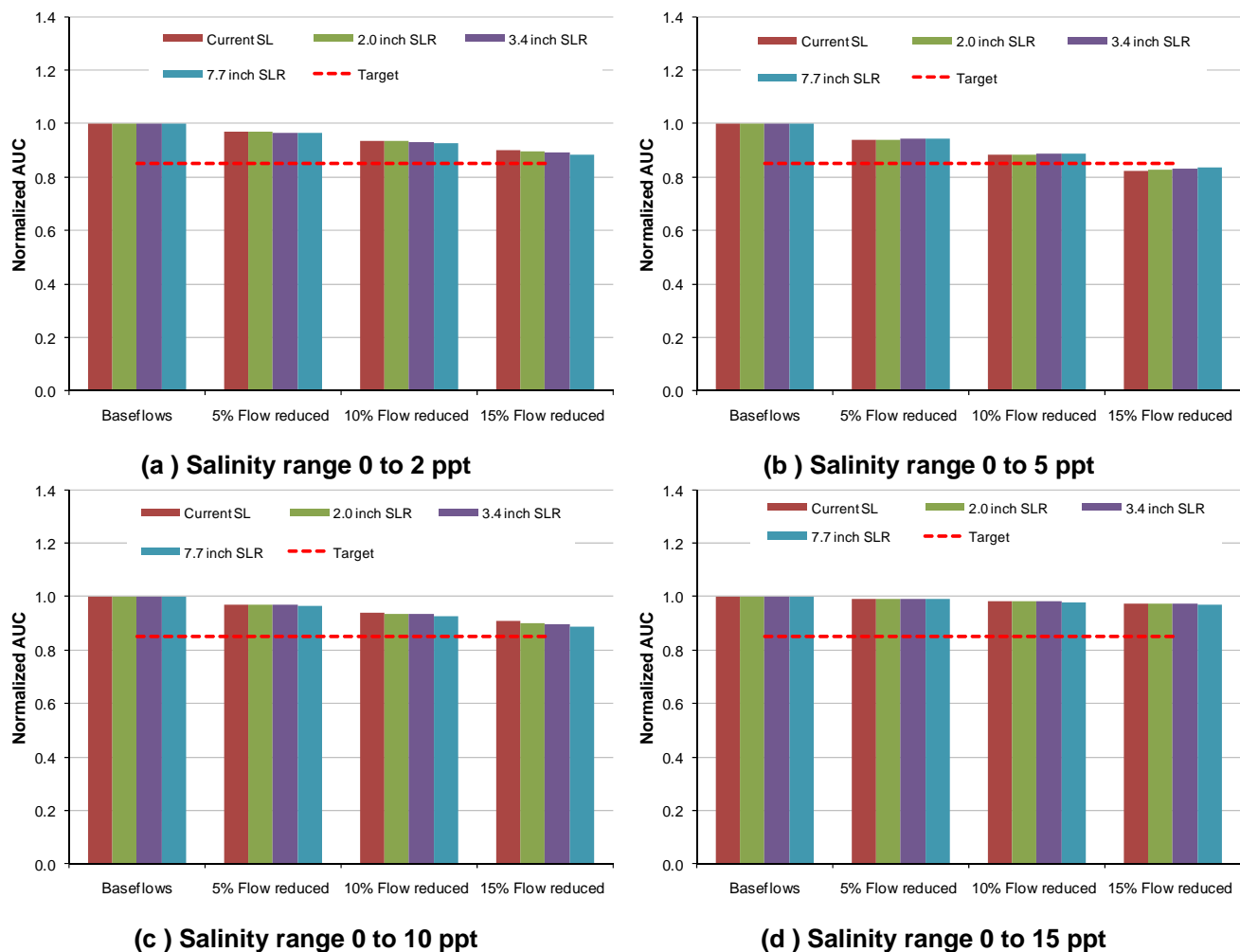
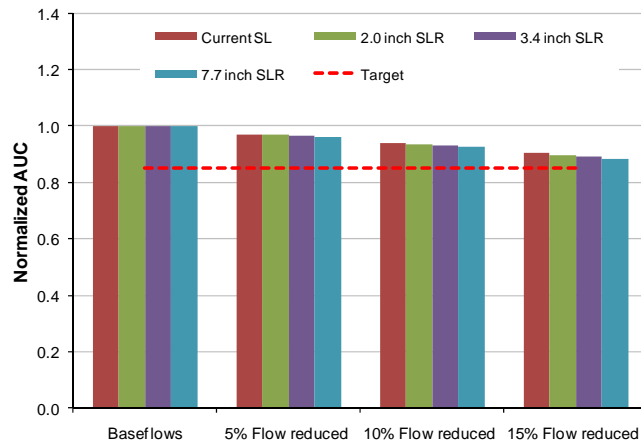
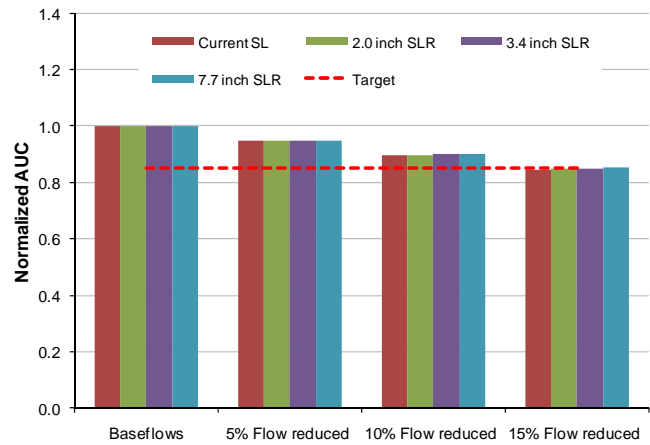


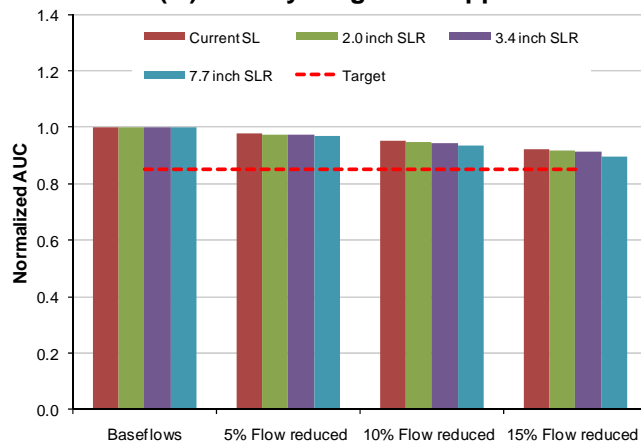
Figure 17 Summary of volume AUC analysis.



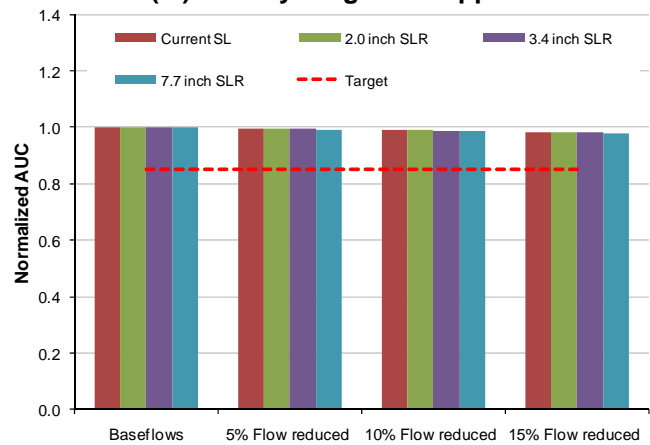
(a) Salinity range 0 to 2 ppt



(b) Salinity range 0 to 5 ppt

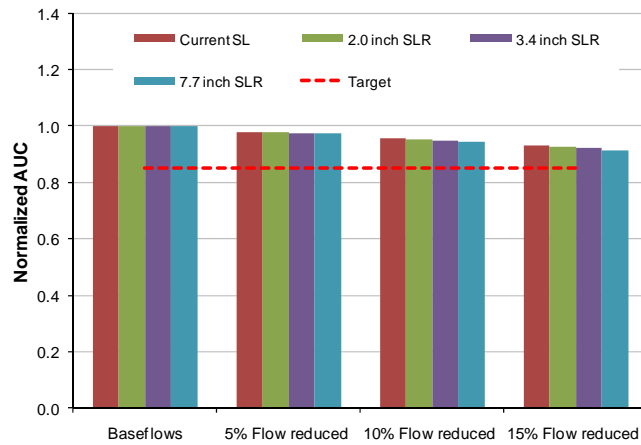


(c) Salinity range 0 to 10 ppt

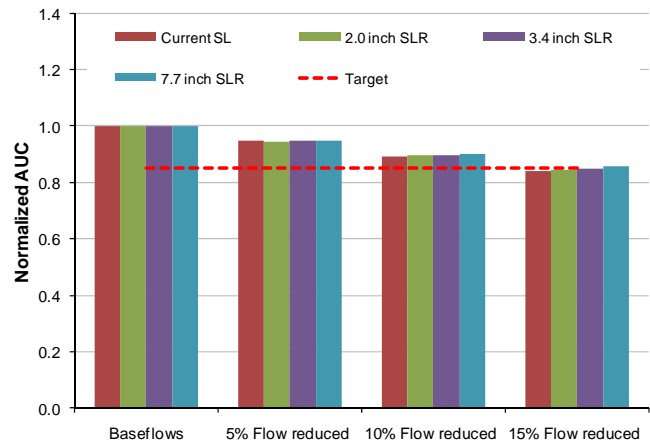


(d) Salinity range 0 to 15 ppt

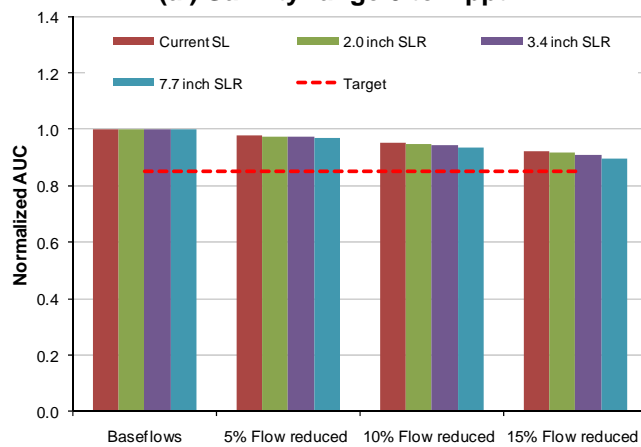
Figure 18 Summary of bottom area AUC analysis



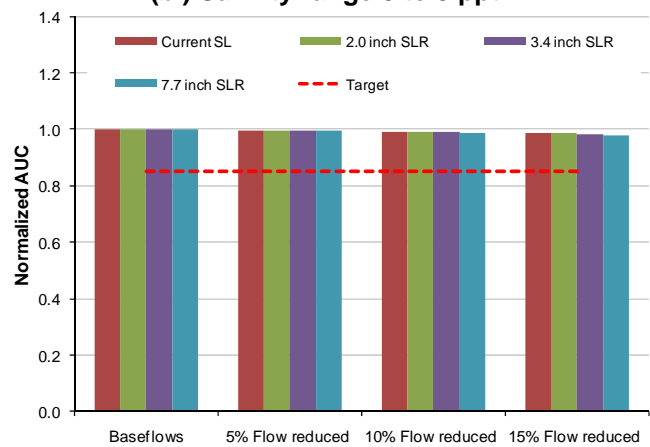
(a) Salinity range 0 to 2 ppt



(b) Salinity range 0 to 5 ppt

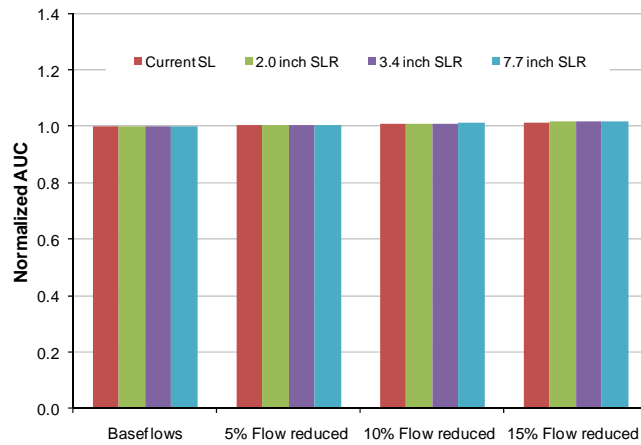


(c) Salinity range 0 to 10 ppt

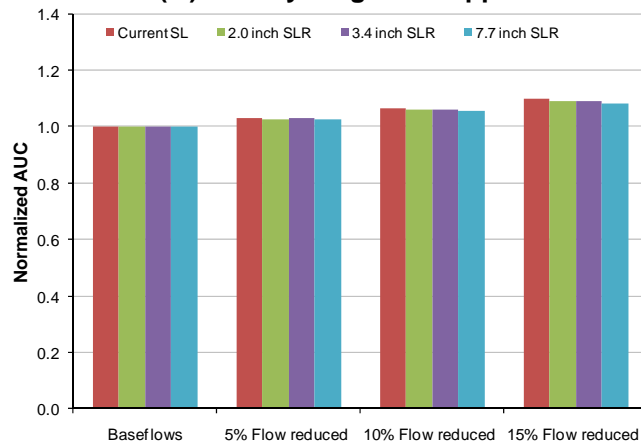


(d) Salinity range 0 to 15 ppt

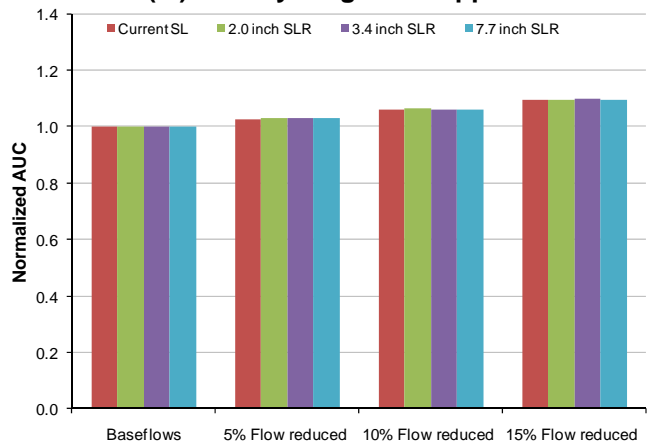
Figure 19 Summary of shoreline length AUC analysis



(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 20 Summary of isohaline location AUC analysis



Table 1 Normalized Area under the CDF Curve (AUC)

Salinity range (ppt)	Normalized Area Under the CDF Curve (AUC)															
	Baseline Flow				2.0 inch SLR								3.4 inch SLR			
					Flow reduced								7.7 inch SLR			
	0%	5%	10%	15%	0%	5%	10%	15%	0%	5%	10%	15%	0%	5%	10%	15%
Volume																
0 to 2	1.000	0.969	0.937	0.901	1.000	0.968	0.935	0.895	1.000	0.967	0.931	0.891	1.000	0.964	0.926	0.884
0 to 5	1.000	0.941	0.882	0.825	1.000	0.941	0.884	0.829	1.000	0.942	0.886	0.832	1.000	0.944	0.888	0.835
0 to 10	1.000	0.972	0.941	0.908	1.000	0.970	0.937	0.902	1.000	0.968	0.934	0.898	1.000	0.964	0.926	0.886
0 to 15	1.000	0.992	0.984	0.975	1.000	0.992	0.983	0.974	1.000	0.992	0.983	0.972	1.000	0.991	0.980	0.968
Bottom Area																
0 to 2	1.000	0.971	0.940	0.905	1.000	0.971	0.937	0.898	1.000	0.967	0.931	0.891	1.000	0.963	0.925	0.881
0 to 5	1.000	0.948	0.896	0.846	1.000	0.948	0.898	0.849	1.000	0.948	0.899	0.851	1.000	0.950	0.900	0.851
0 to 10	1.000	0.977	0.952	0.924	1.000	0.974	0.947	0.917	1.000	0.973	0.943	0.912	1.000	0.968	0.934	0.898
0 to 15	1.000	0.995	0.990	0.985	1.000	0.995	0.989	0.983	1.000	0.995	0.988	0.981	1.000	0.993	0.985	0.976
Shoreline Length																
0 to 2	1.000	0.978	0.956	0.931	1.000	0.977	0.953	0.926	1.000	0.976	0.950	0.921	1.000	0.973	0.945	0.914
0 to 5	1.000	0.946	0.891	0.841	1.000	0.945	0.895	0.846	1.000	0.947	0.897	0.848	1.000	0.950	0.901	0.856
0 to 10	1.000	0.977	0.951	0.924	1.000	0.975	0.947	0.917	1.000	0.973	0.943	0.911	1.000	0.968	0.933	0.898
0 to 15	1.000	0.996	0.993	0.988	1.000	0.996	0.990	0.986	1.000	0.995	0.990	0.983	1.000	0.994	0.987	0.978
Isohaline Location																
0 to 2	1.000	1.005	1.009	1.014	1.000	1.005	1.010	1.016	1.000	1.005	1.010	1.016	1.000	1.005	1.011	1.018
0 to 5	1.000	1.019	1.038	1.060	1.000	1.019	1.038	1.058	1.000	1.018	1.038	1.058	1.000	1.019	1.038	1.057
0 to 10	1.000	1.031	1.063	1.097	1.000	1.027	1.059	1.092	1.000	1.028	1.059	1.090	1.000	1.027	1.055	1.084
0 to 15	1.000	1.026	1.059	1.096	1.000	1.029	1.064	1.094	1.000	1.030	1.061	1.098	1.000	1.029	1.061	1.094



5 15% Loss Flow Reduction Estimates

The reduction of flows that would result in a 15% loss of each habitat criteria was estimated. The estimation was based on developing a second order polynomial fit of the AUC's for each sea level and habitat criteria case with flow reduction rate (Table 2). The 15% loss was then computed from the best fit polynomials. Table 3 summarizes these flow reductions for the volume, bottom area and shoreline lengths for each of the SLR scenarios.

In general, the percent reduction of spring flow resulting in the 15% habitat loss is reduced with increasing sea levels.



Table 1 AUC and flow reduction trend relation.

	0.0 inch SLR	2.0 inch SLR	3.4 inch SLR	7.7 inch SLR
Volume				
0 to 2	$y = -0.49318x^2 - 0.58538x + 1.0$	$y = -0.77626x^2 - 0.58074x + 1.0$	$y = -0.65113x^2 - 0.63062x + 1.0$	$y = -0.64650x^2 - 0.67786x + 1.0$
0 to 5	$y = 0.20483x^2 - 1.20040x + 1.0$	$y = 0.45709x^2 - 1.20978x + 1.0$	$y = 0.33621x^2 - 1.17182x + 1.0$	$y = 0.26341x^2 - 1.14243x + 1.0$
0 to 10	$y = -0.46252x^2 - 0.54309x + 1.0$	$y = -0.44296x^2 - 0.58600x + 1.0$	$y = -0.43308x^2 - 0.61499x + 1.0$	$y = -0.36140x^2 - 0.70478x + 1.0$
0 to 15	$y = -0.15882x^2 - 0.14006x + 1.0$	$y = -0.14518x^2 - 0.15349x + 1.0$	$y = -0.17927x^2 - 0.15716x + 1.0$	$y = -0.22781x^2 - 0.17906x + 1.0$
Area				
0 to 2	$y = -0.51676x^2 - 0.55429x + 1.0$	$y = -0.95454x^2 - 0.53376x + 1.0$	$y = -0.67190x^2 - 0.62198x + 1.0$	$y = -0.61538x^2 - 0.69439x + 1.0$
0 to 5	$y = 0.17767x^2 - 1.05288x + 1.0$	$y = 0.35581x^2 - 1.05752x + 1.0$	$y = 0.32320x^2 - 1.04451x + 1.0$	$y = 0.18516x^2 - 1.02004x + 1.0$
0 to 10	$y = -0.47302x^2 - 0.43400x + 1.0$	$y = -0.45624x^2 - 0.48368x + 1.0$	$y = -0.46591x^2 - 0.51971x + 1.0$	$y = -0.37762x^2 - 0.62179x + 1.0$
0 to 15	$y = -0.10760x^2 - 0.08547x + 1.0$	$y = -0.10852x^2 - 0.09757x + 1.0$	$y = -0.18773x^2 - 0.09676x + 1.0$	$y = -0.20463x^2 - 0.12683x + 1.0$
Shoreline Length				
0 to 2	$y = -0.30444x^2 - 0.41002x + 1.0$	$y = -0.53728x^2 - 0.41447x + 1.0$	$y = -0.50508x^2 - 0.45129x + 1.0$	$y = -0.35320x^2 - 0.51721x + 1.0$
0 to 5	$y = 0.42698x^2 - 1.12988x + 1.0$	$y = 0.58068x^2 - 1.11397x + 1.0$	$y = 0.44742x^2 - 1.07683x + 1.0$	$y = 0.49932x^2 - 1.03790x + 1.0$
0 to 10	$y = -0.47088x^2 - 0.43846x + 1.0$	$y = -0.50660x^2 - 0.47619x + 1.0$	$y = -0.50386x^2 - 0.51700x + 1.0$	$y = -0.33500x^2 - 0.63094x + 1.0$
0 to 15	$y = -0.08725x^2 - 0.06620x + 1.0$	$y = -0.00817x^2 - 0.09491x + 1.0$	$y = -0.25453x^2 - 0.07376x + 1.0$	$y = -0.19432x^2 - 0.11540x + 1.0$

y= AUC; x=percent of flow reduction

**Table 2 Flow Reductions based on a 15% loss of volume, area or shoreline length for the salinity ranges.**

Salinity range (ppt)	0.0 inch SLR	2.0 inch SLR	3.4 inch SLR	7.7 inch SLR
Volume				
0 to 2	22%	20%	20%	19%
0 to 5	13%	13%	13%	14%
0 to 10	23%	22%	21%	19%
0 to 15	>40.00%	>40.00%	>40.00%	>40.00%
Bottom Area				
0 to 2	23%	20%	20%	19%
0 to 5	15%	15%	15%	15%
0 to 10	26%	25%	24%	21%
0 to 15	>40.00%	>40.00%	>40.00%	>40.00%
Shoreline Length				
0 to 2	30%	27%	26%	25%
0 to 5	14%	15%	15%	16%
0 to 10	27%	25%	24%	21%
0 to 15	>40.00%	>40.00%	>40.00%	>40.00%

6 Conclusions and Limitations

The impact on the salinity regime in the Chassahowitzka River System due to SLR and flow reduction was analyzed with the EFDC hydrodynamic model. The results indicate that SLR would reduce the availability of salinity habitat of water with salinities of 0-2 ppt, 0-5 ppt or 0-10 ppt in the system (in terms of volume, area, shoreline length, and isohaline location). The habitat criteria of water with salinity in the range of 0-15 ppt are less sensitive to SLR.

Within the 20-year horizon, the salinity habitat criteria is weakly impacted under the historic curve but is significantly impacted under the modified NRC curve I. Under the modified NRC curve III, the SLR would have a dramatic decrease in freshwater habitat area and shoreline length.

The analysis conducted here was subject to the following limitations:



- With SLR, the modeled open sea boundary condition may be more saline than currently measured conditions. For this analysis, the salinity at the sea boundary was assumed to be the same concentration as used in the baseline model.
- The model domain used in this analysis covers only the currently wetted area in the system. In the case of SLR, existing low-lying areas would likely be flooded resulting in a significant increase in the wetted area and shoreline length. The potential change in wetted area would have an impact on the hydrodynamic and salinity regimes.



7 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 (07PO0001577-5)

Additional Numeric Model Simulations of the Chassahowitzka River – Part Five

(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 (SLR) 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 and subsequent 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.

SLR scenarios for 2030 are taken from a) extrapolation of regional historic records (2.0 inch), b) USACOE² recommended NRC modified Curve I (3.4 inches) and c) USACOE recommended NRC modified Curve III (7.7 inches). The CONSULTANT previously completed an evaluation of a two-inch SLR.

Scope of Work

Task 1. Simulate the change in salinity and stage for the following scenarios using the baseline conditions previously established for 2004 – 2006:

- a) Current Sea Level using baseline flows reduced 5%
- b) Current Sea Level using baseline flows reduced 15%

- c) 2.0 inch SLR using baseline flows reduced 5%
- d) 2.0 inch SLR using baseline flows reduced 10%
- e) 2.0 inch SLR using baseline flows reduced 15%

- f) 3.4 inch SLR on baseline flow conditions
- g) 3.4 inch SLR using baseline flows reduced 5%
- h) 3.4 inch SLR using baseline flows reduced 10%
- i) 3.4 inch SLR using baseline flows reduced 15%

- j) 7.7 inch SLR on baseline flow conditions
- k) 7.7 inch SLR using baseline flows reduced 5%
- l) 7.7 inch SLR using baseline flows reduced 10%
- m) 7.7 inch SLR using baseline flows reduced 15%

- n) Results of above simulations shall be briefly described in a letter report.

² USACOE Sea Level Rise Circular No. 1165-2-211 as amended.



Task 2. Post process the Task 1a-1m 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 has previously provided an example of output required.
- b) Post process existing 11%, 20% and 40% flow reduction results for 2, 10 and 15 ppt isohaline location.

