Sensitivity Analyses of Salinity Habitats to SGD and SGD Salinity in Chassahowitzka and Homosassa Rivers

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This document reports some of the additional model runs and analyses that the peer-review panel had requested during the scientific review of the MFL re-evaluations for the Chassahowitzka and Homosassa Rivers. Included here are results of a sensitivity analysis, which is to examine how sensitive salinity habitats in Chassahowitzka and Homosassa Rivers are to submarine groundwater discharges (SGDs) and to salinities in the SGDs. Also included are results of a study on effects of the negative spring flow of the Crab Creek on salinity habitats in the Chassahowitzka River.

Results of Sensitivity Analysis

Following the standard of practice, let's focus on the point in the input space where the LAMFE models were calibrated for the Chassahowitzka and Homosassa River. For SGD salinities, a 1% perturbation in both directions was added to the input data during the model runs. Water volumes, bottom areas, and shoreline lengths for salinity ≤ 1, 2, 3, 5, 10, and 15 psu were calculated, before dimensionless local derivatives (DLDs) of these salinity habitats with respect to SGD salinities were calculated using central differencing. Please refer to Chen (2012 and 2019) for details about DLD calculations and the use of DLDs to represent sensitivities in the analysis. For SGDs, model results for the baseline and 2.5% flow reduction scenarios were analyzed to calculate DLDs of salinity habitats with respect to SGDs in the Chassahowitzka and Homosassa Rivers, as the existing SGD is somewhere close to the middle point between the baseline and the 2.5% reduction. DLDs using forward and backward differencing were averaged to get the DLD at the point of the "Existing" flow condition.

Tables 1 and 2 show results of the sensitivity analysis for the Chassahowitzka and Homosassa Rivers, respectively. Plots of these DLD results are shown in Figures 1 – 3 for the Chassahowitzka River and in Figures 4 – 6 for the Homosassa River.

Table 1. Dimensionless local derivatives of salinity habitats with respect to SGDs and SGD salinities in the Chassahowitzka River.

Salinity ≤	1 psu	2 psu	3 psu	5 psu	10 psu	15 psu
	Volume					
SGD Salinity	-5.1701	-2.4330	-0.4000	-0.1774	-0.0279	-0.0035
SGD	1.8804	0.6475	0.6279	0.6488	0.1980	0.0335
	Bottom Area					
SGD Salinity	-5.2934	-3.0160	-0.3564	-0.1645	-0.0267	-0.0031
SGD	2.0184	0.5722	0.5351	0.5955	0.1789	0.0266
	Shoreline Length					
SGD Salinity	-3.7243	-6.7239	-0.2911	-0.1587	-0.0266	-0.0026

SGD	1.3600	0.4103	0.3740	0.5466	0.1670	0.0201

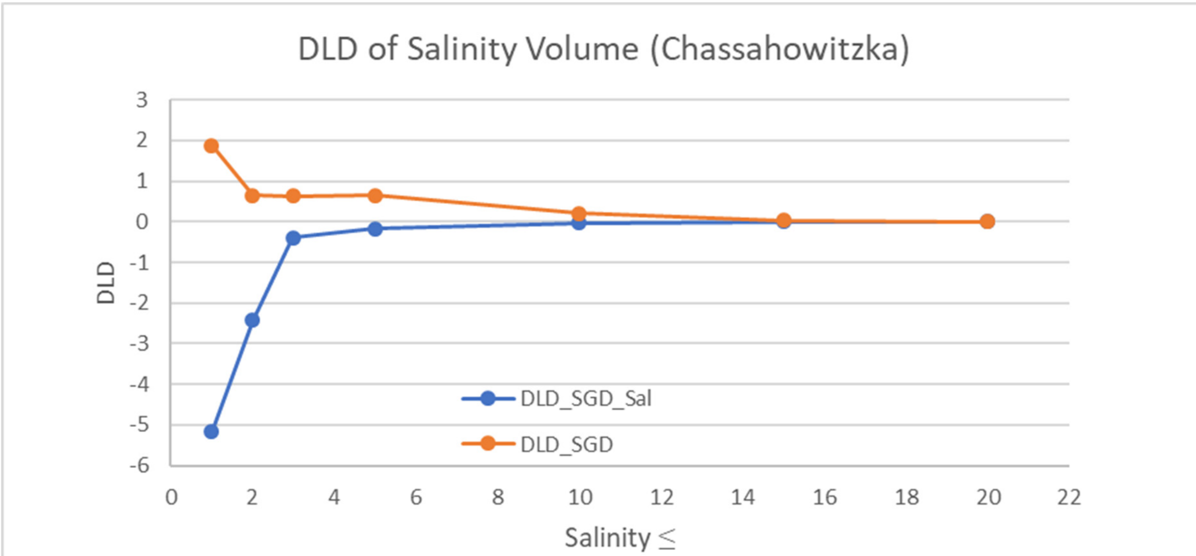

Figure 1. DLDs of water volumes for salinity ≤ 1, 2, 3, 5, 10, and 15 psu with respect to SGD (orange) and SGD salinity (blue) in the Chassahowitzka River.