Schedule

The CONSULTANT shall complete Tasks 1 and 2 and submit all deliverables no later than 15-Sep-2011



Appendix B – Time Series Plots

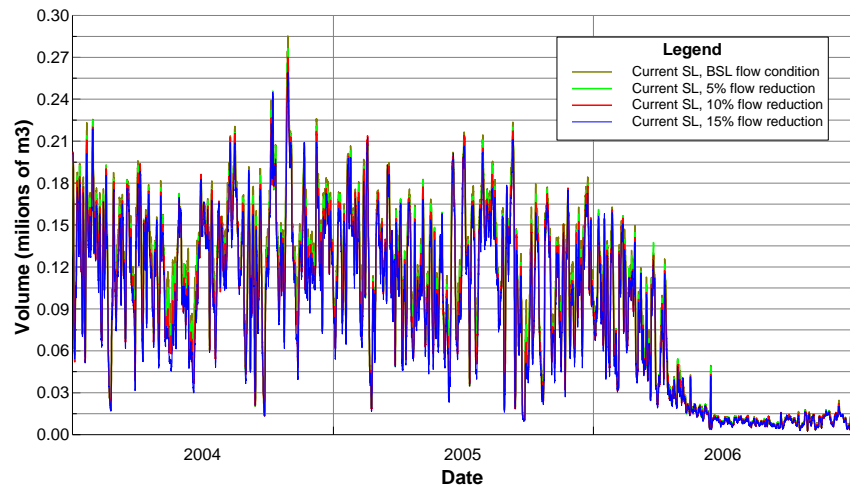


Figure B1 Daily volume of water: salinity range 0-2ppt, current sea level.

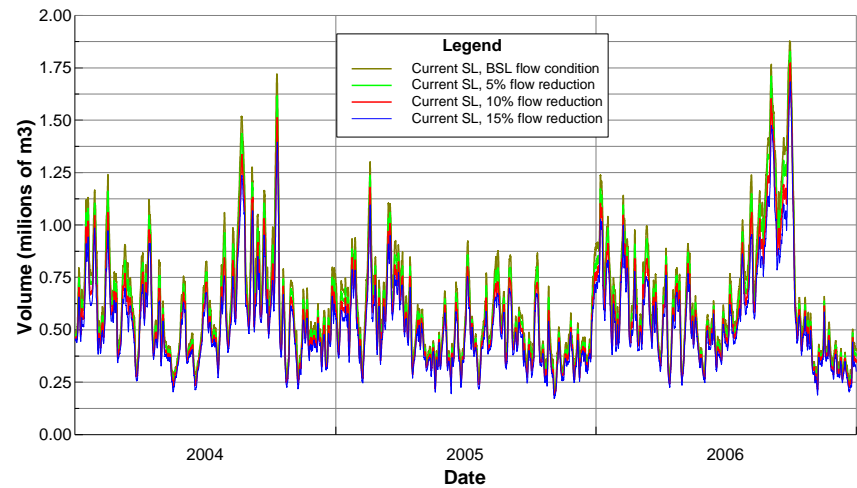


Figure B2 Daily volume of water: salinity range 0-5ppt, current sea level.

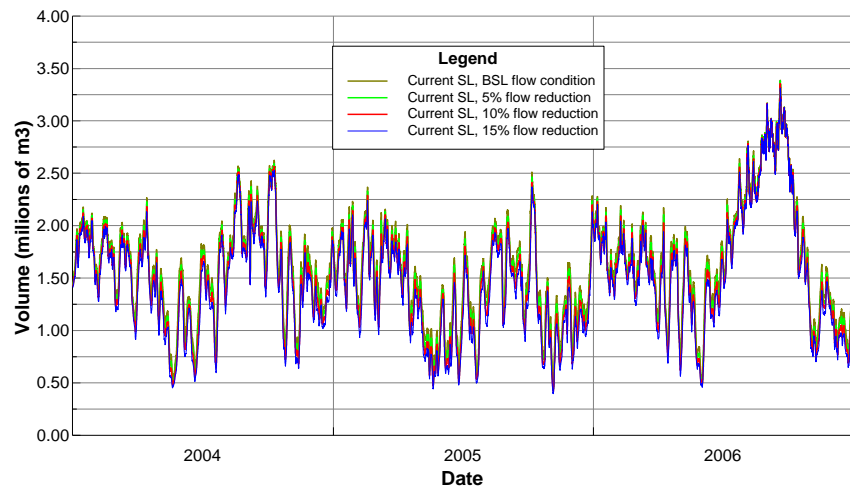


Figure B3 Daily volume of water: salinity range 0-10ppt, current sea level.

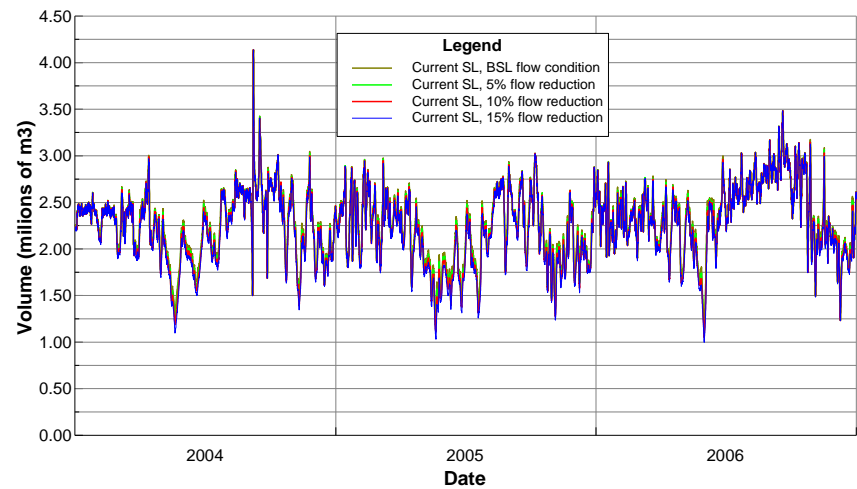


Figure B4 Daily volume of water: salinity range 0-15ppt, current sea level.

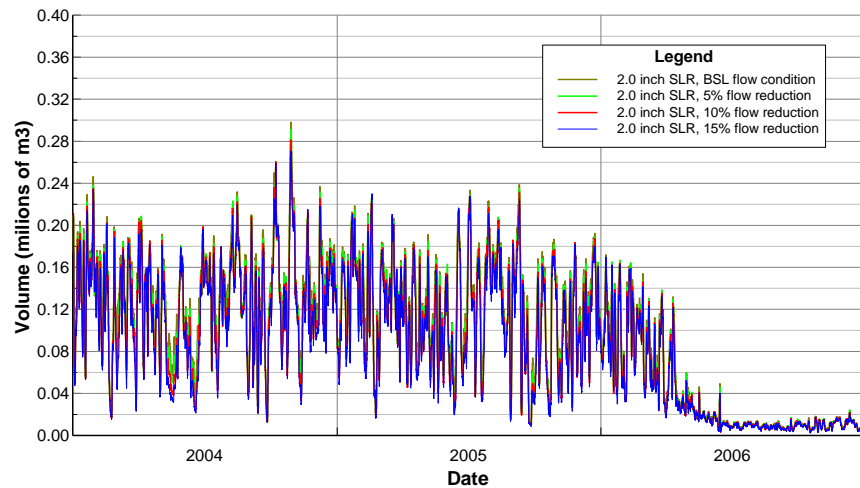


Figure B5 Daily volume of water: salinity range 0-2ppt, 2.0 inch SLR.

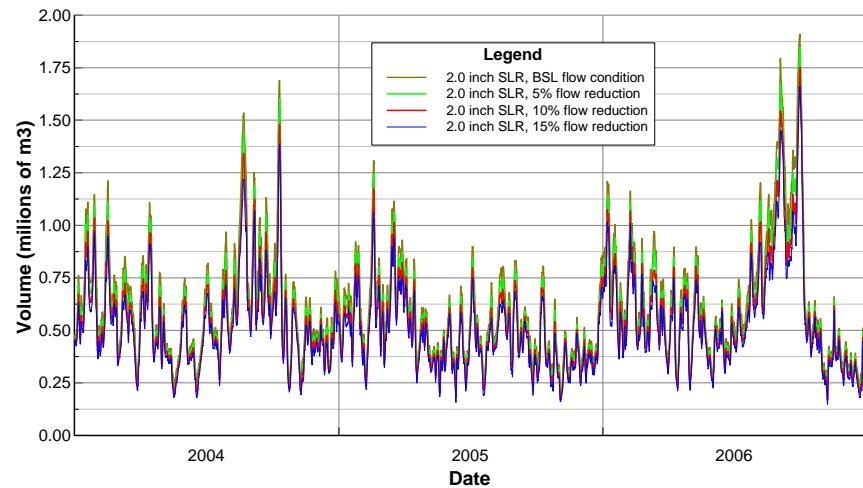


Figure B6 Daily volume of water: salinity range 0-5ppt, 2.0 inch SLR.

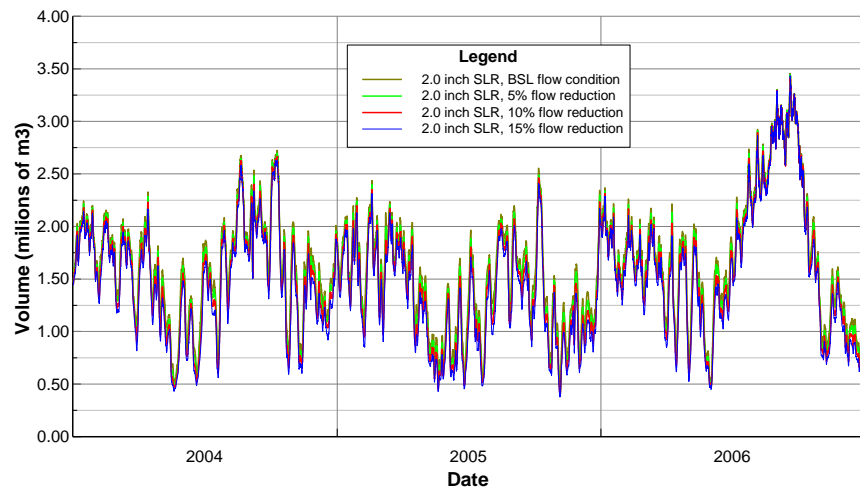


Figure B7 Daily volume of water: salinity range 0-10ppt, 2.0 inch SLR.

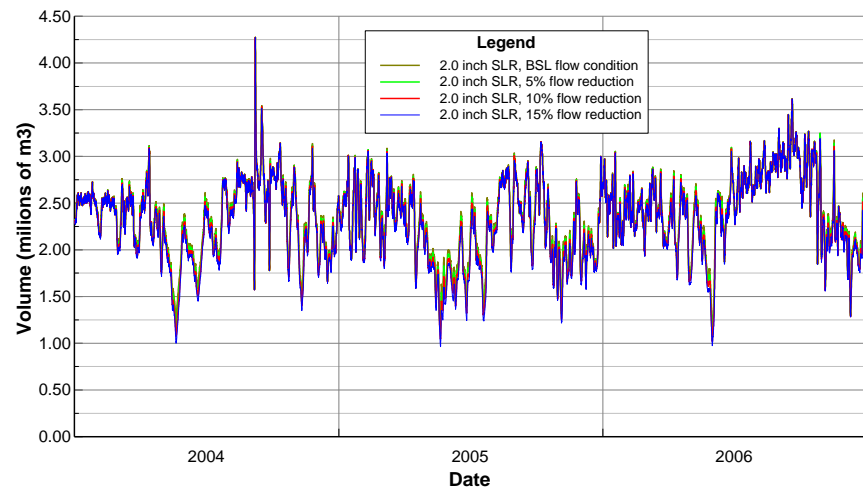


Figure B8 Daily volume of water: salinity range 0-15ppt, 2.0 inch SLR.

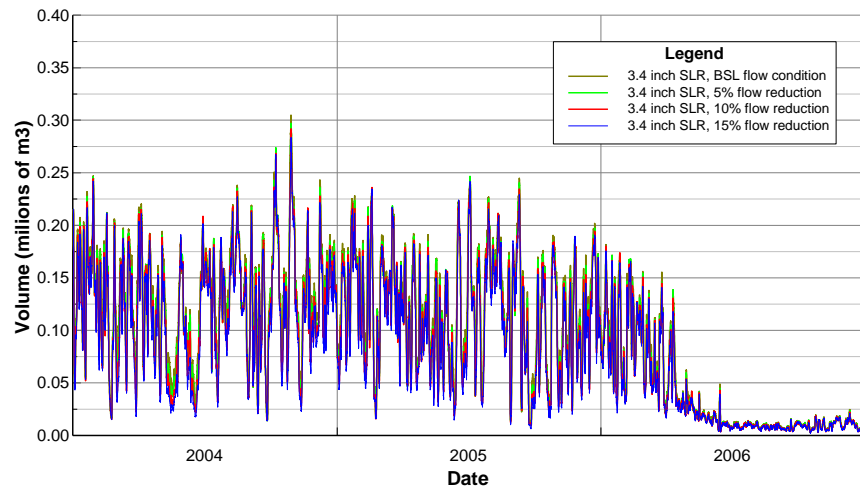


Figure B9 Daily volume of water: salinity range 0-2ppt, 3.4 inch SLR.

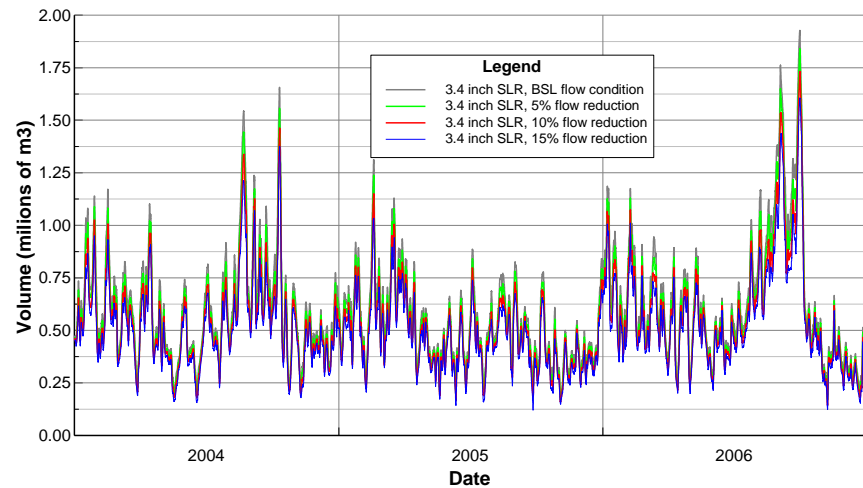


Figure B10 Daily volume of water: salinity range 0-5ppt, 3.4 inch SLR.

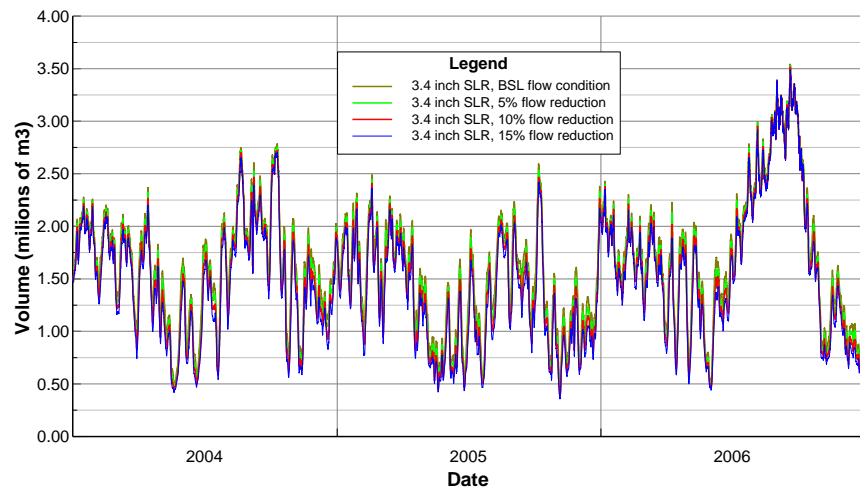


Figure B11 Daily volume of water: salinity range 0-10ppt, 3.4 inch SLR.

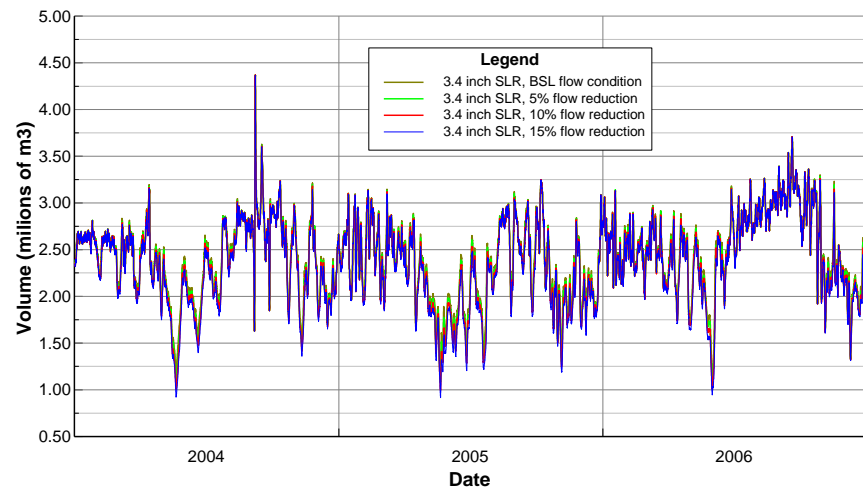


Figure B12 Daily volume of water: salinity range 0-15ppt, 3.4 inch SLR.

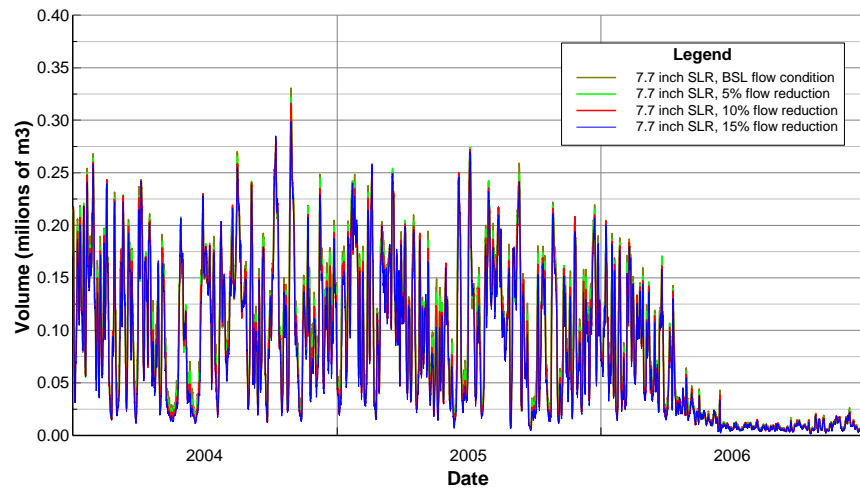


Figure B13 Daily volume of water: salinity range 0-2ppt, 7.7 inch SLR.

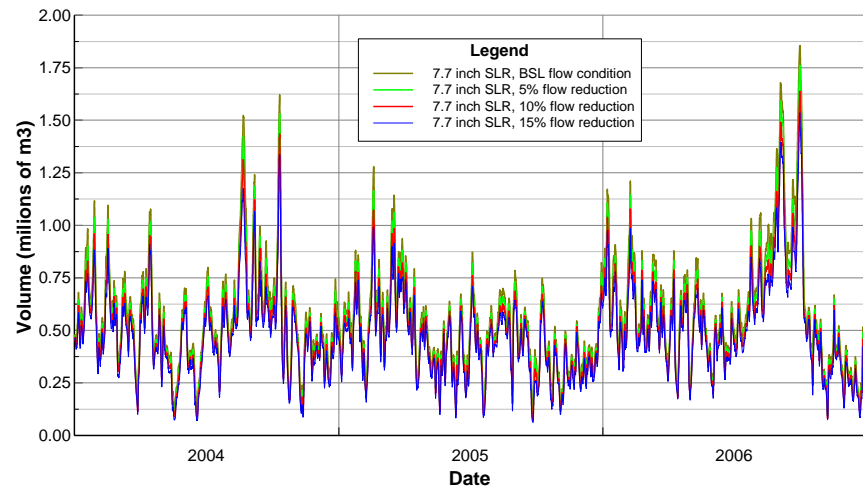


Figure B14 Daily volume of water: salinity range 0-5ppt, 7.7 inch SLR.

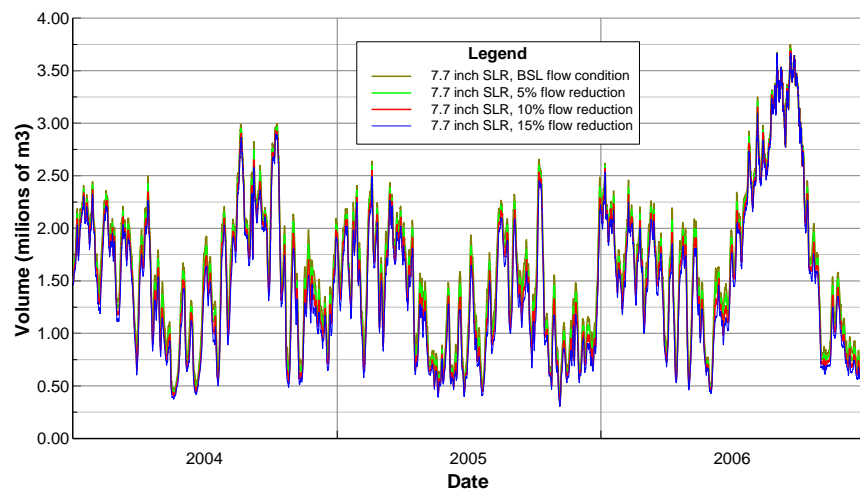


Figure B15 Daily volume of water: salinity range 0-10ppt, 7.7 inch SLR.

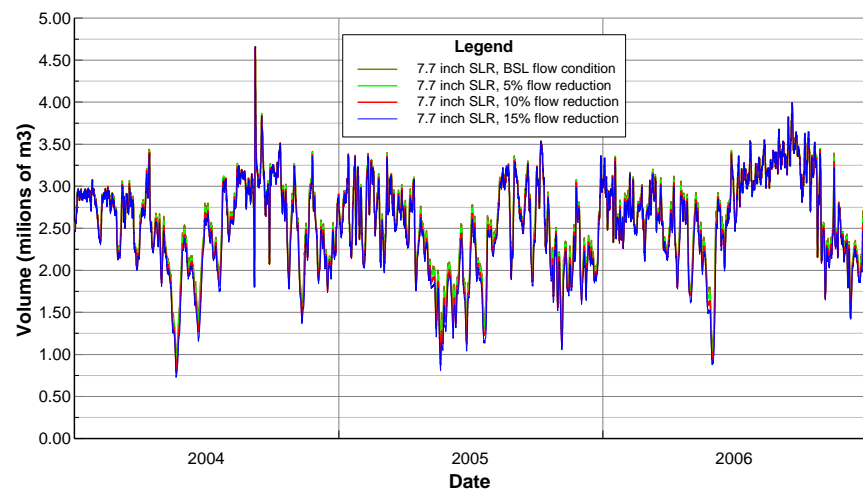


Figure B16 Daily volume of water: salinity range 0-15ppt, 7.7 inch SLR.

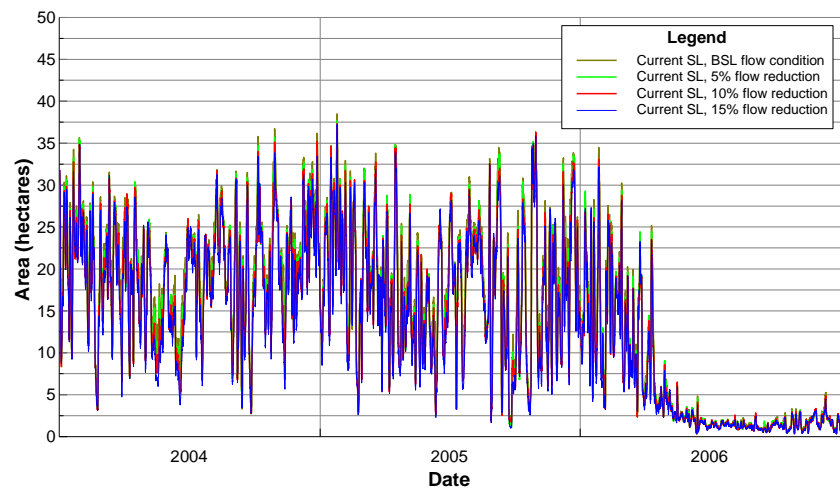


Figure B17 Daily Bottom area of water: salinity range 0-2ppt, current sea level.

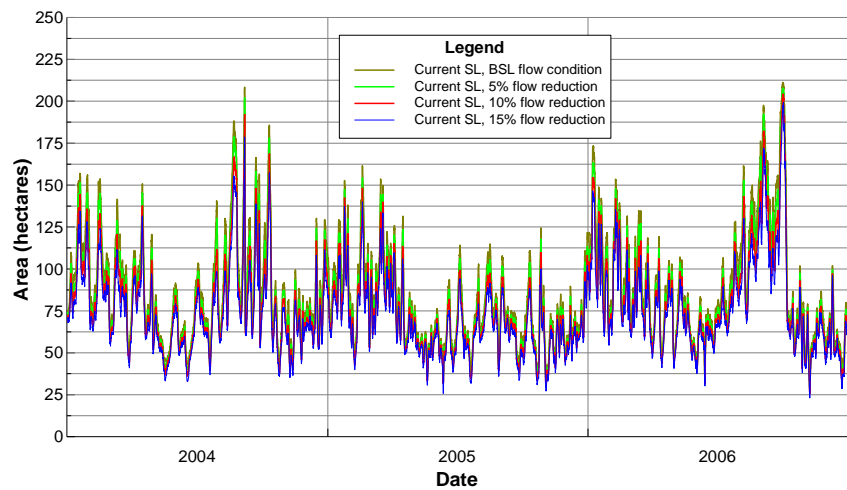


Figure B18 Daily Bottom area of water: salinity range 0-5ppt, current sea level.

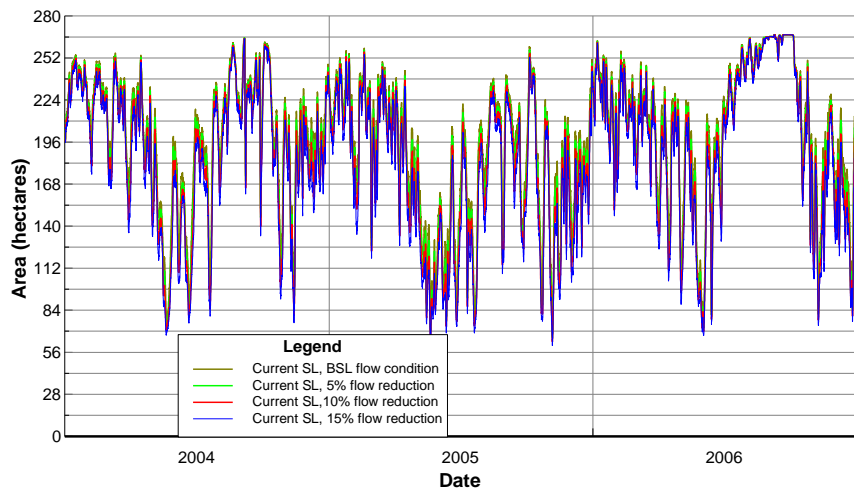


Figure B19 Daily Bottom area of water: salinity range 0-10ppt, current sea level.

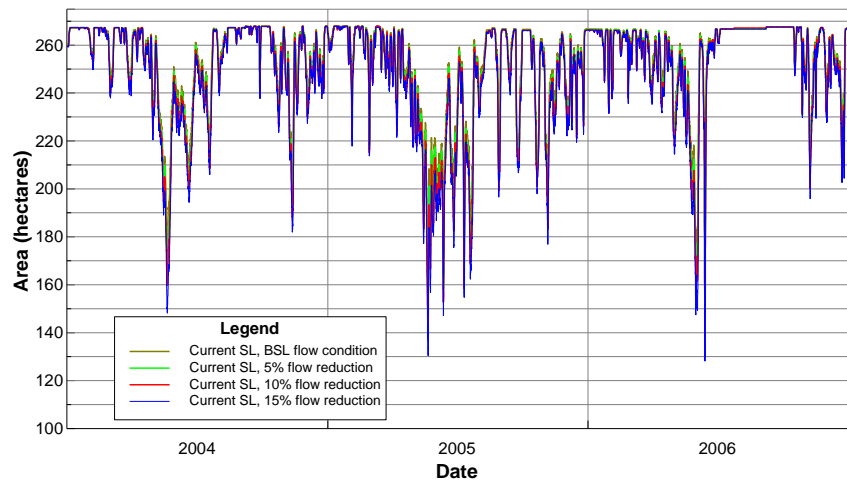
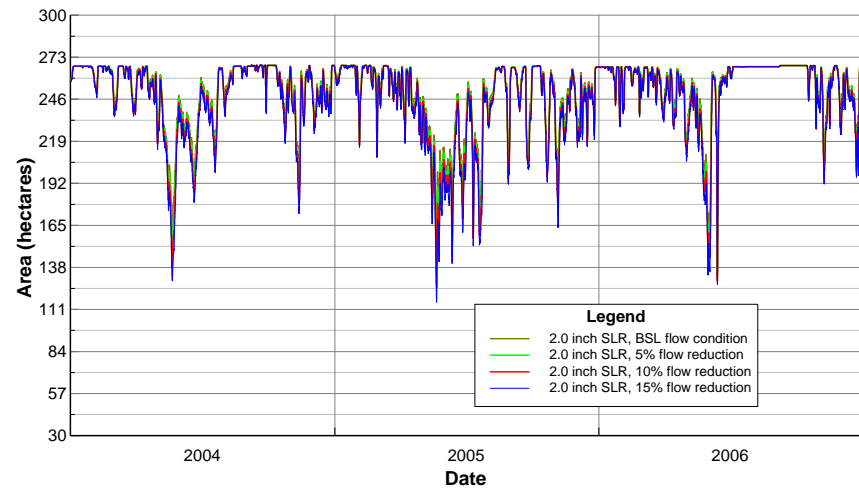
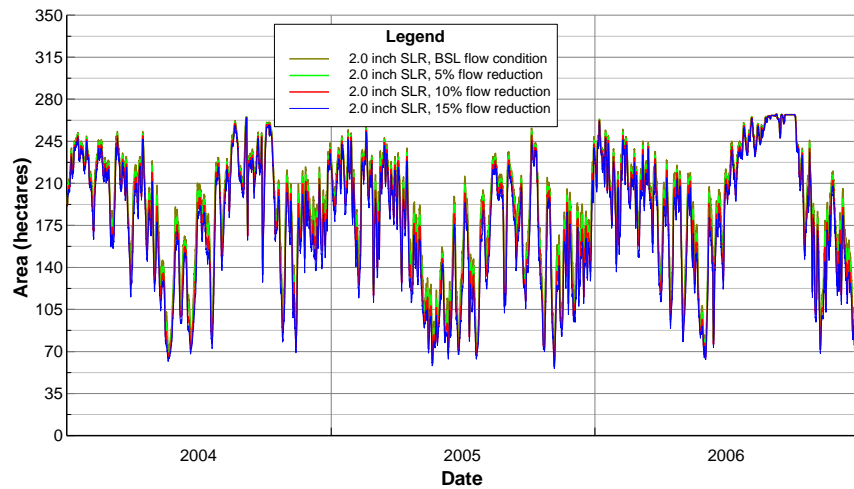
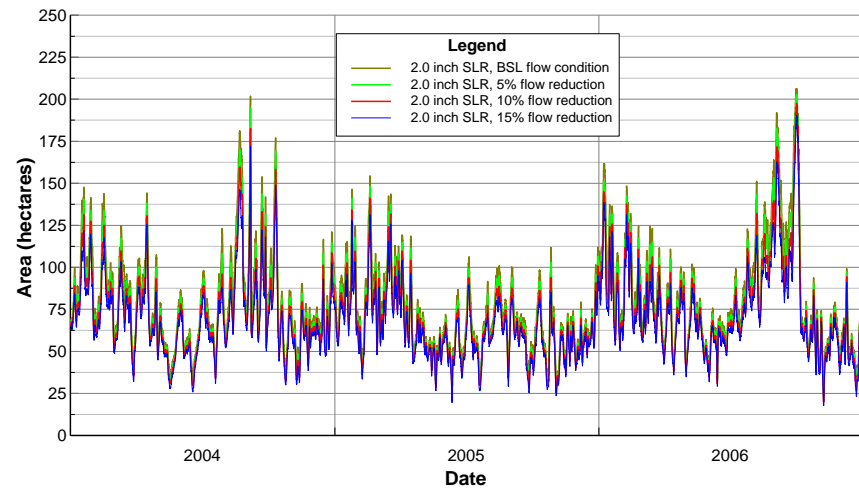
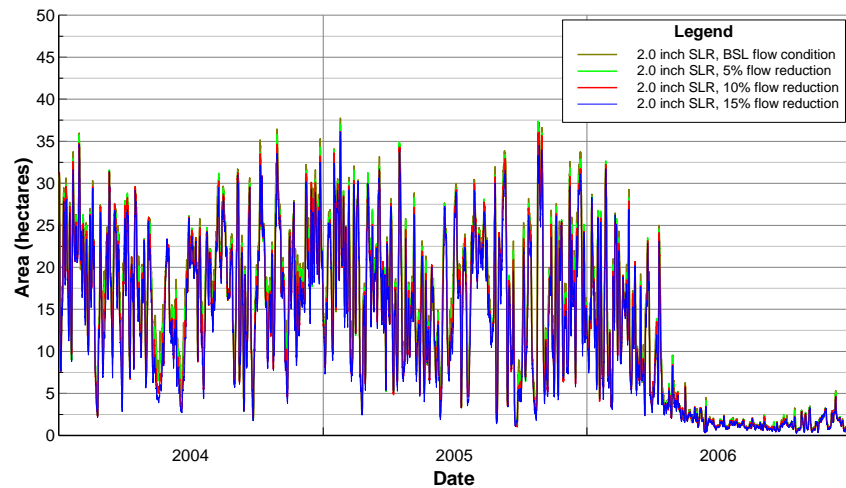


Figure B20 Daily Bottom area of water: salinity range 0-15ppt, current sea level.



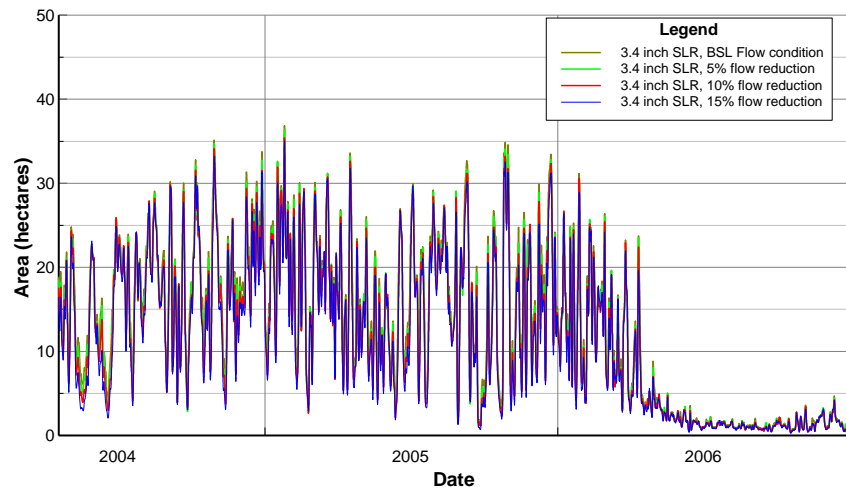


Figure B25 Daily Bottom area of water: salinity range 0-2ppt, 3.4 inch SLR.

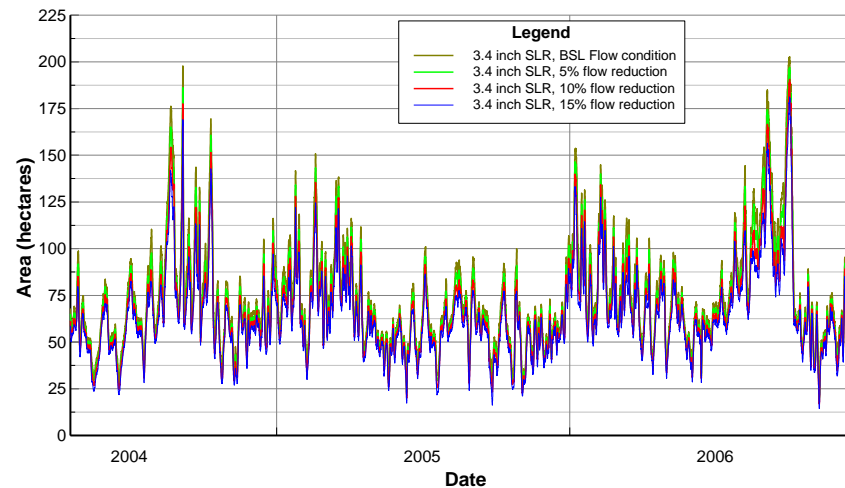


Figure B26 Daily Bottom area of water: salinity range 0-5ppt, 3.4 inch SLR.

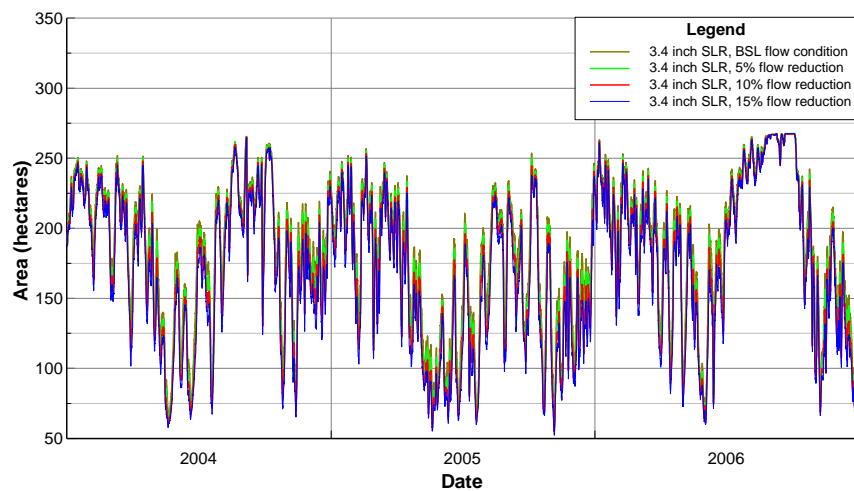


Figure B27 Daily Bottom area of water: salinity range 0-10ppt, 3.4 inch SLR.

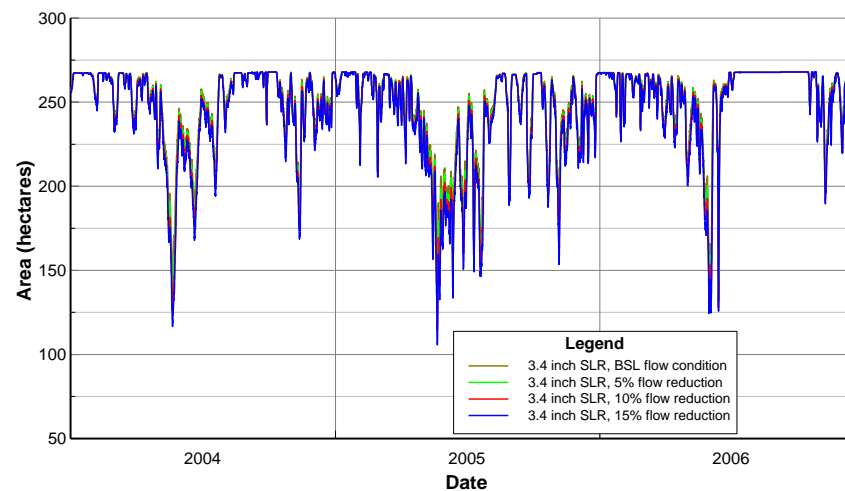
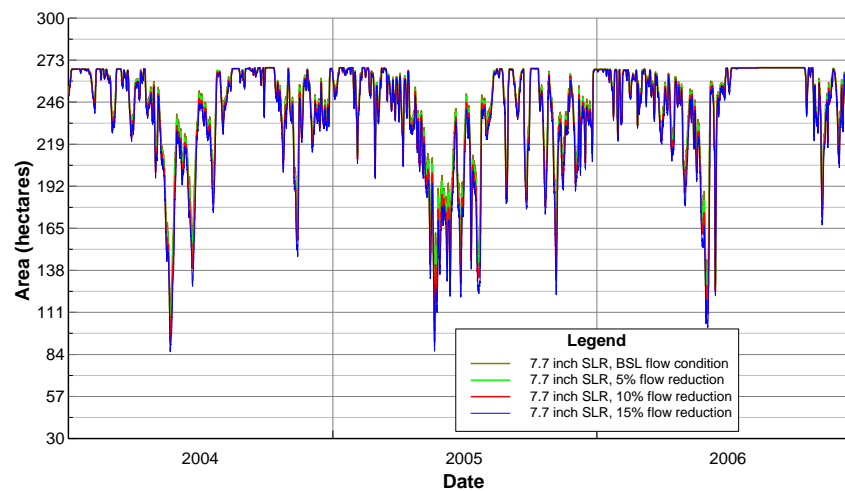
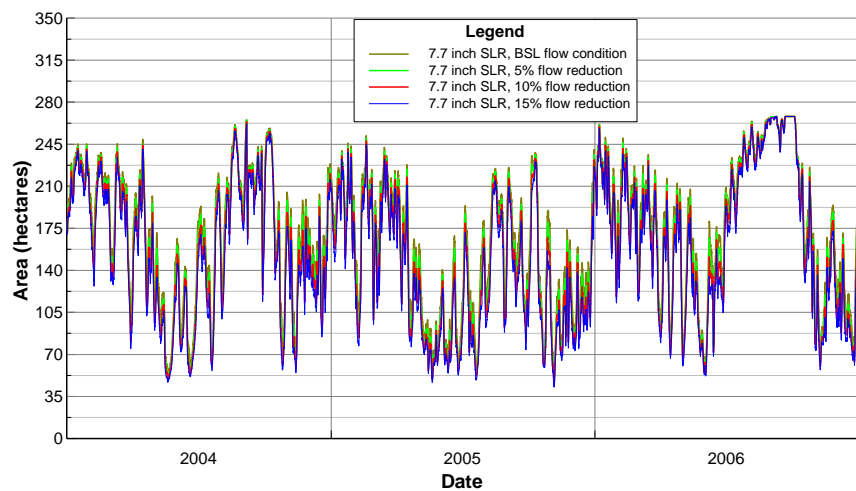
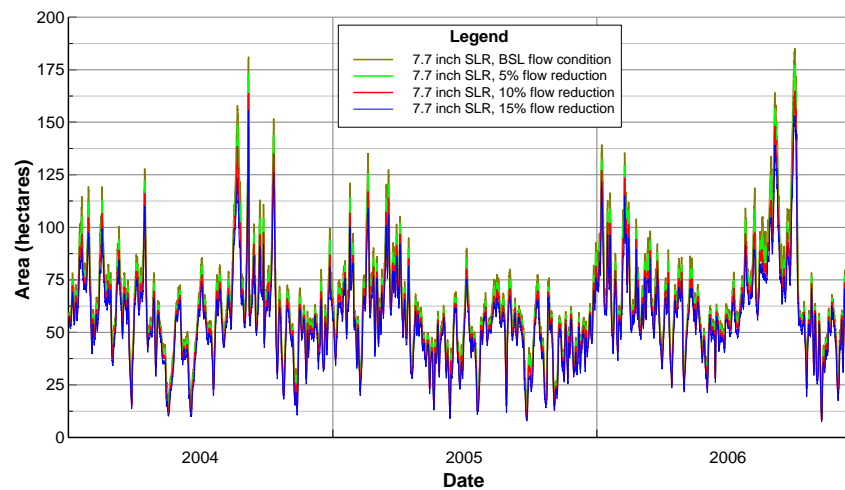
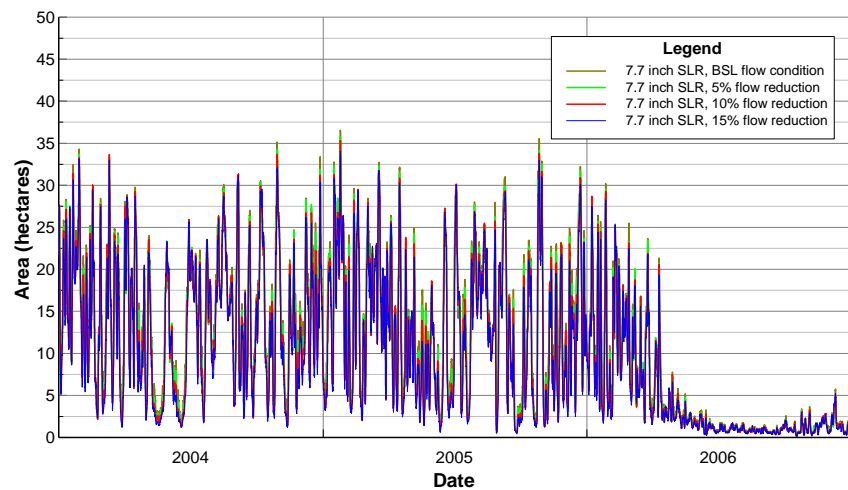


Figure B28 Daily Bottom area of water: salinity range 0-15ppt, 3.4 inch SLR.



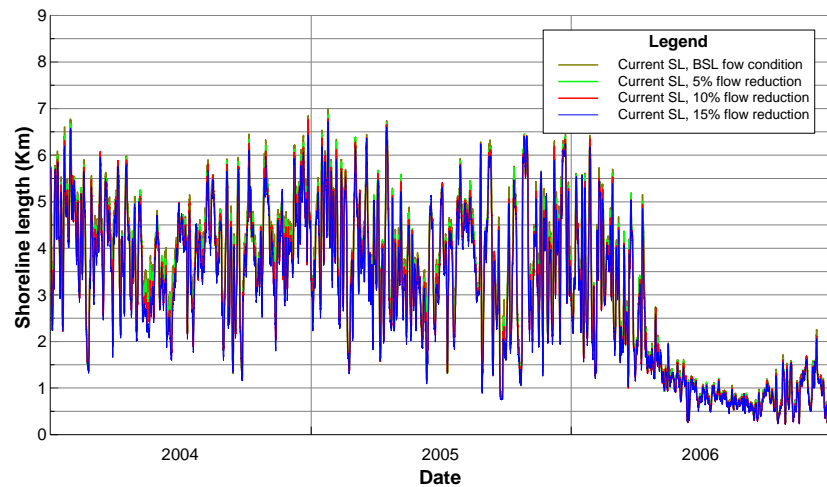


Figure B33 Daily shoreline length of water: salinity range 0-2ppt, current sea level.

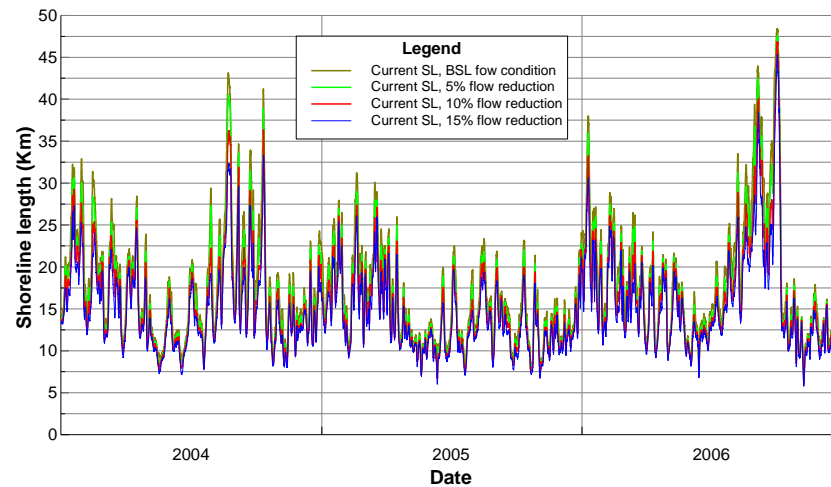


Figure B34 Daily shoreline length of water: salinity range 0-5ppt, current sea level.

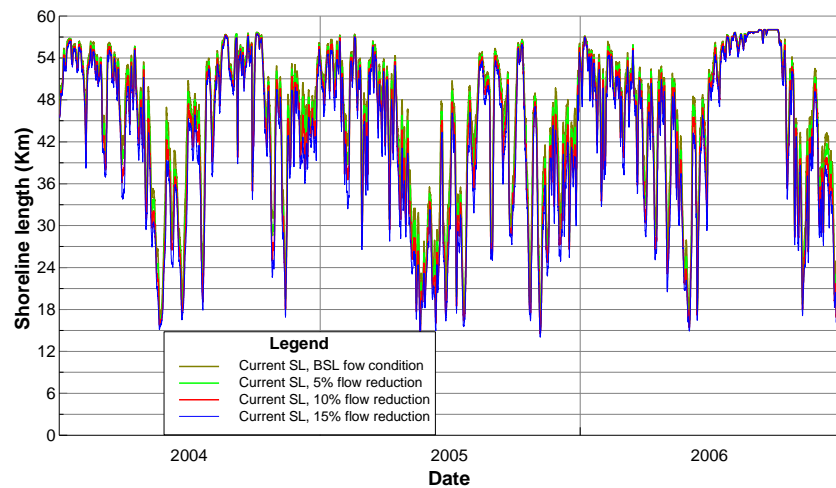


Figure B35 Daily shoreline length of water: salinity range 0-10ppt, current sea level.

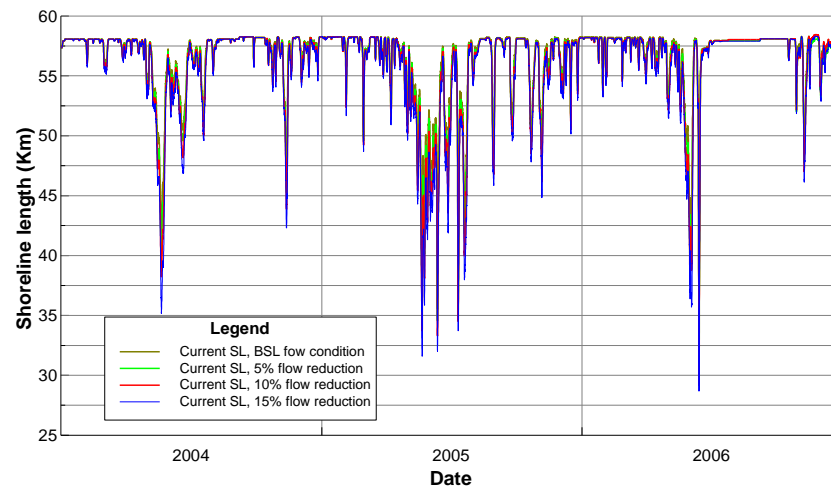


Figure B36 Daily shoreline length of water: salinity range 0-15ppt, current sea level.

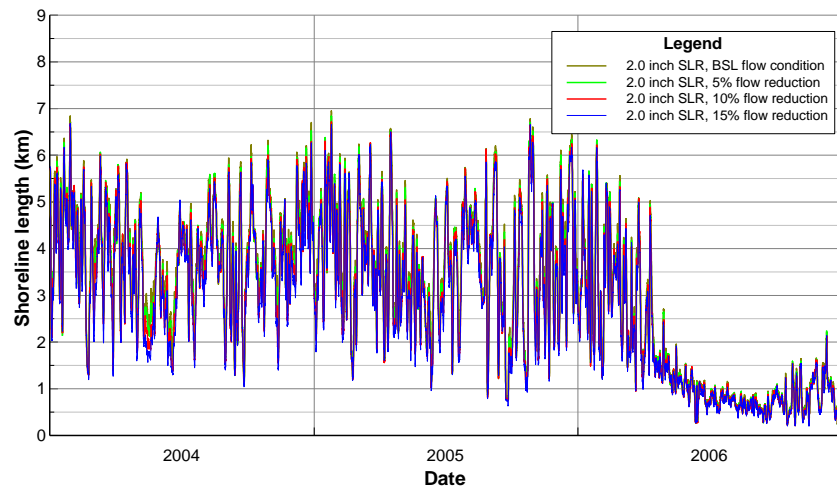


Figure B37 Daily shoreline length of water: salinity range 0-2ppt, 2.0 inch SLR.

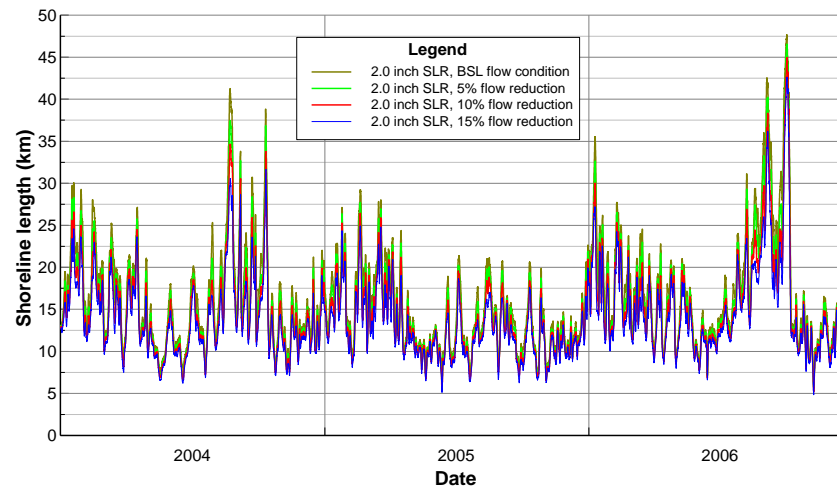


Figure B38 Daily shoreline length of water: salinity range 0-5ppt, 2.0 inch SLR.

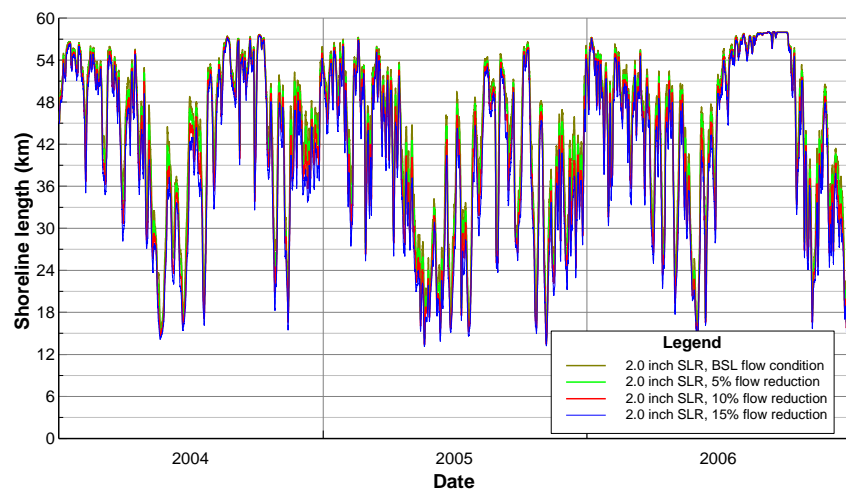


Figure B39 Daily shoreline length of water: salinity range 0-10ppt, 2.0 inch SLR.

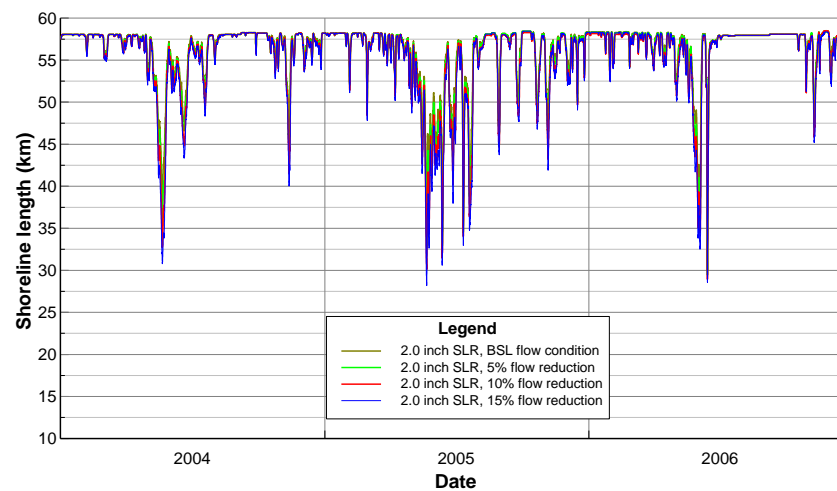


Figure B40 Daily shoreline length of water: salinity range 0-15ppt, 2.0 inch SLR.

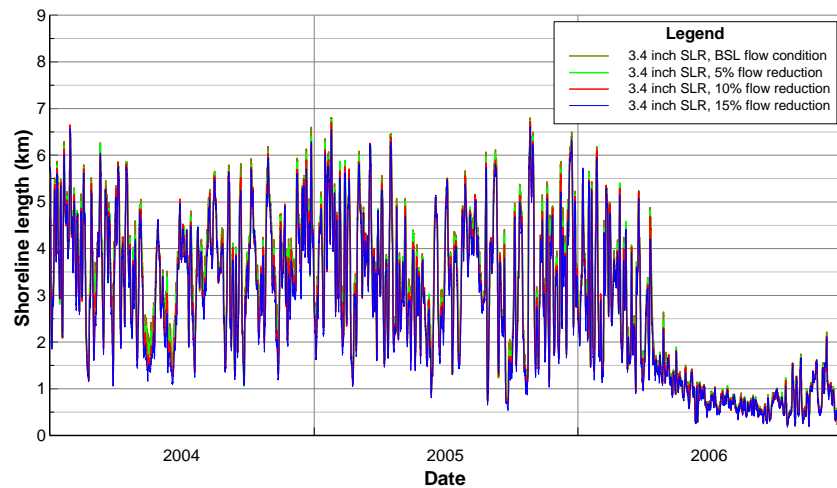


Figure B41 Daily shoreline length of water: salinity range 0-2ppt, 3.4 inch SLR.

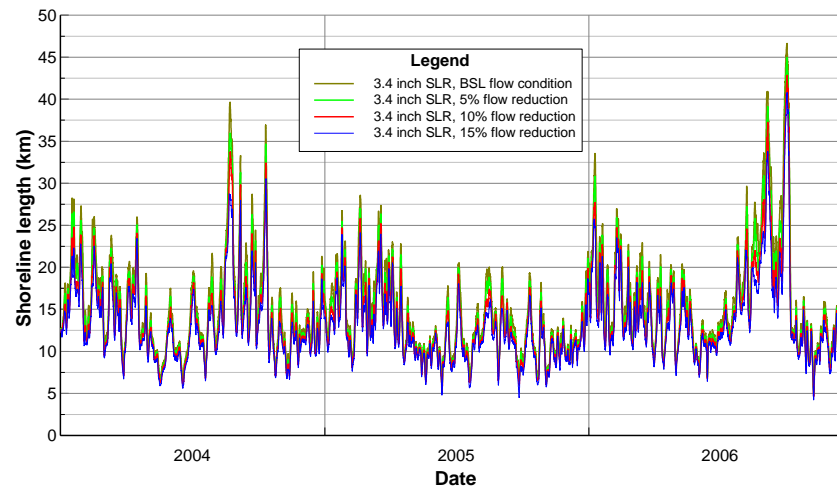


Figure B42 Daily shoreline length of water: salinity range 0-5ppt, 3.4 inch SLR.

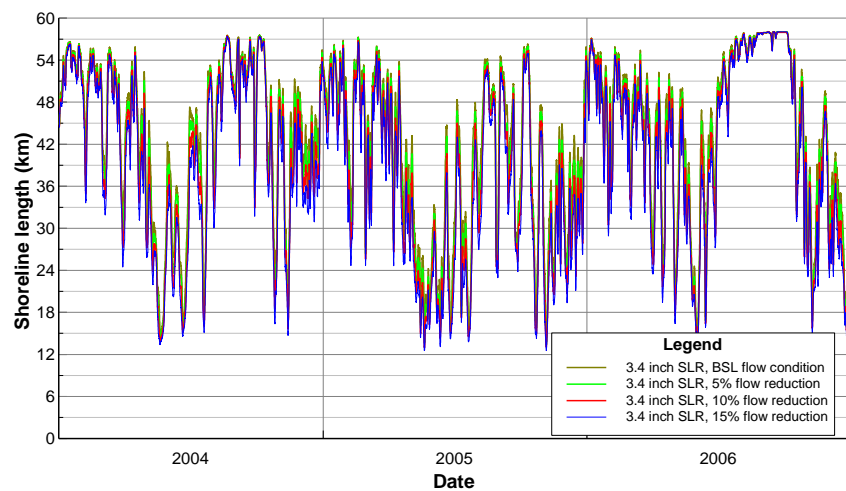


Figure B43 Daily shoreline length of water: salinity range 0-10ppt, 3.4 inch SLR.

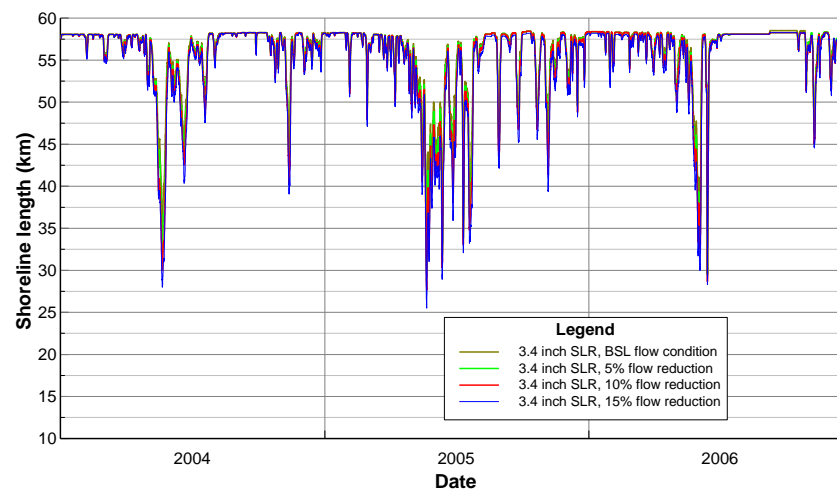


Figure B44 Daily shoreline length of water: salinity range 0-15ppt, 3.4 inch SLR.

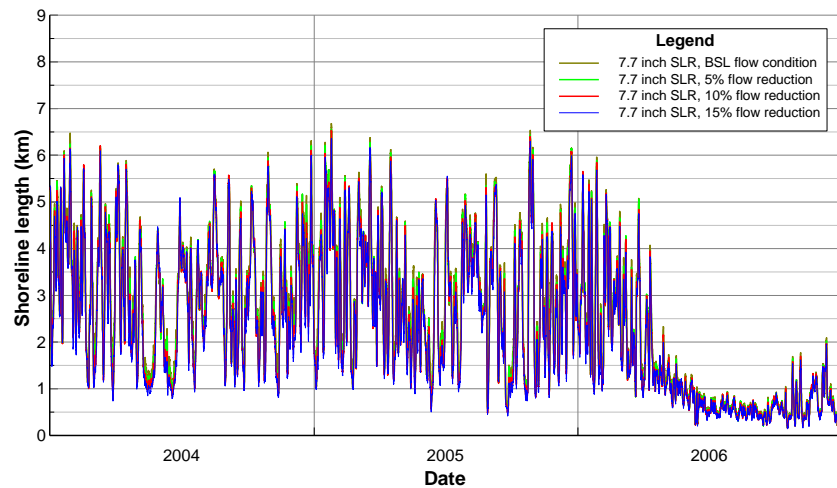


Figure B45 Daily shoreline length of water: salinity range 0-2ppt, 7.7 inch SLR.

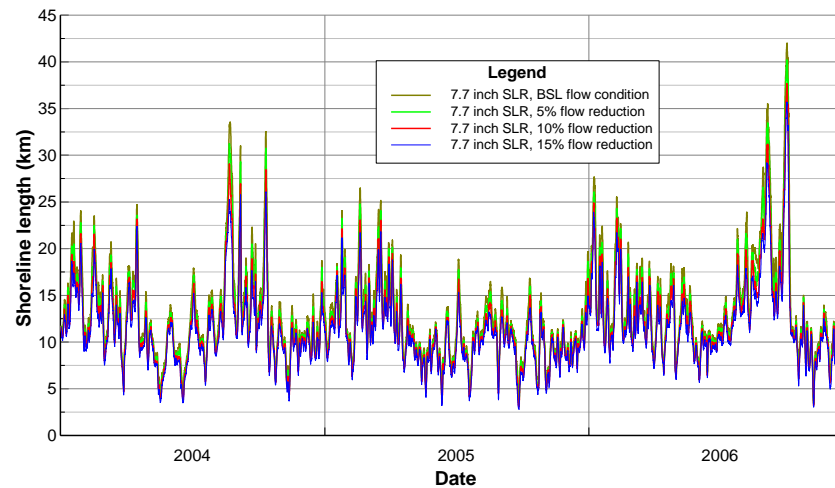


Figure B46 Daily shoreline length of water: salinity range 0-5ppt, 7.7 inch SLR.

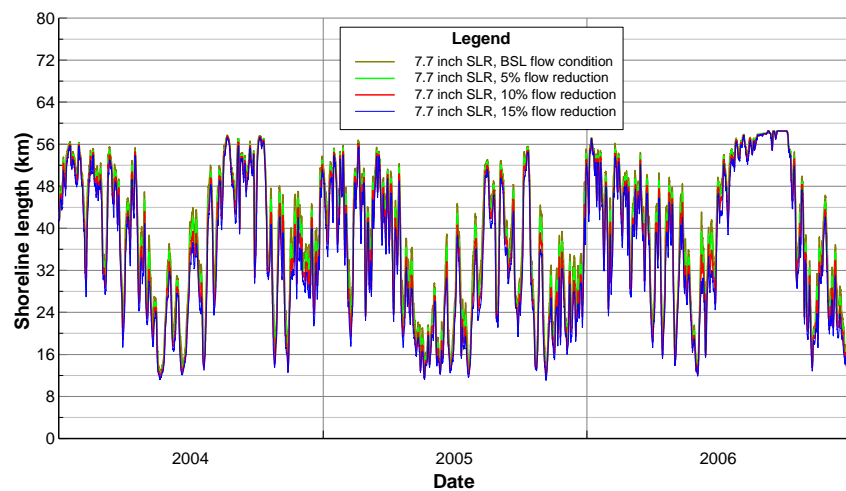


Figure B47 Daily shoreline length of water: salinity range 0-10ppt, 7.7 inch SLR.

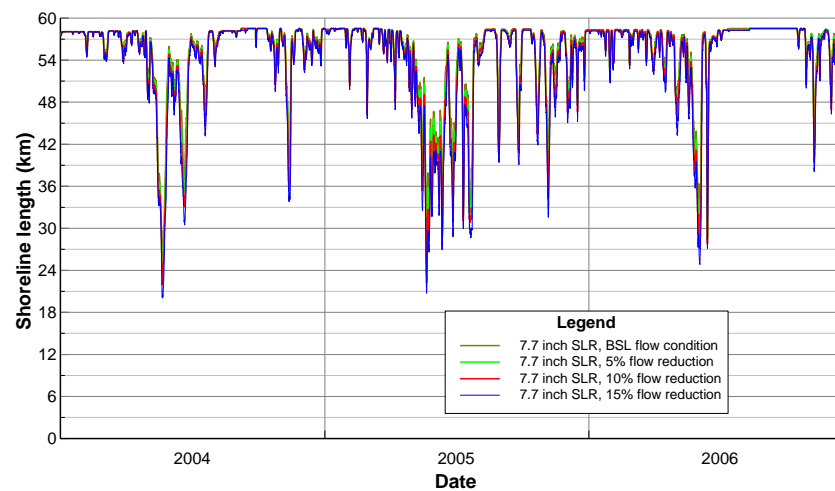


Figure B48 Daily shoreline length of water: salinity range 0-15ppt, 7.7 inch SLR.

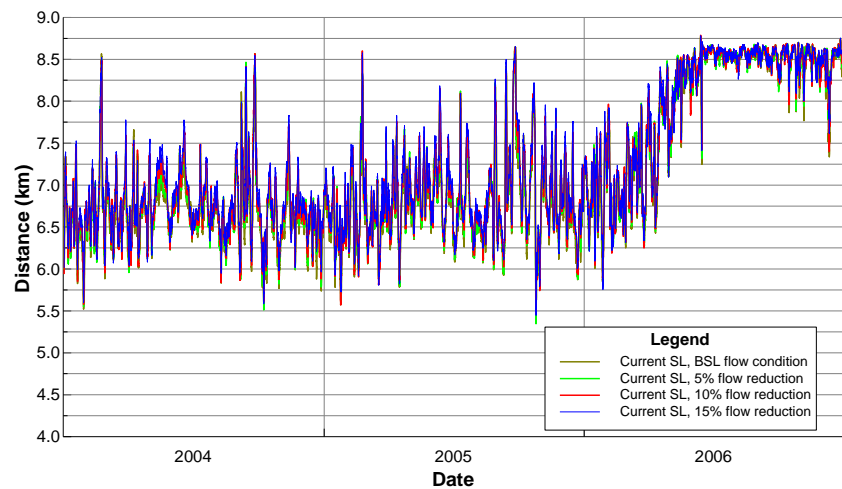


Figure B49 Daily isohaline location of water: salinity range 0-2ppt, current sea level.

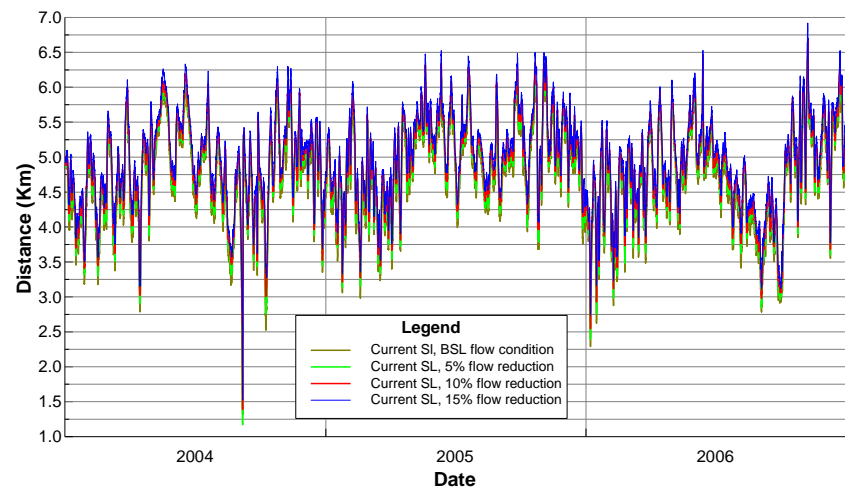


Figure B50 Daily isohaline location of water: salinity range 0-5ppt, current sea level.

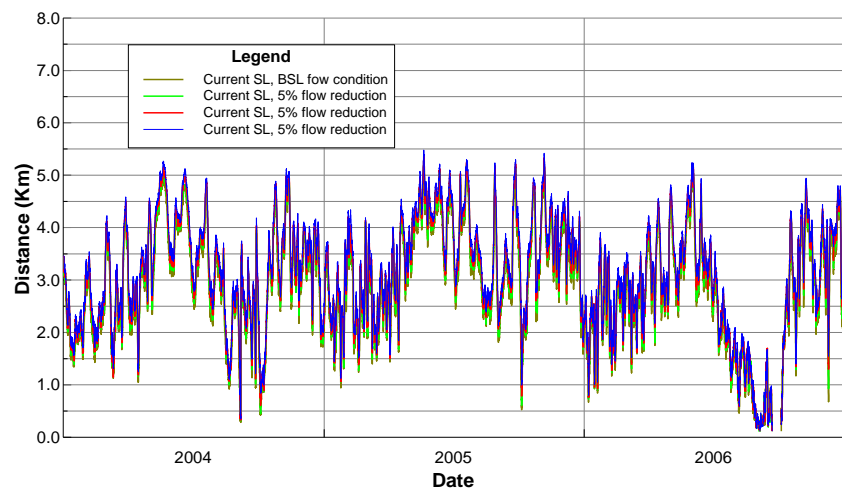


Figure B51 Daily isohaline location of water: salinity range 0-10ppt, current sea level.

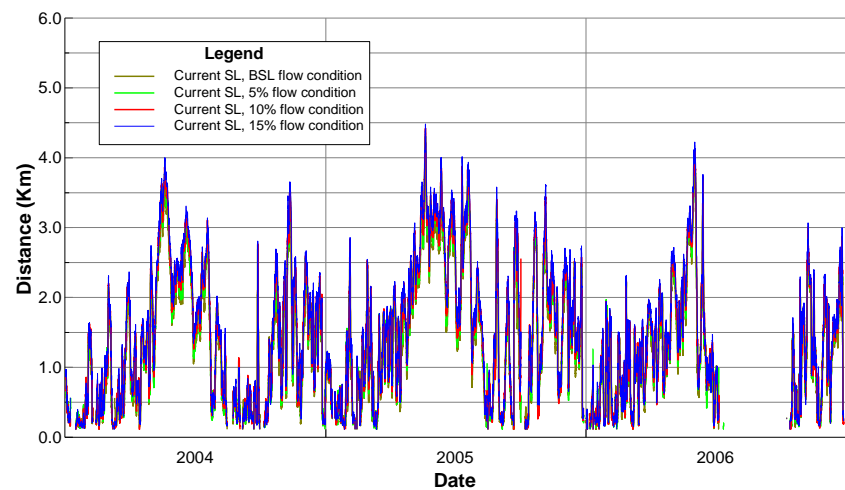


Figure B52 Daily isohaline location of water: salinity range 0-15ppt, current sea level.

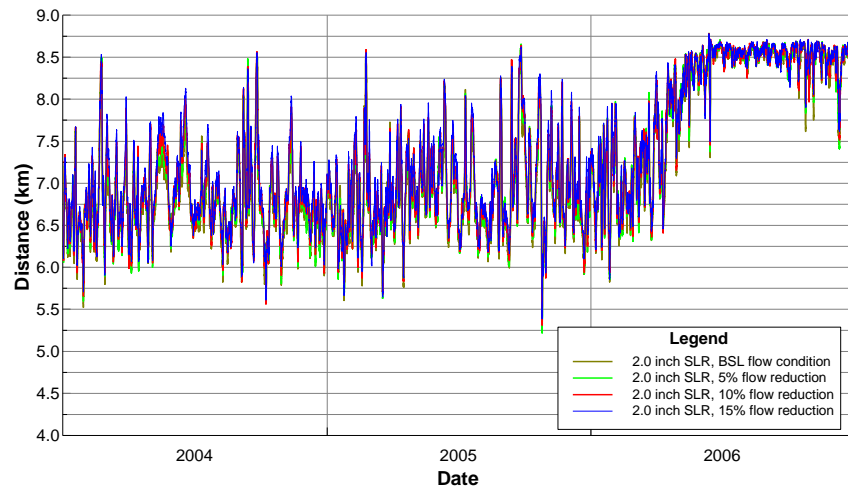


Figure B53 Daily isohaline location of water: salinity range 0-2ppt, 2.0 inch SLR.

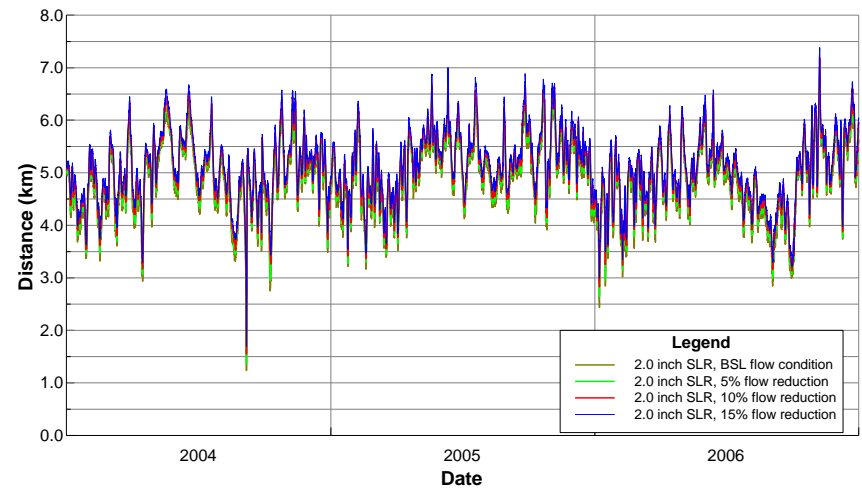


Figure B54 Daily isohaline location of water: salinity range 0-5ppt, 2.0 inch SLR.

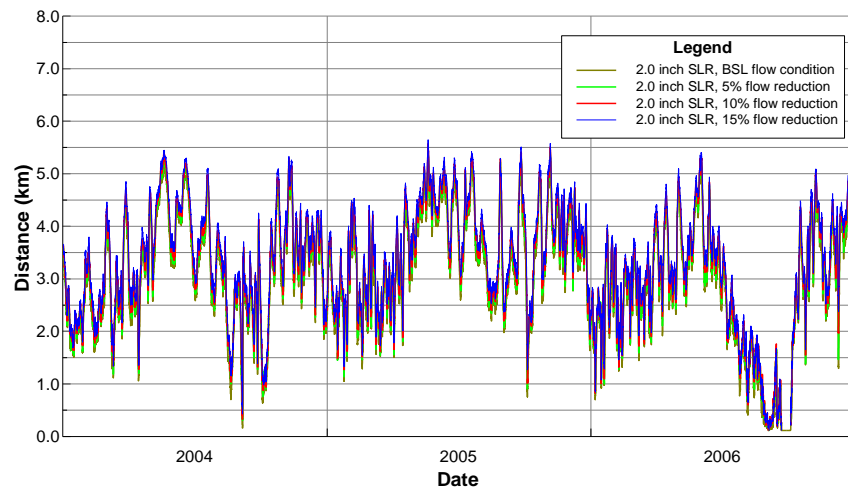


Figure B55 Daily isohaline location of water: salinity range 0-10ppt, 2.0 inch SLR.

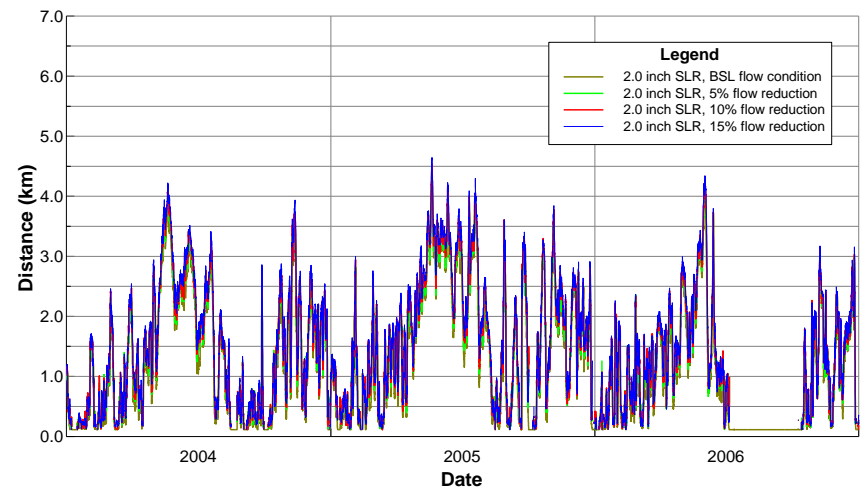


Figure B56 Daily isohaline location of water: salinity range 0-15ppt, 2.0 inch SLR.

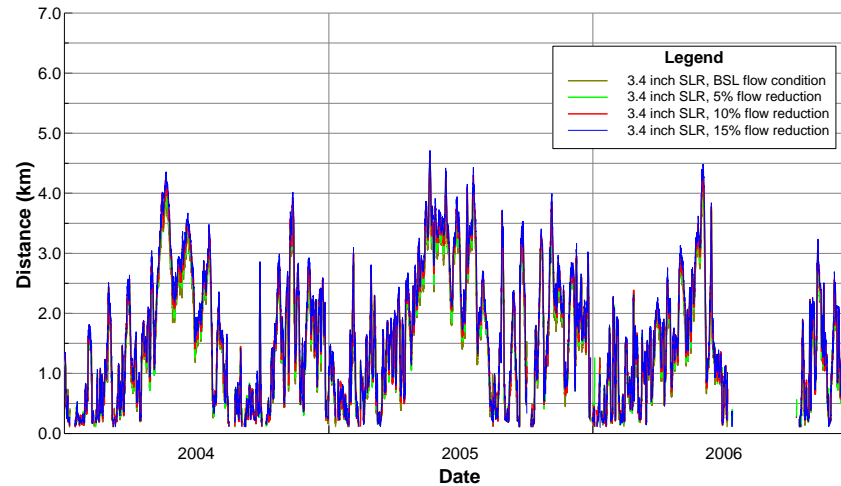
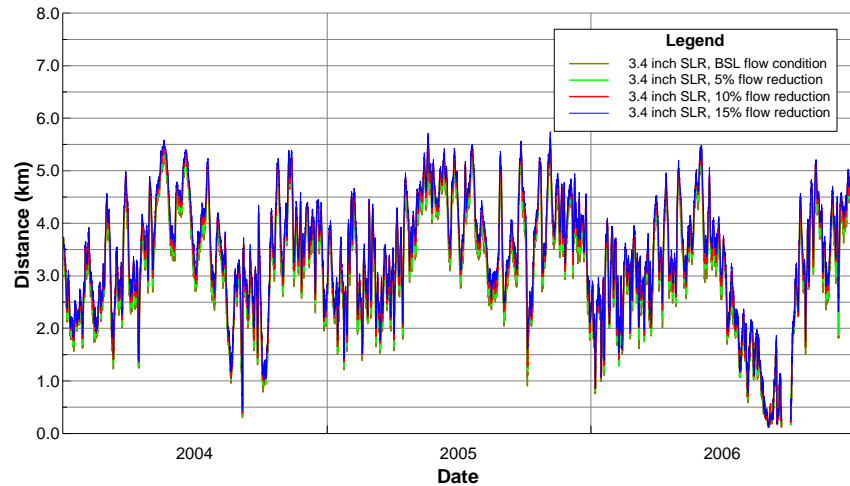
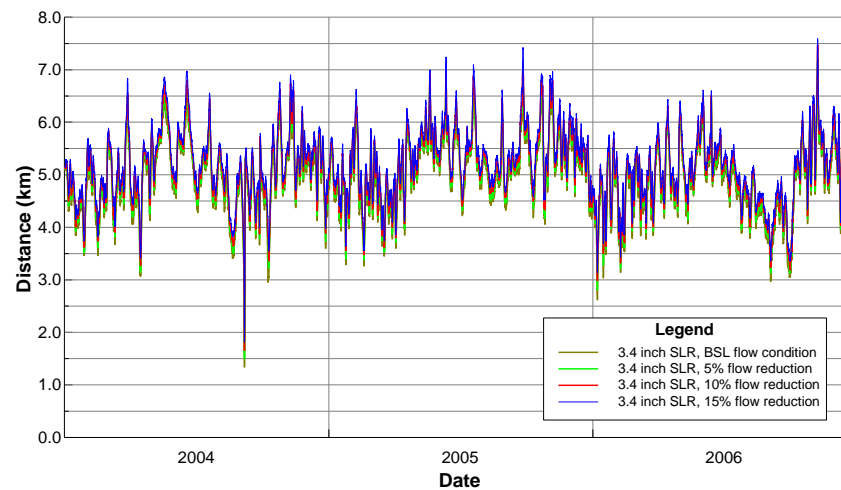
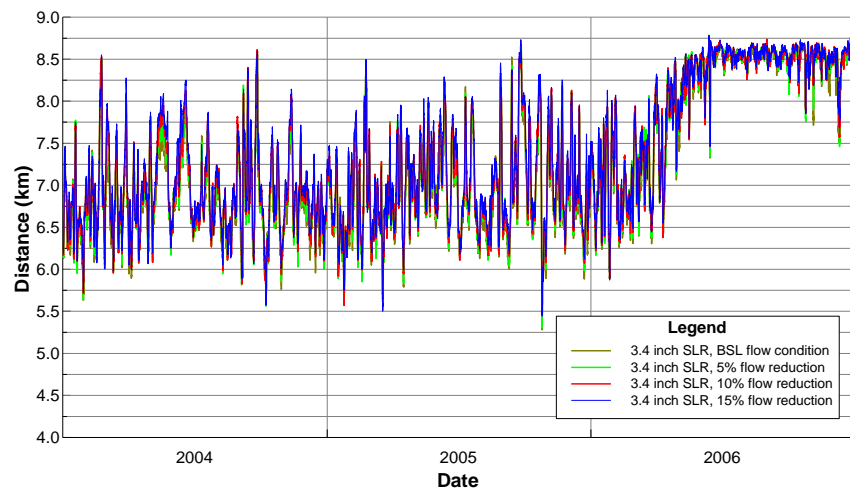
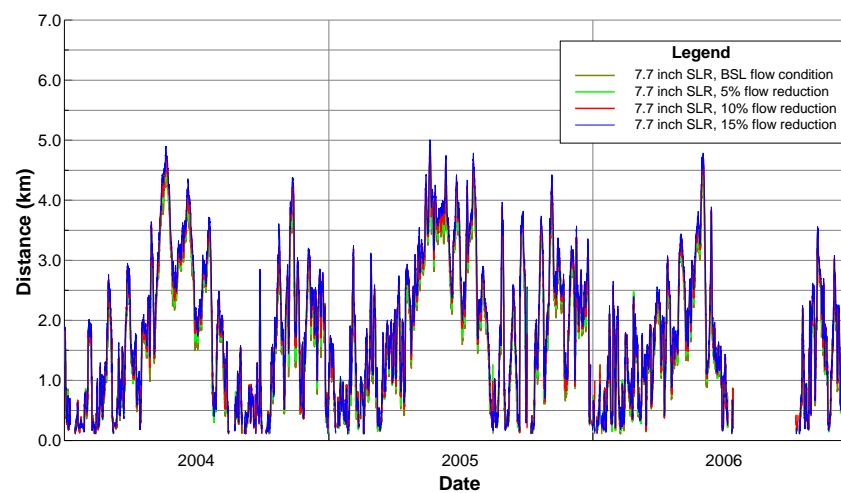
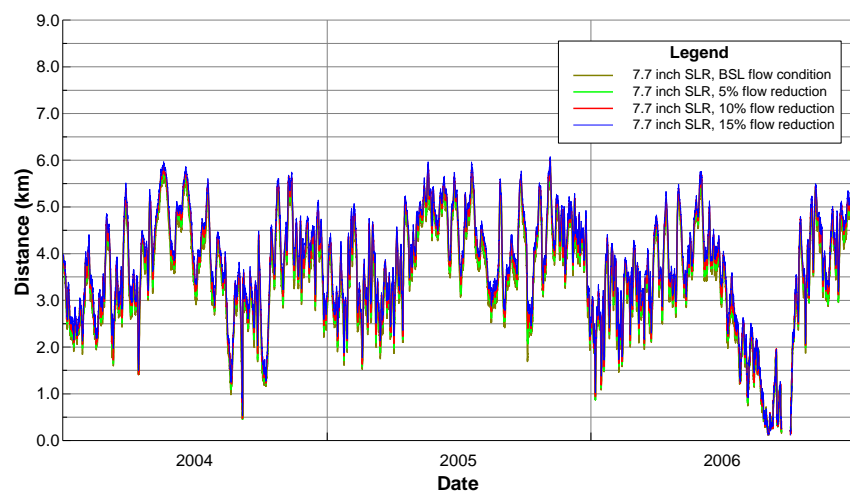
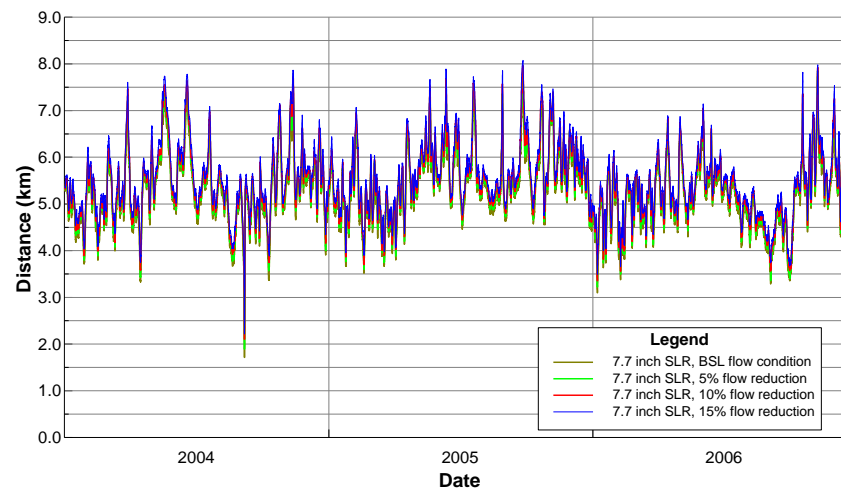
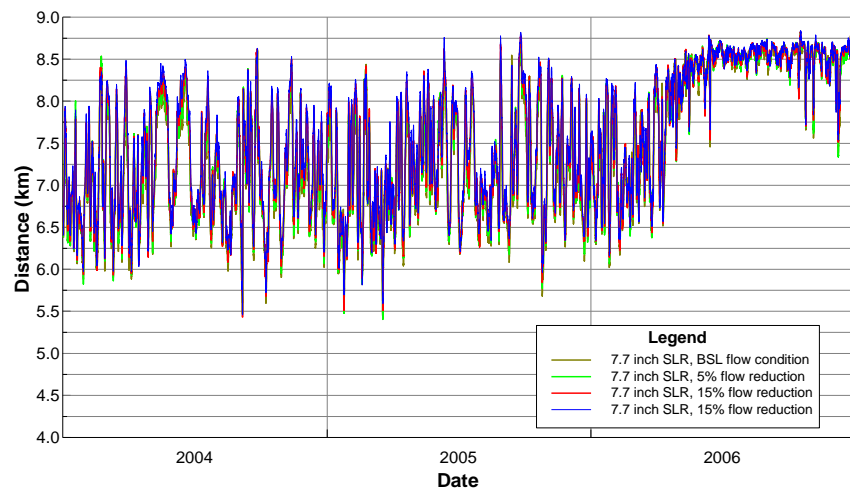


Figure B57 Daily isohaline location of water: salinity range 0-2ppt, 3.4 inch SLR.

Figure B58 Daily isohaline location of water: salinity range 0-5ppt, 3.4 inch SLR.

Figure B59 Daily isohaline location of water: salinity range 0-10ppt, 3.4 inch SLR.

Figure B60 Daily isohaline location of water: salinity range 0-15ppt, 3.4 inch SLR.



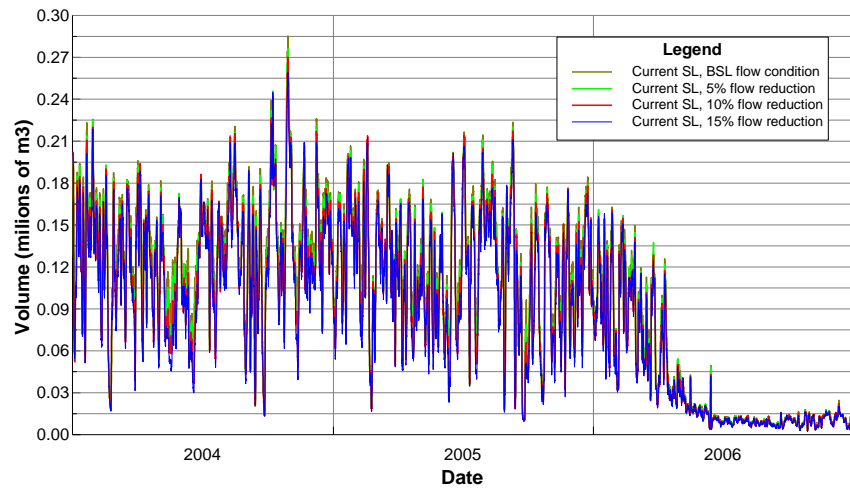


Figure B1 Daily volume of water: salinity range 0-2ppt, current sea level.

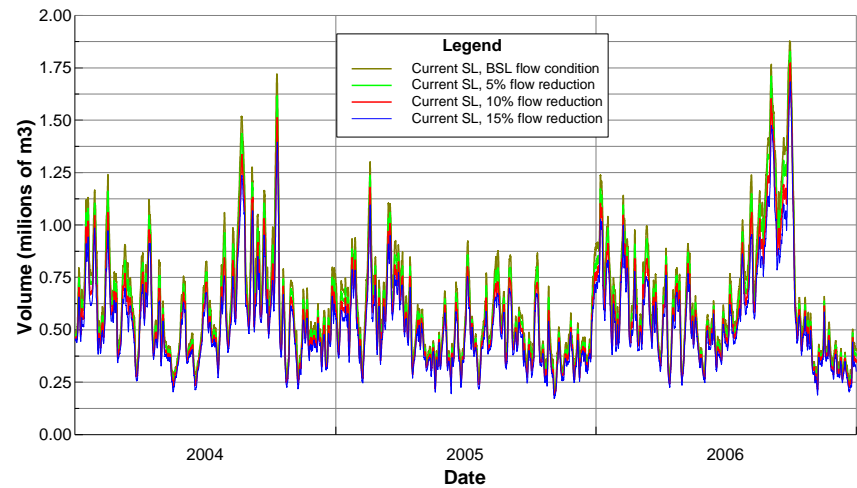


Figure B2 Daily volume of water: salinity range 0-5ppt, current sea level.

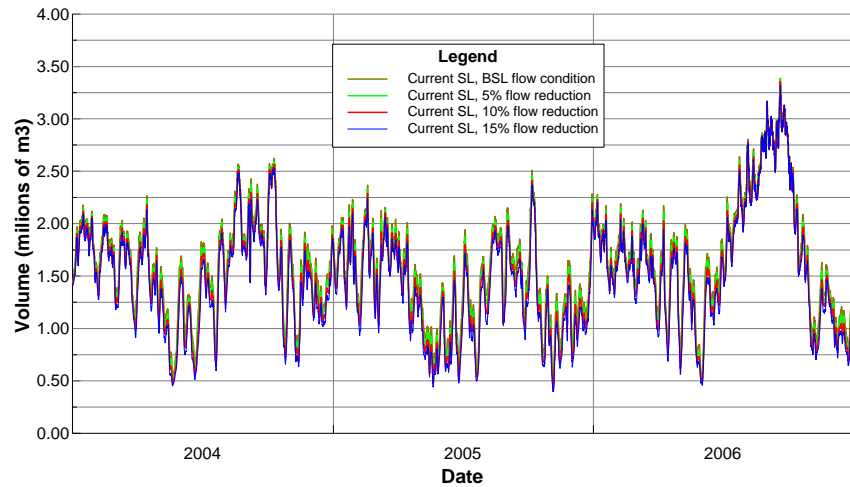


Figure B3 Daily volume of water: salinity range 0-10ppt, current sea level.

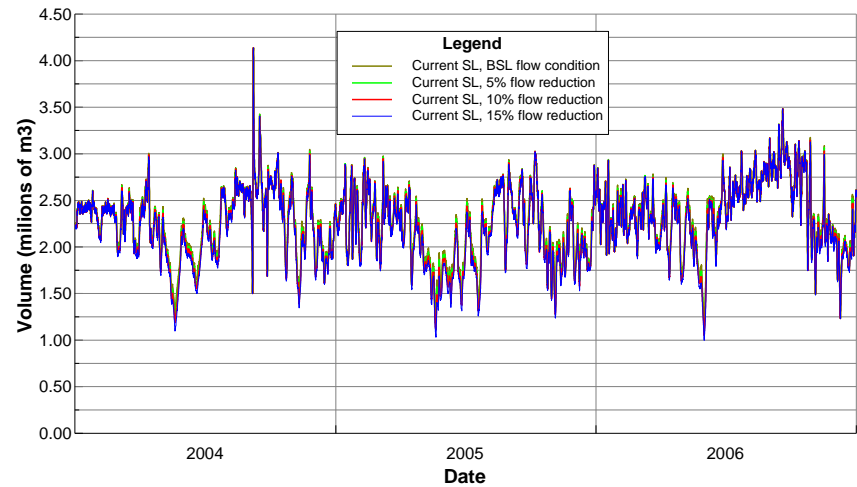


Figure B4 Daily volume of water: salinity range 0-15ppt, current sea level.

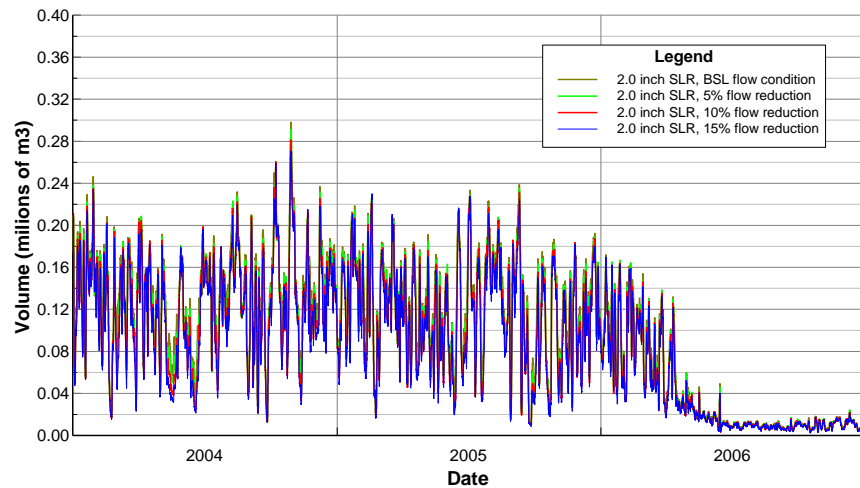


Figure B5 Daily volume of water: salinity range 0-2ppt, 2.0 inch SLR.

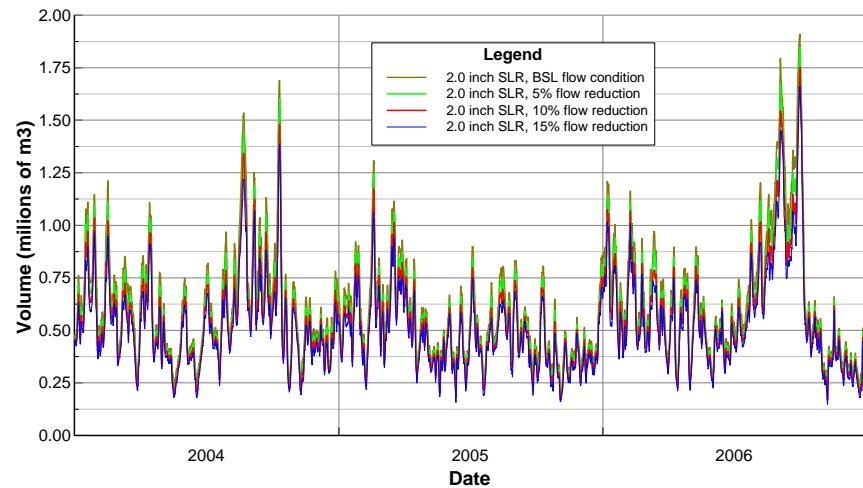


Figure B6 Daily volume of water: salinity range 0-5ppt, 2.0 inch SLR.

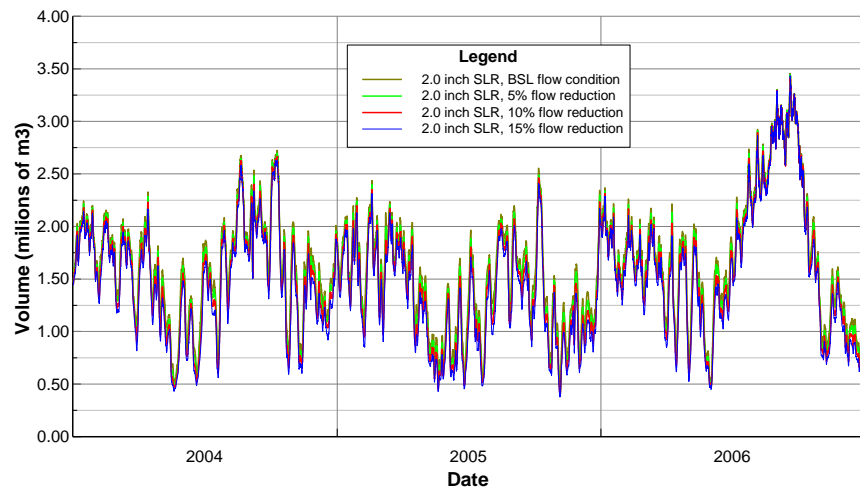


Figure B7 Daily volume of water: salinity range 0-10ppt, 2.0 inch SLR.

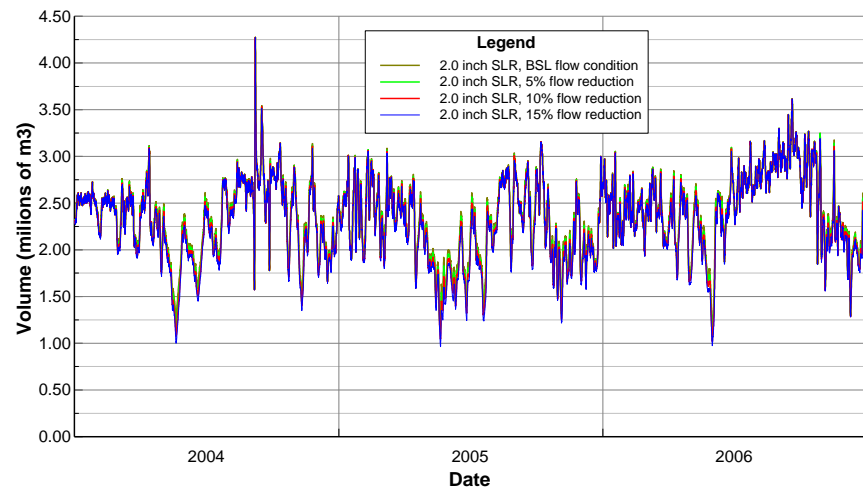


Figure B8 Daily volume of water: salinity range 0-15ppt, 2.0 inch SLR.

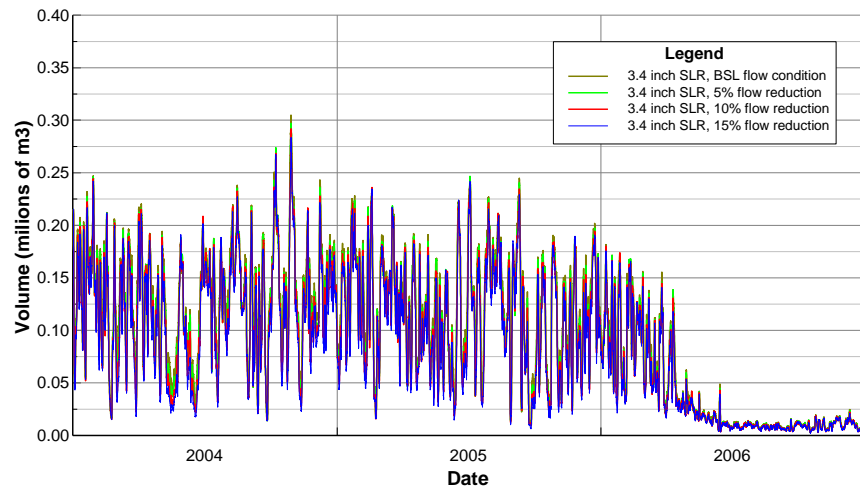


Figure B9 Daily volume of water: salinity range 0-2ppt, 3.4 inch SLR.

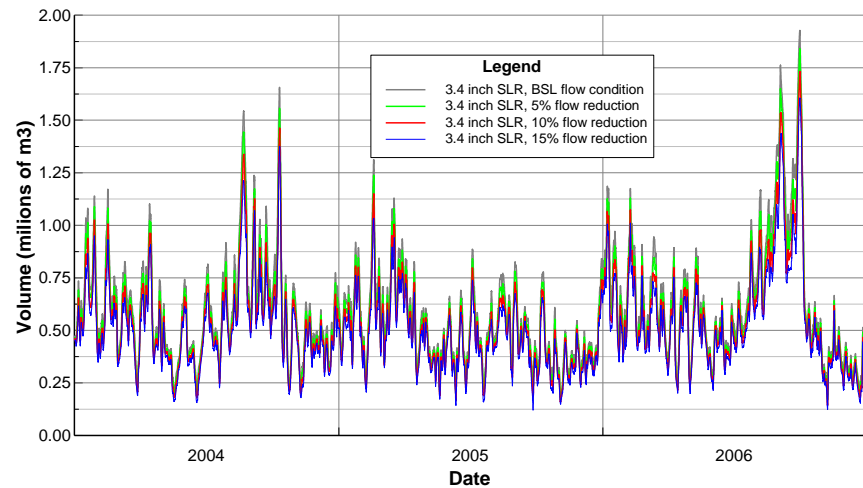


Figure B10 Daily volume of water: salinity range 0-5ppt, 3.4 inch SLR.

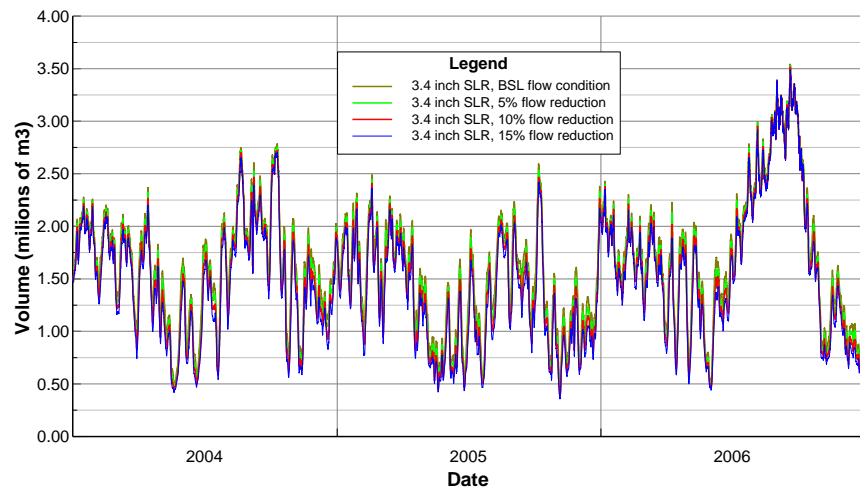


Figure B11 Daily volume of water: salinity range 0-10ppt, 3.4 inch SLR.

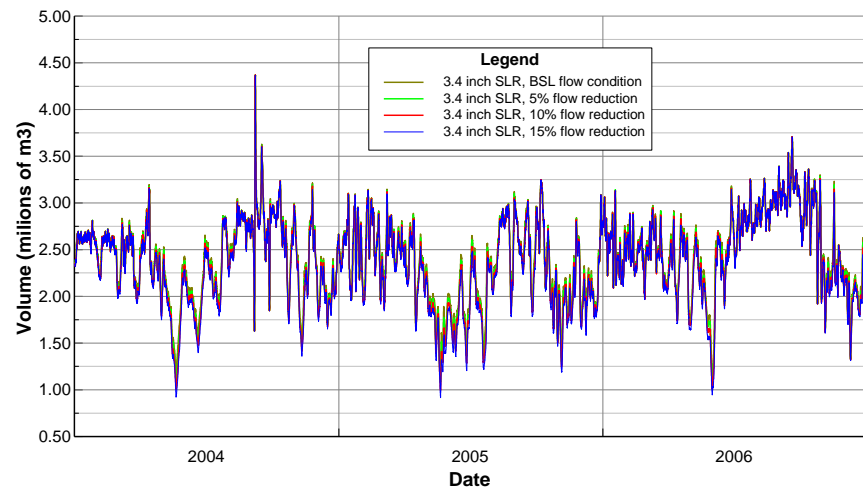


Figure B12 Daily volume of water: salinity range 0-15ppt, 3.4 inch SLR.

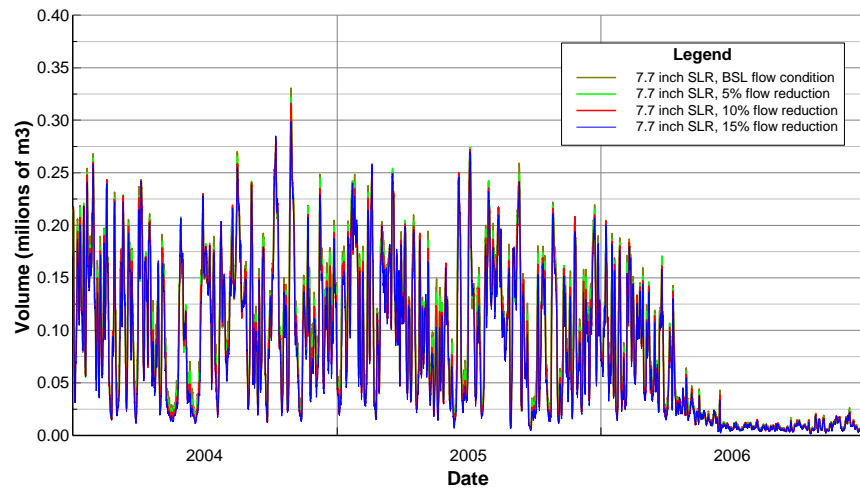


Figure B13 Daily volume of water: salinity range 0-2ppt, 7.7 inch SLR.

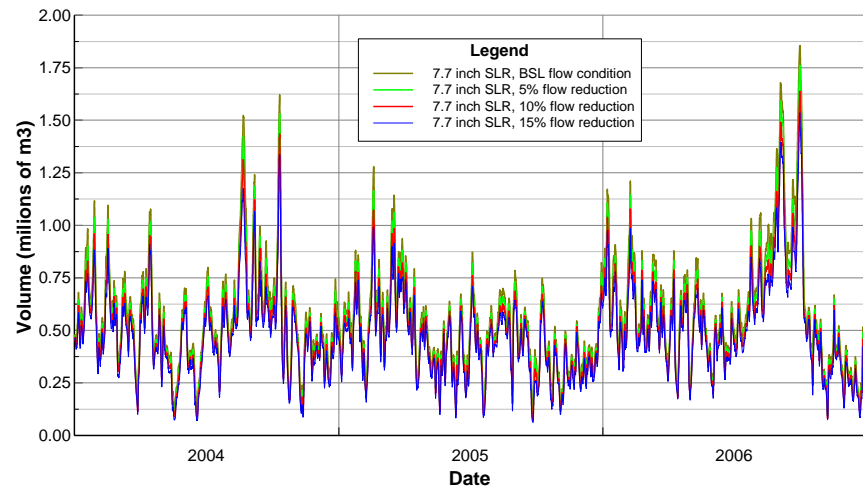


Figure B14 Daily volume of water: salinity range 0-5ppt, 7.7 inch SLR.

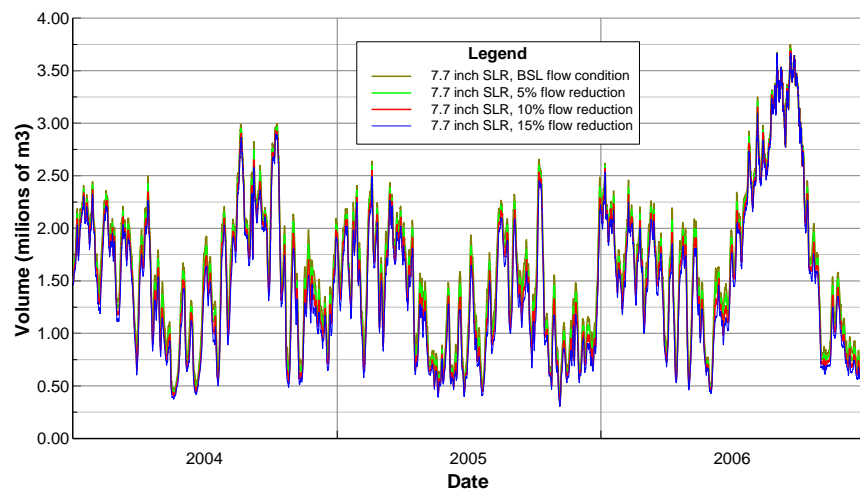


Figure B15 Daily volume of water: salinity range 0-10ppt, 7.7 inch SLR.

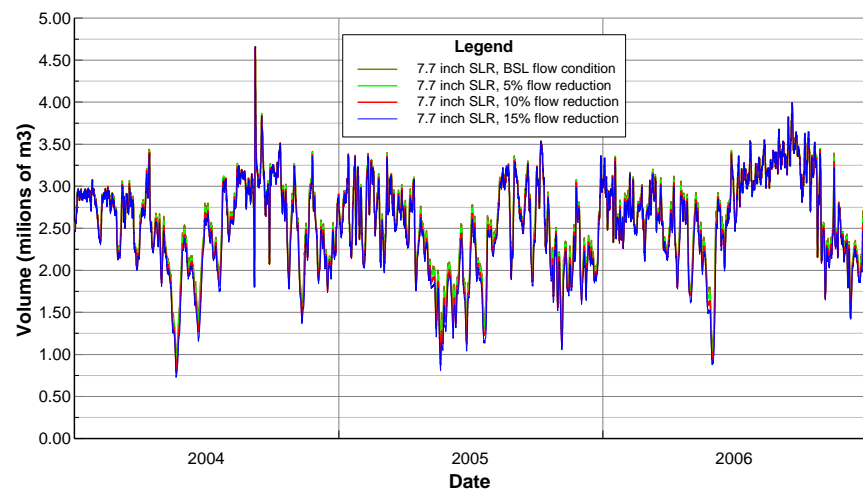


Figure B16 Daily volume of water: salinity range 0-15ppt, 7.7 inch SLR.

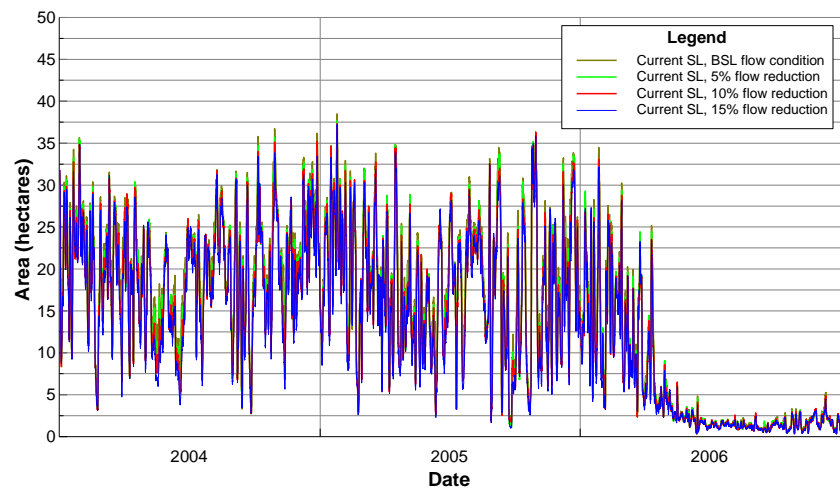


Figure B17 Daily Bottom area of water: salinity range 0-2ppt, current sea level.

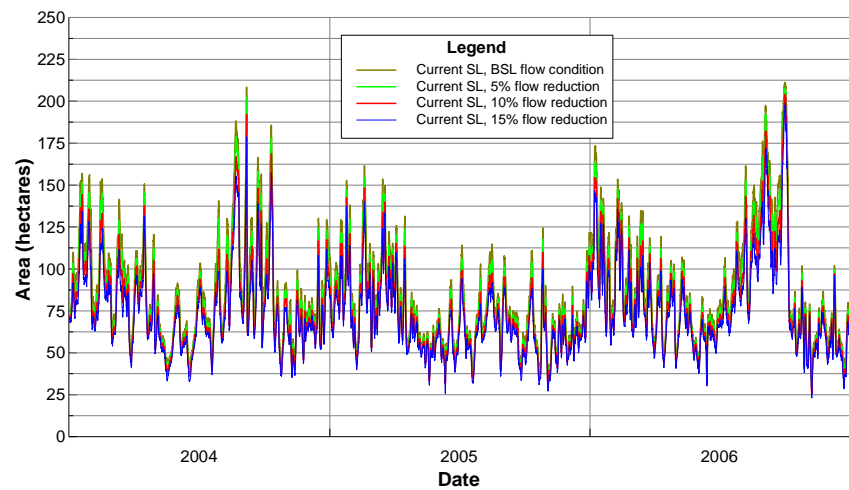


Figure B18 Daily Bottom area of water: salinity range 0-5ppt, current sea level.

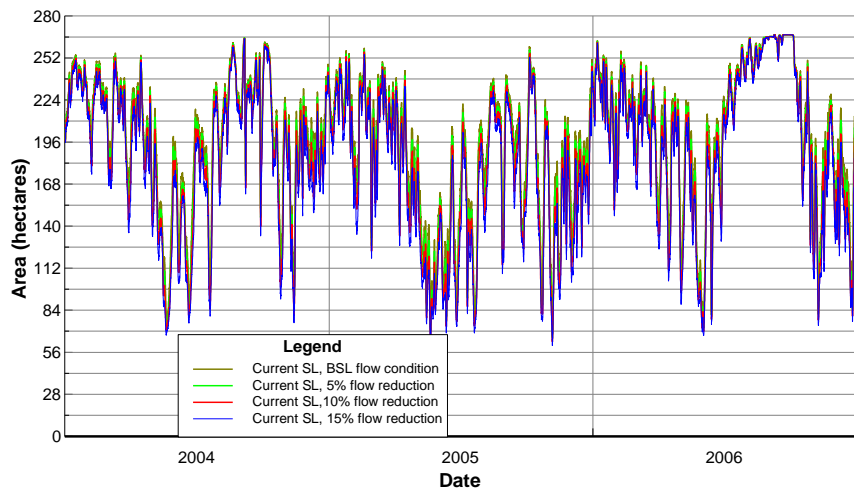


Figure B19 Daily Bottom area of water: salinity range 0-10ppt, current sea level.

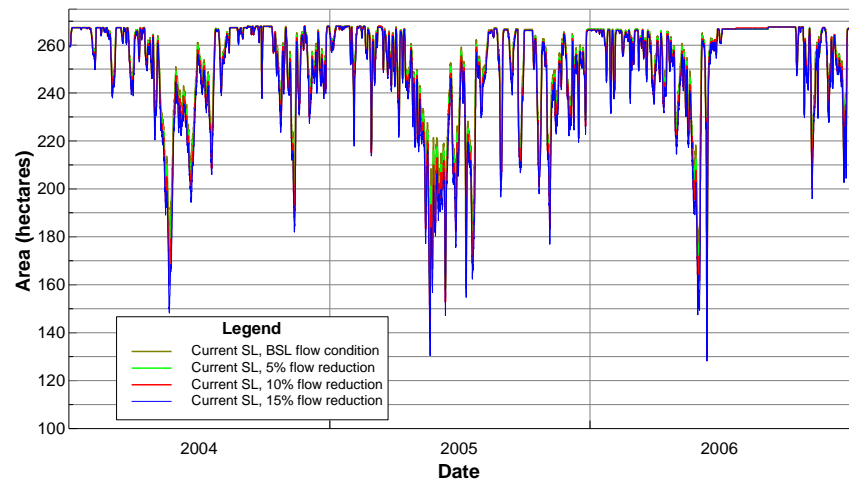


Figure B20 Daily Bottom area of water: salinity range 0-15ppt, current sea level.

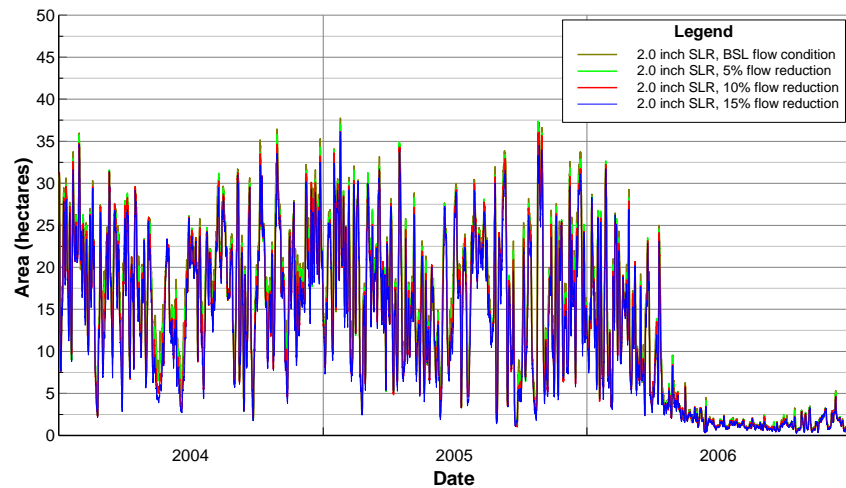


Figure B21 Daily Bottom area of water: salinity range 0-2ppt, 2.0 inch SLR.

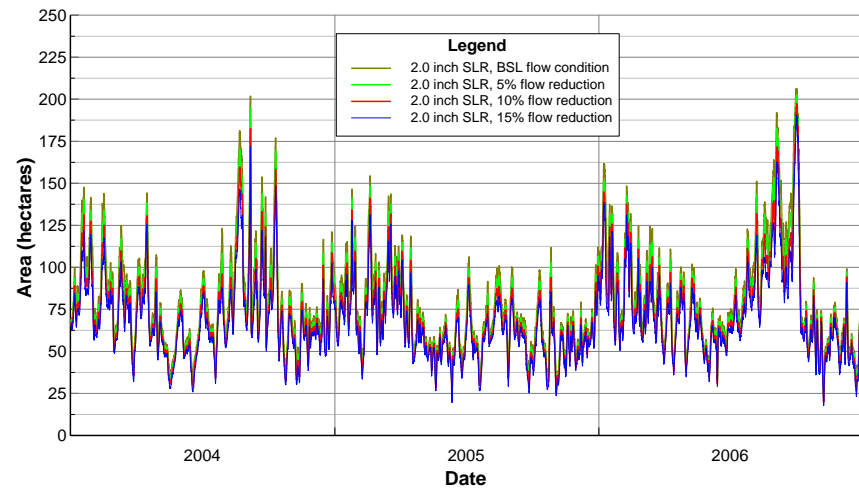


Figure B22 Daily Bottom area of water: salinity range 0-5ppt, 2.0 inch SLR.

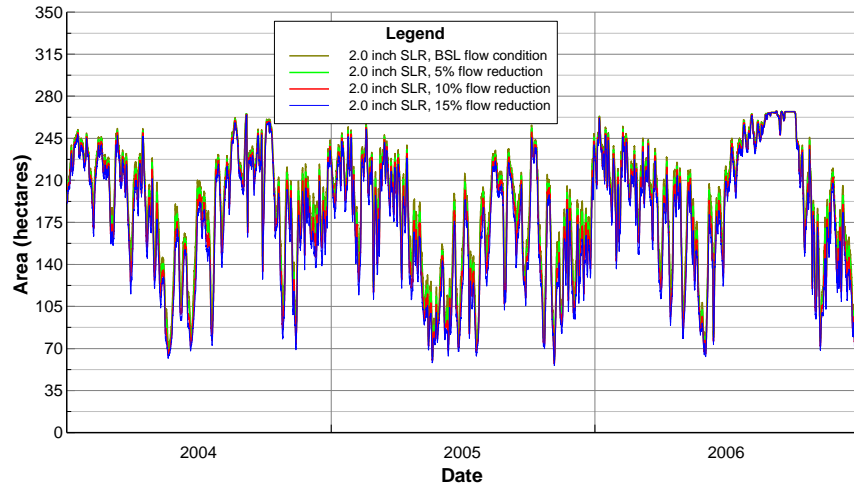


Figure B23 Daily Bottom area of water: salinity range 0-10ppt, 2.0 inch SLR.

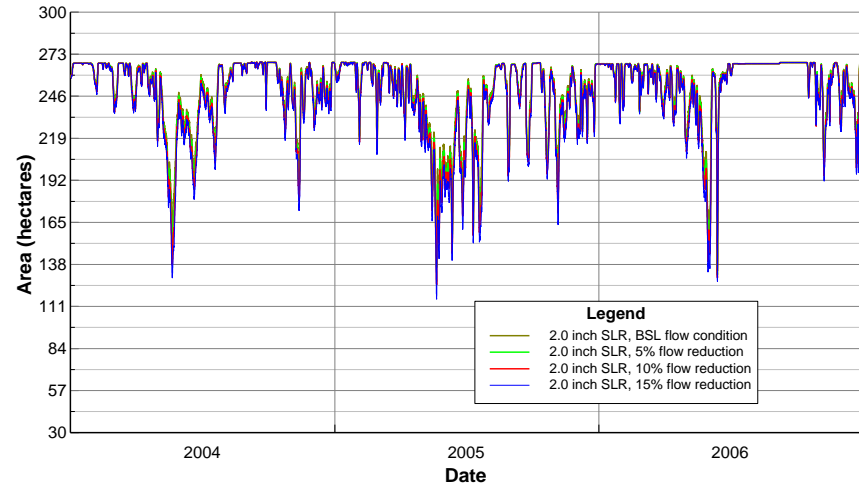


Figure B24 Daily Bottom area of water: salinity range 0-15ppt, 2.0 inch SLR.

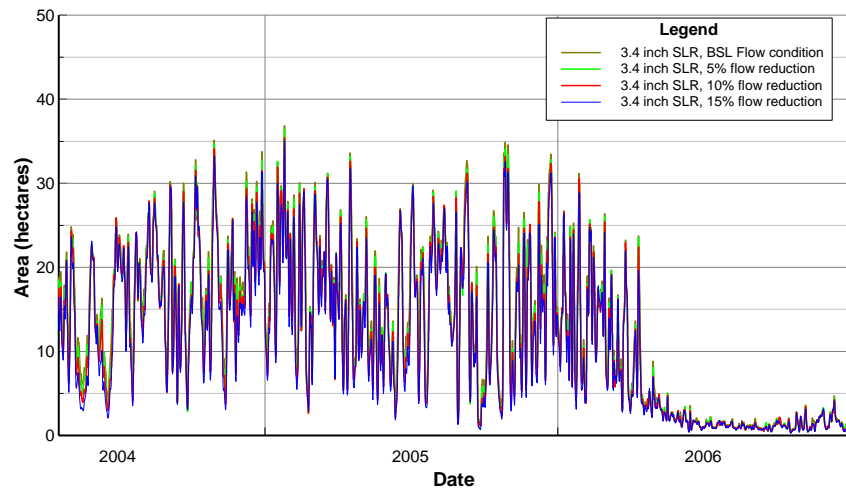


Figure B25 Daily Bottom area of water: salinity range 0-2ppt, 3.4 inch SLR.

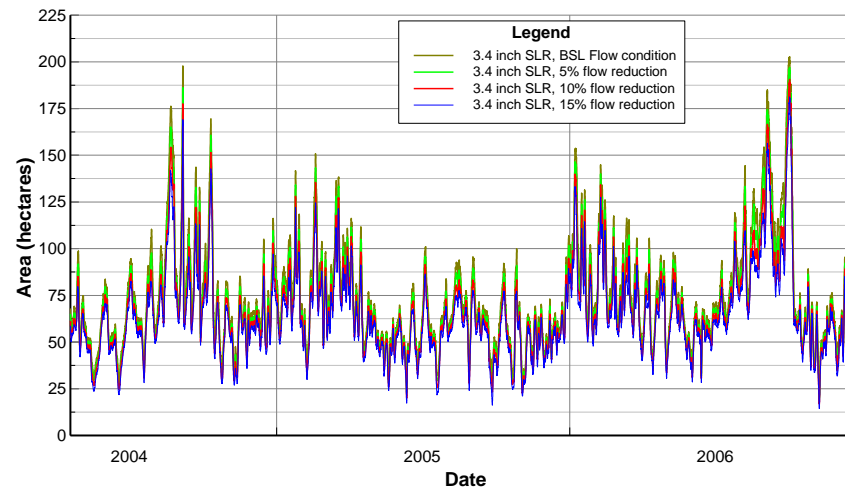


Figure B26 Daily Bottom area of water: salinity range 0-5ppt, 3.4 inch SLR.

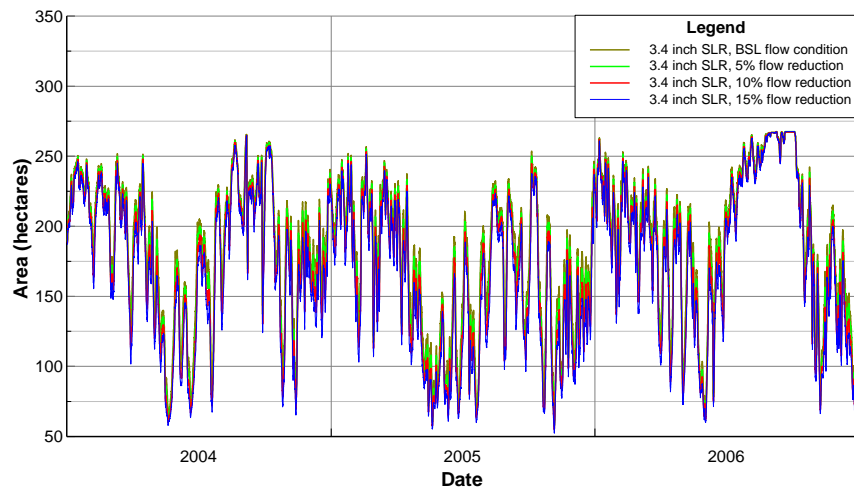


Figure B27 Daily Bottom area of water: salinity range 0-10ppt, 3.4 inch SLR.

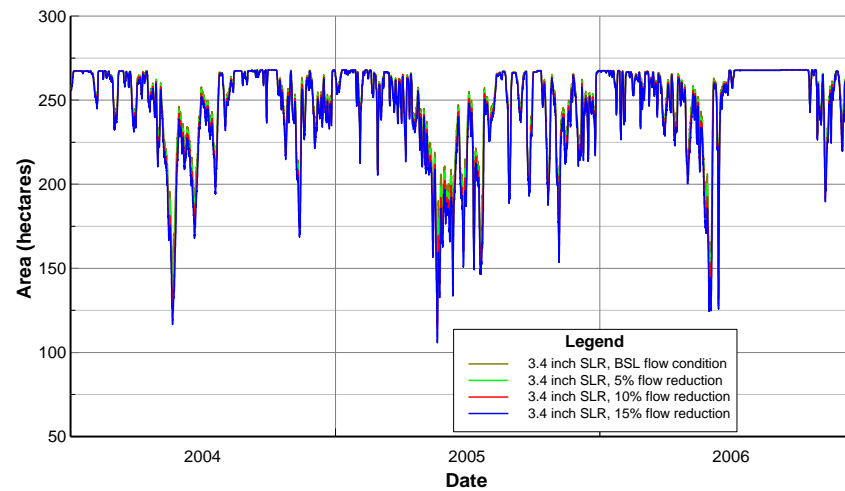
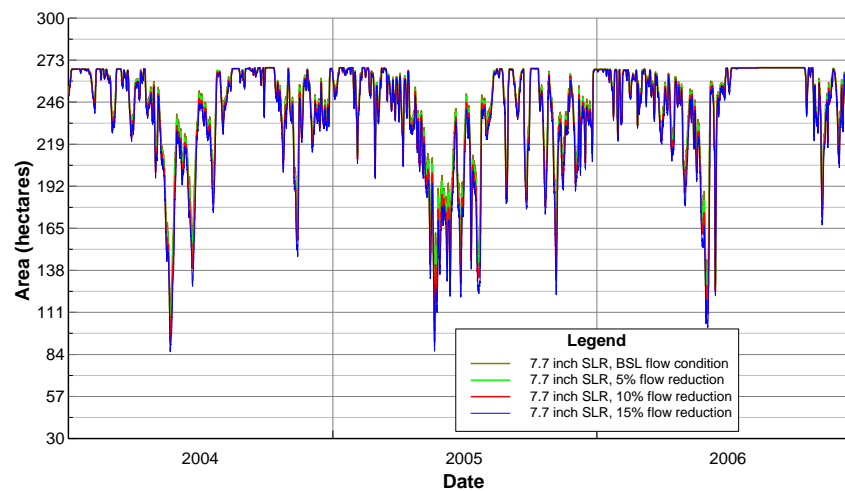
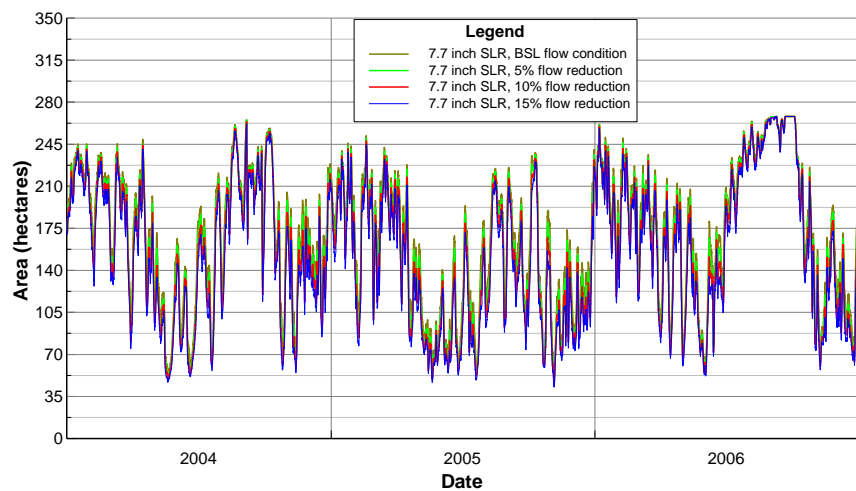
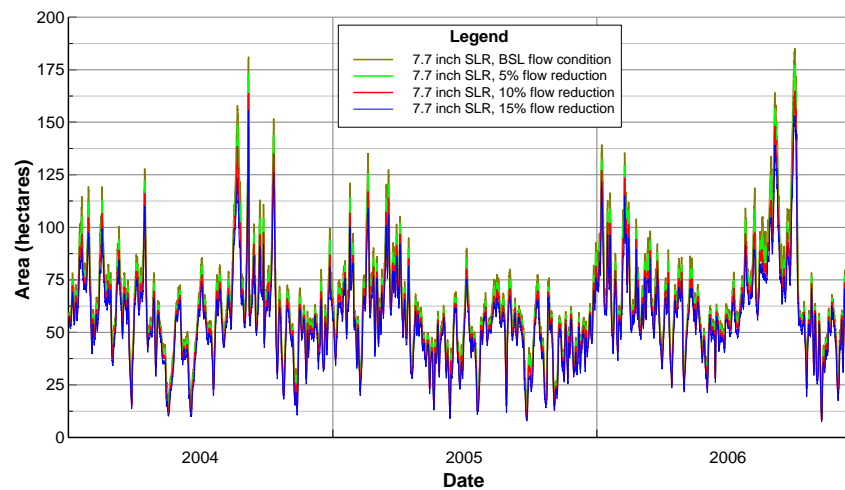
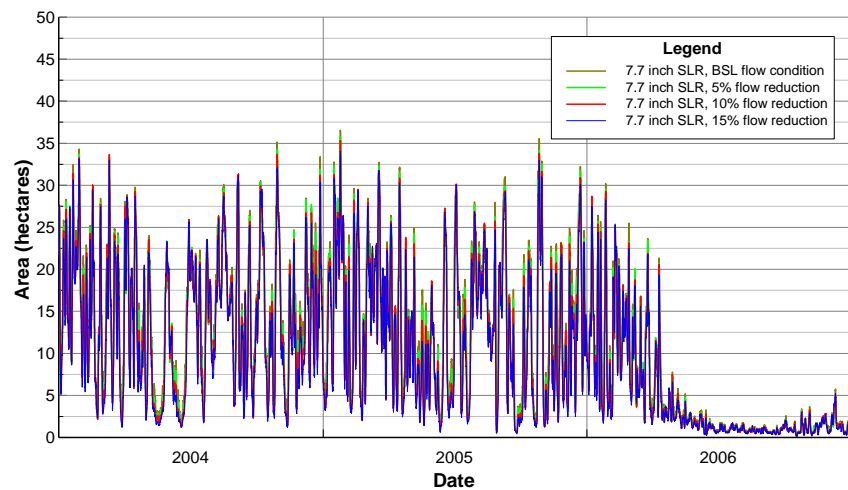


Figure B28 Daily Bottom area of water: salinity range 0-15ppt, 3.4 inch SLR.



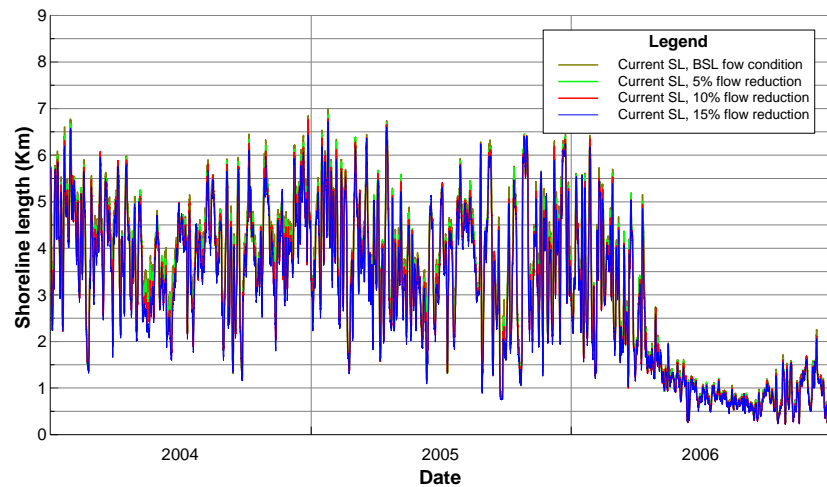


Figure B33 Daily shoreline length of water: salinity range 0-2ppt, current sea level.

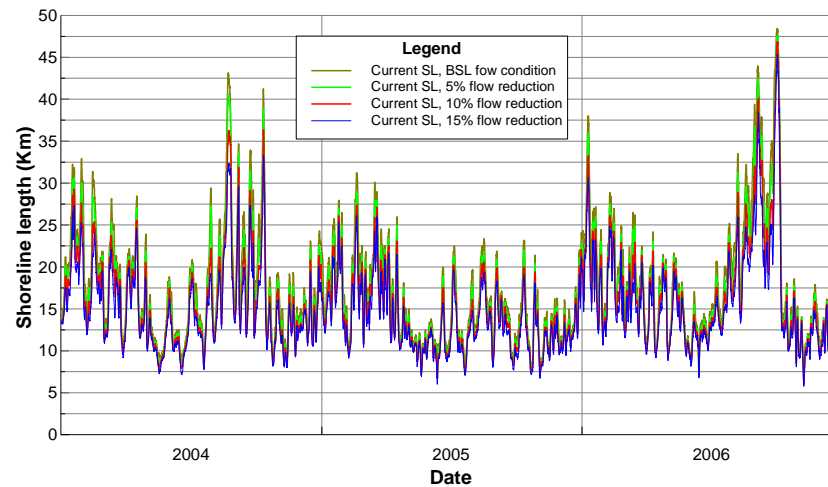


Figure B34 Daily shoreline length of water: salinity range 0-5ppt, current sea level.

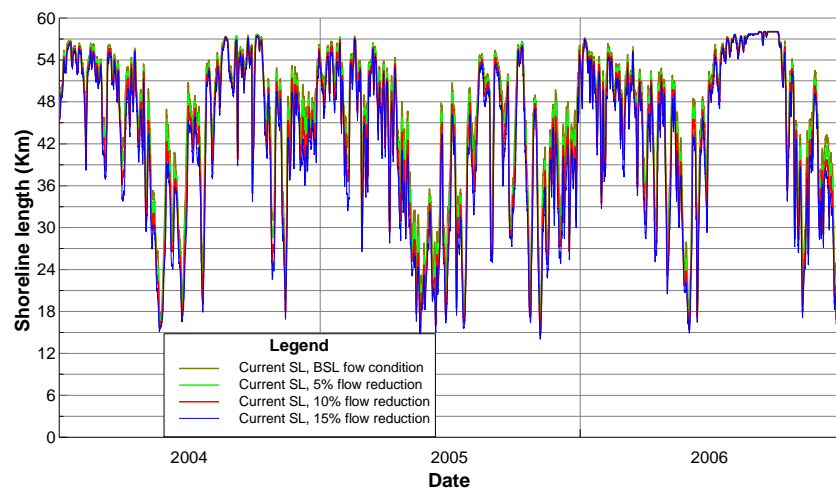


Figure B35 Daily shoreline length of water: salinity range 0-10ppt, current sea level.

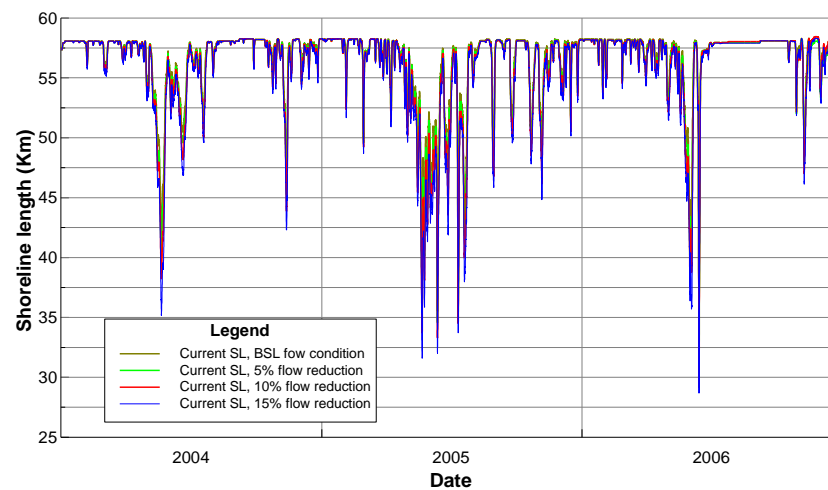


Figure B36 Daily shoreline length of water: salinity range 0-15ppt, current sea level.

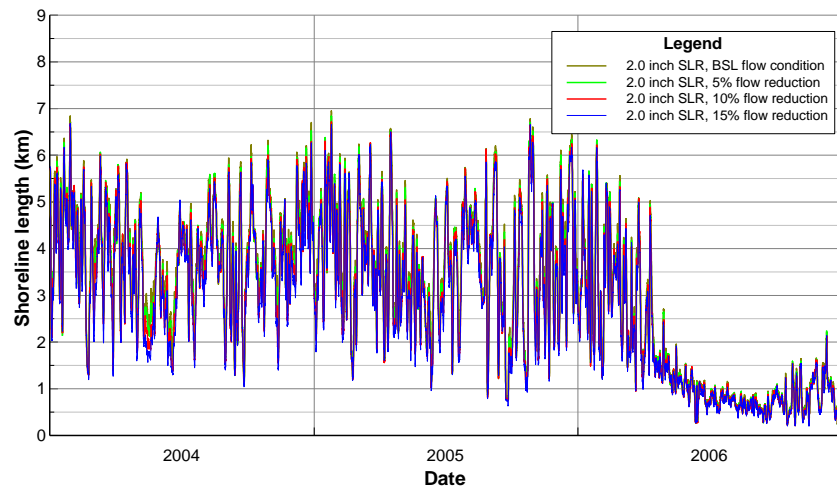


Figure B37 Daily shoreline length of water: salinity range 0-2ppt, 2.0 inch SLR.

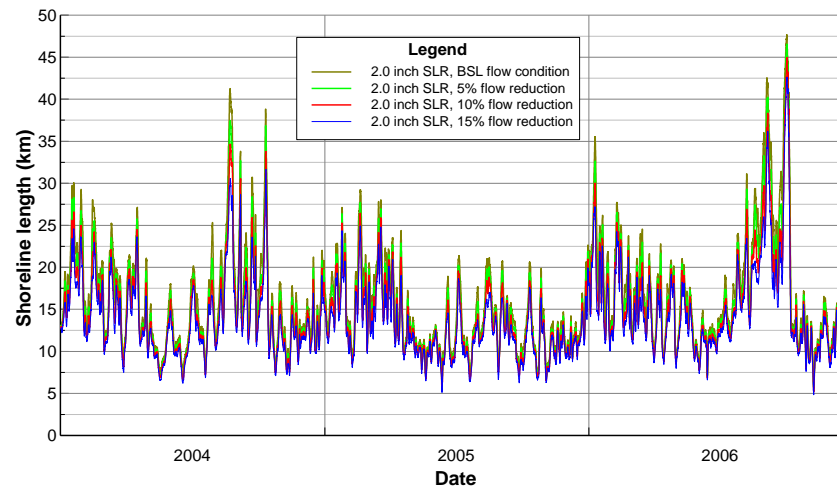


Figure B38 Daily shoreline length of water: salinity range 0-5ppt, 2.0 inch SLR.

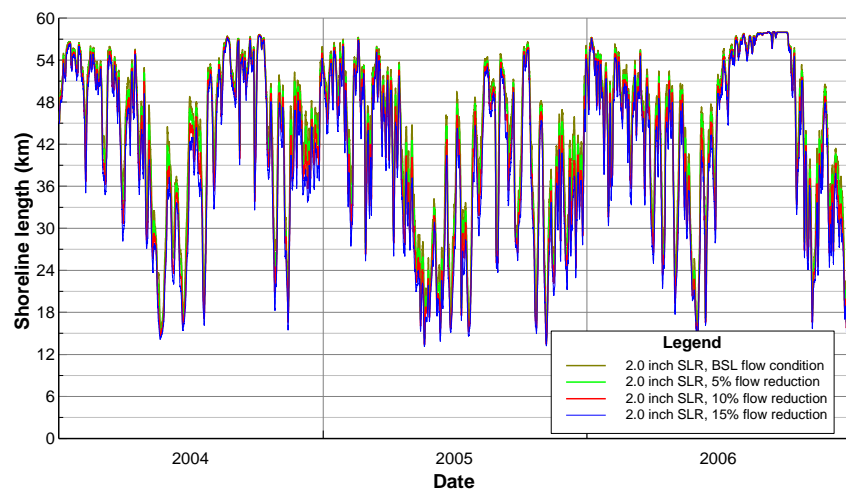


Figure B39 Daily shoreline length of water: salinity range 0-10ppt, 2.0 inch SLR.

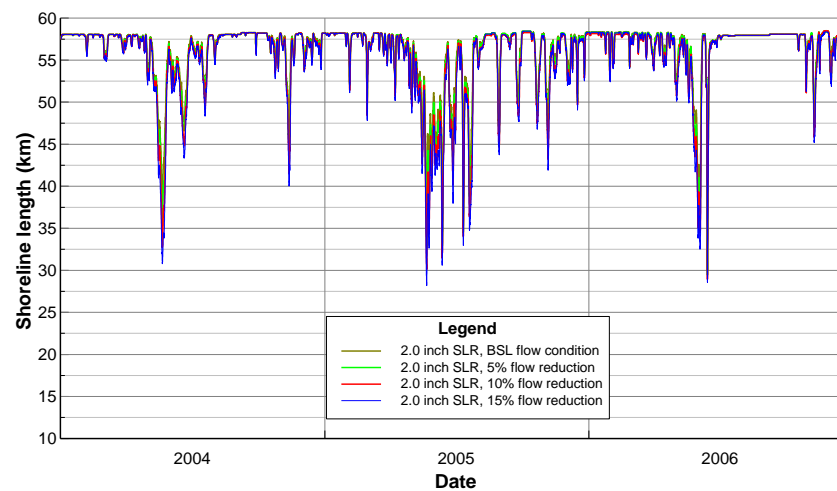


Figure B40 Daily shoreline length of water: salinity range 0-15ppt, 2.0 inch SLR.

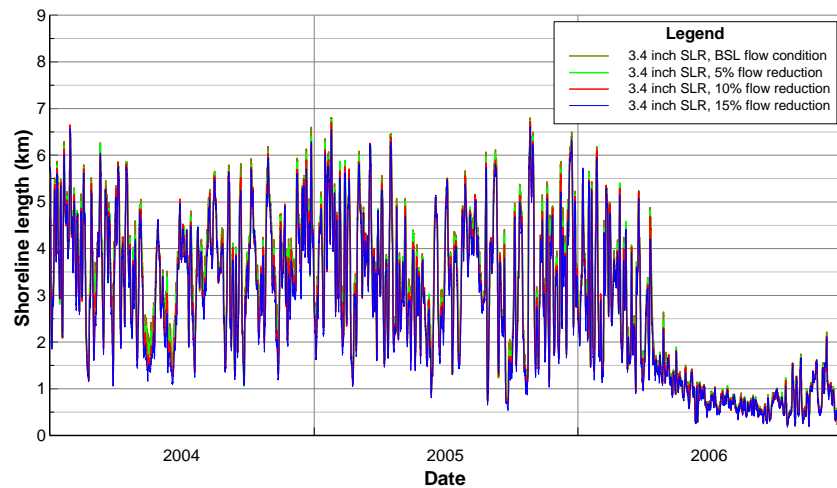


Figure B41 Daily shoreline length of water: salinity range 0-2ppt, 3.4 inch SLR.

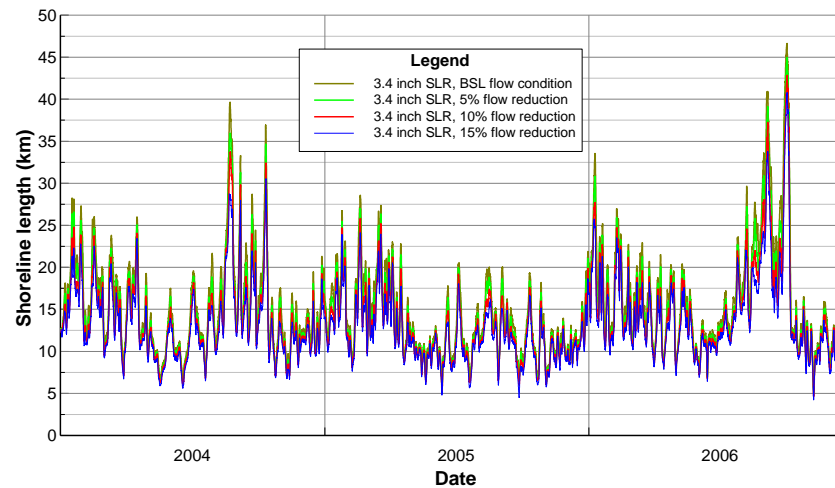


Figure B42 Daily shoreline length of water: salinity range 0-5ppt, 3.4 inch SLR.

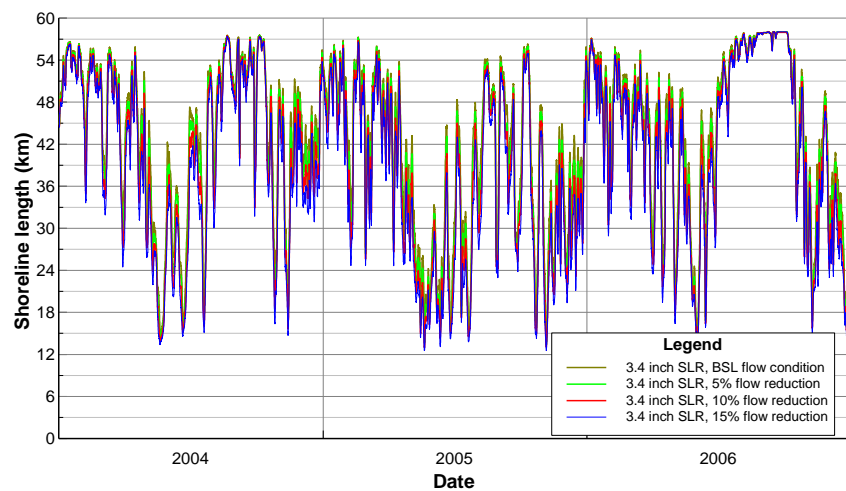


Figure B43 Daily shoreline length of water: salinity range 0-10ppt, 3.4 inch SLR.

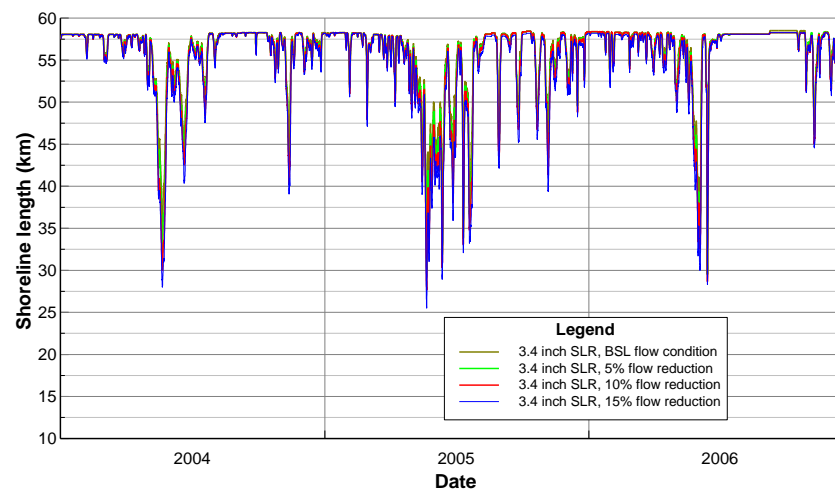


Figure B44 Daily shoreline length of water: salinity range 0-15ppt, 3.4 inch SLR.

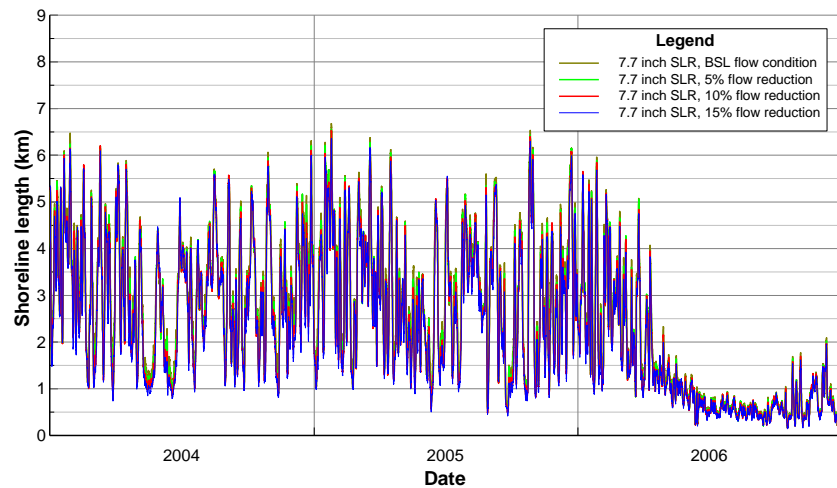


Figure B45 Daily shoreline length of water: salinity range 0-2ppt, 7.7 inch SLR.

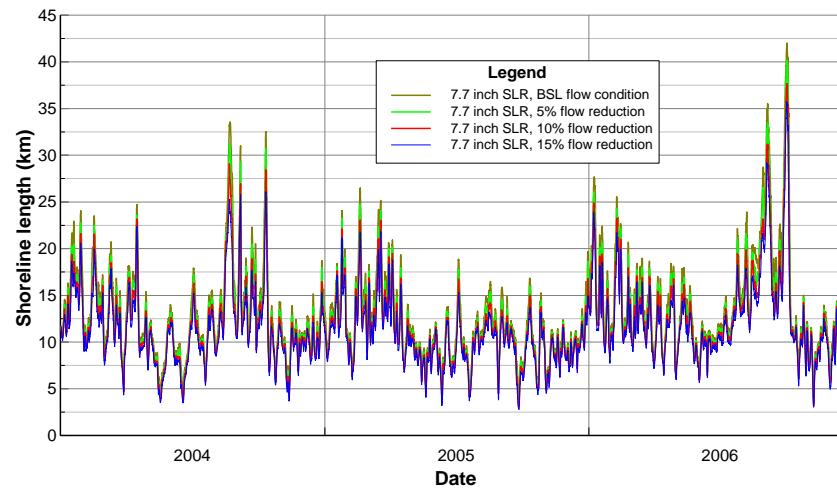


Figure B46 Daily shoreline length of water: salinity range 0-5ppt, 7.7 inch SLR.

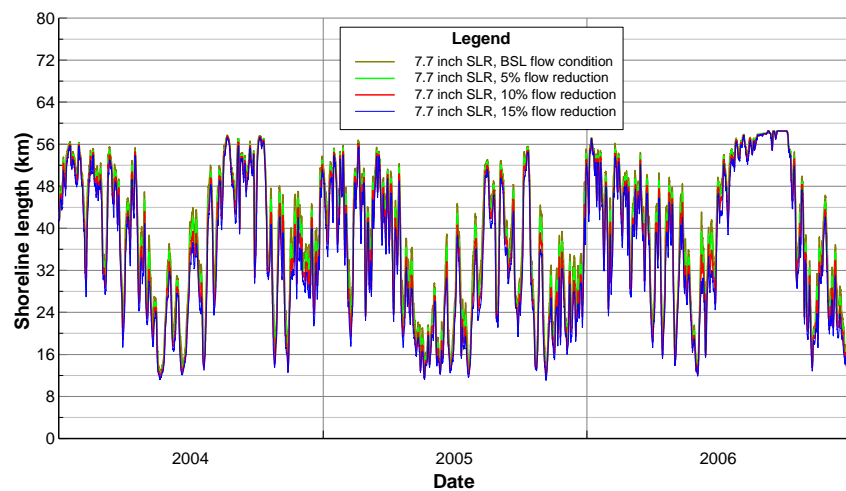


Figure B47 Daily shoreline length of water: salinity range 0-10ppt, 7.7 inch SLR.

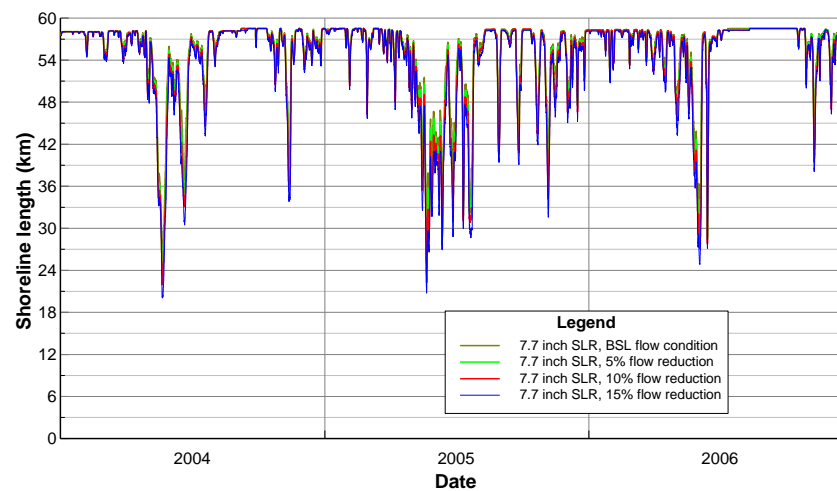


Figure B48 Daily shoreline length of water: salinity range 0-15ppt, 7.7 inch SLR.

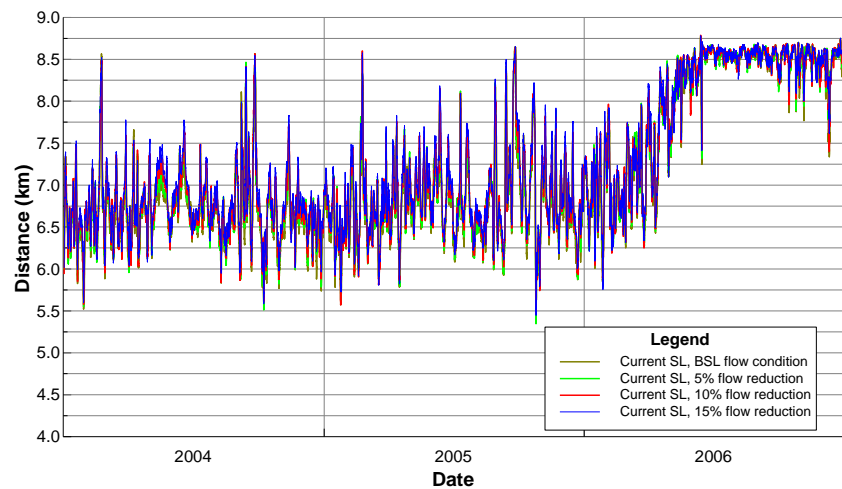


Figure B49 Daily isohaline location of water: salinity range 0-2ppt, current sea level.

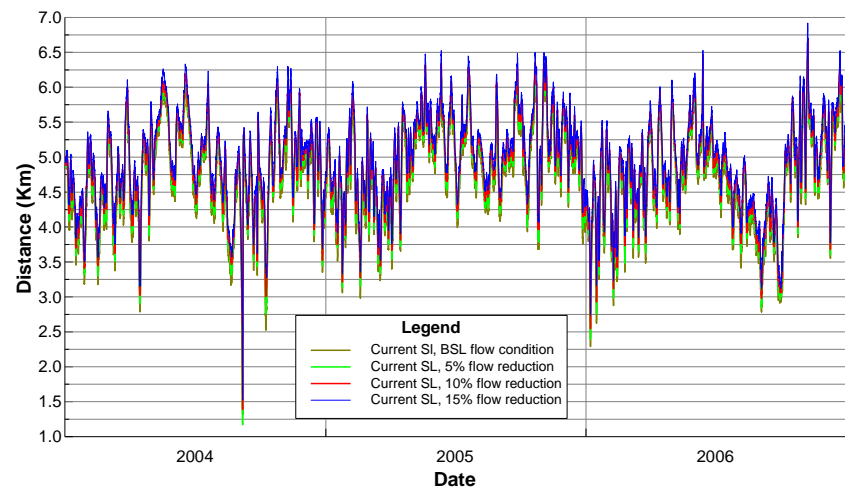


Figure B50 Daily isohaline location of water: salinity range 0-5ppt, current sea level.

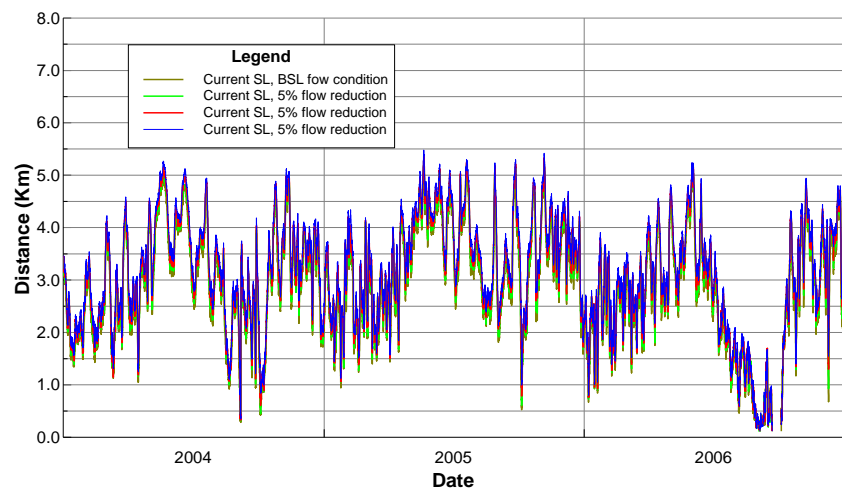


Figure B51 Daily isohaline location of water: salinity range 0-10ppt, current sea level.

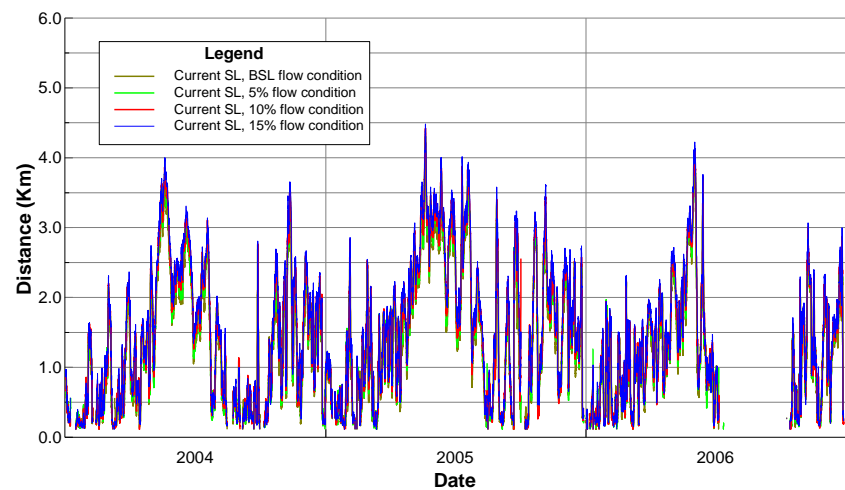


Figure B52 Daily isohaline location of water: salinity range 0-15ppt, current sea level.

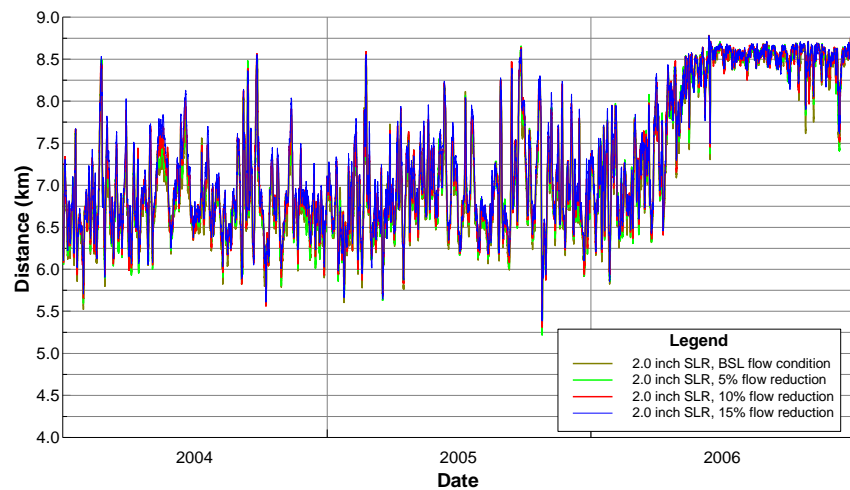


Figure B53 Daily isohaline location of water: salinity range 0-2ppt, 2.0 inch SLR.

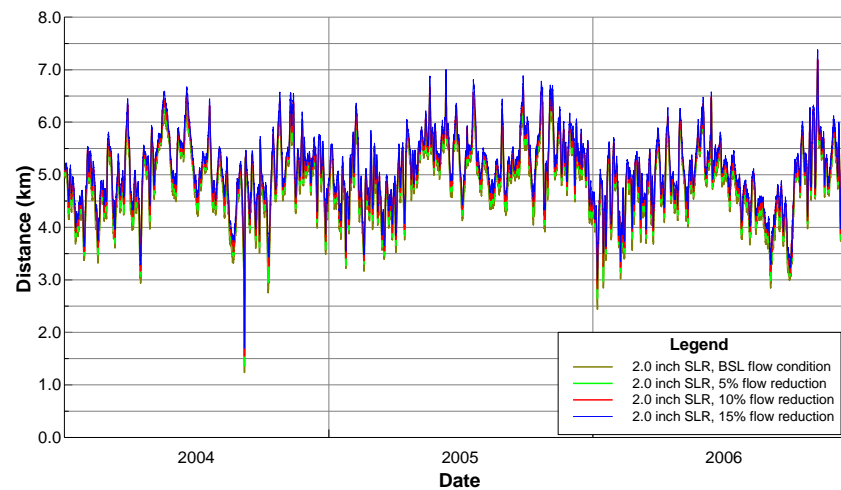


Figure B54 Daily isohaline location of water: salinity range 0-5ppt, 2.0 inch SLR.

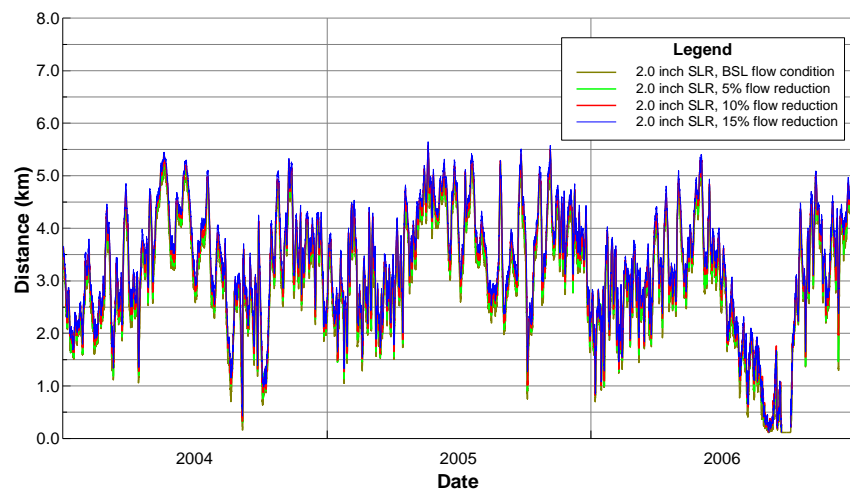


Figure B55 Daily isohaline location of water: salinity range 0-10ppt, 2.0 inch SLR.

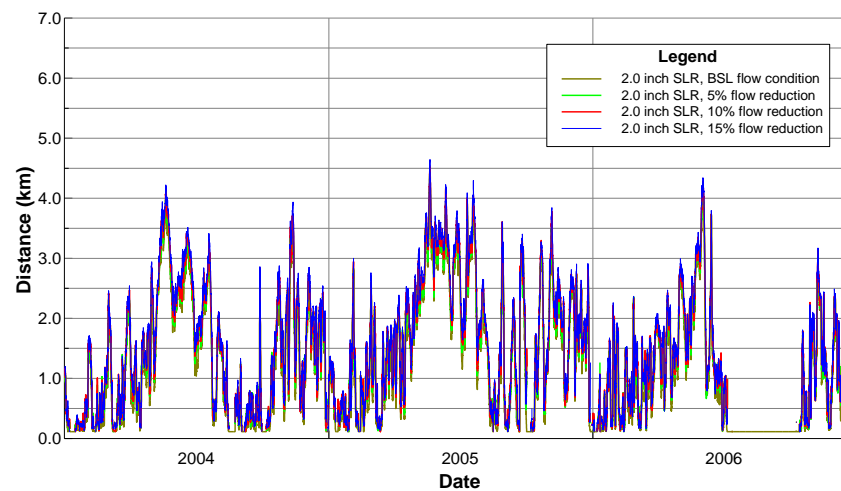


Figure B56 Daily isohaline location of water: salinity range 0-15ppt, 2.0 inch SLR.

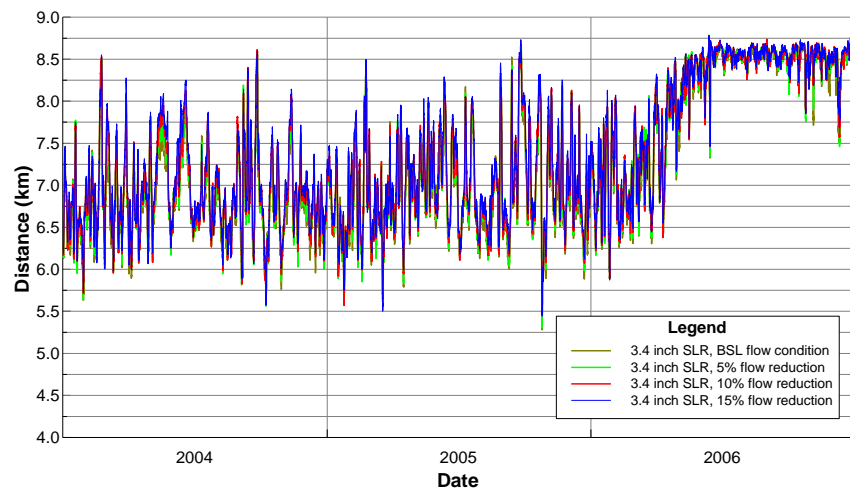


Figure B57 Daily isohaline location of water: salinity range 0-2ppt, 3.4 inch SLR.

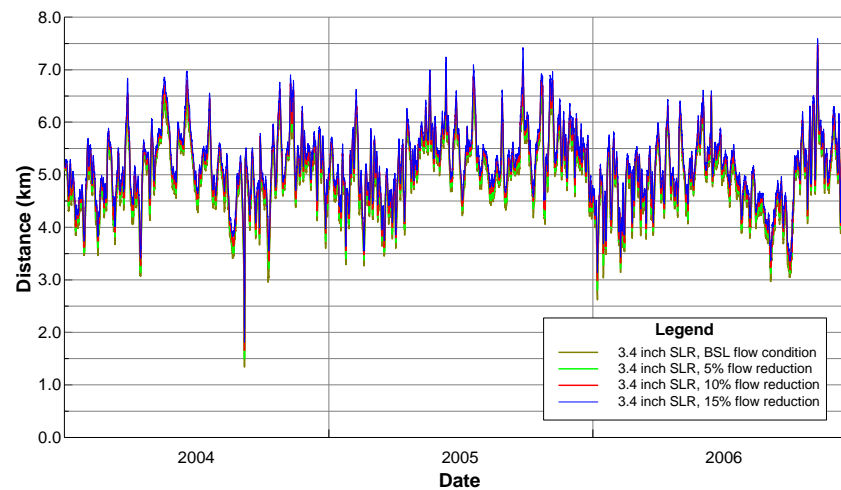


Figure B58 Daily isohaline location of water: salinity range 0-5ppt, 3.4 inch SLR.

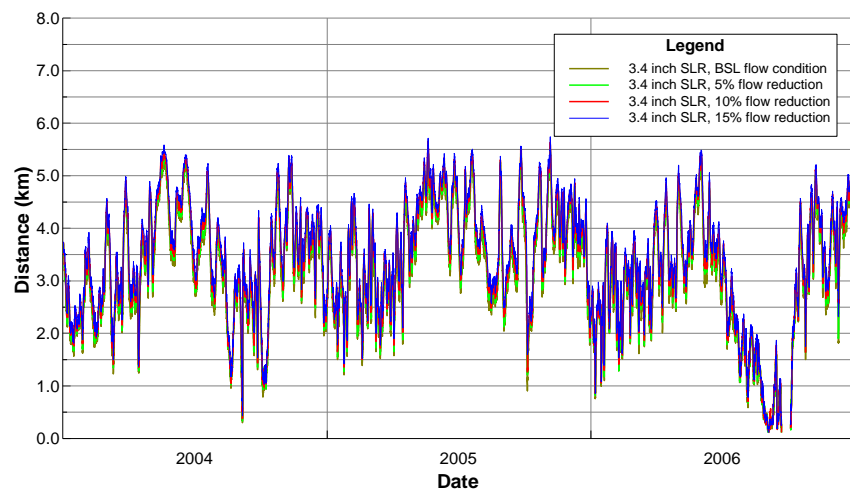


Figure B59 Daily isohaline location of water: salinity range 0-10ppt, 3.4 inch SLR.

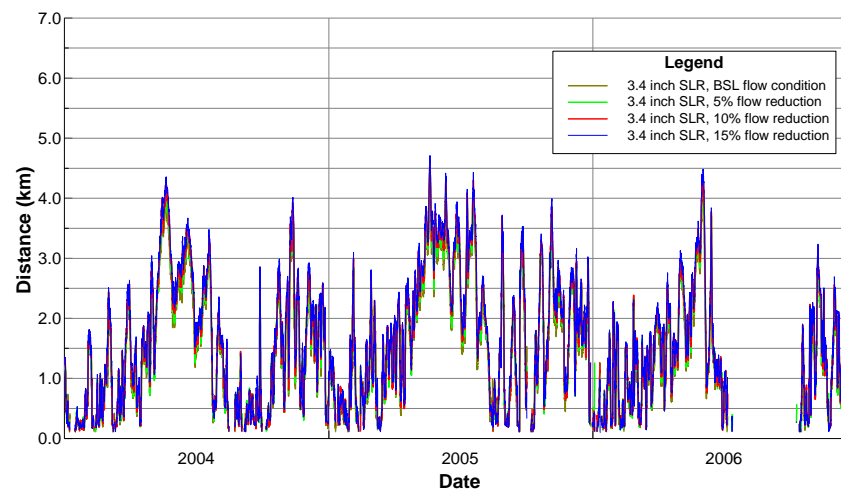


Figure B60 Daily isohaline location of water: salinity range 0-15ppt, 3.4 inch SLR.

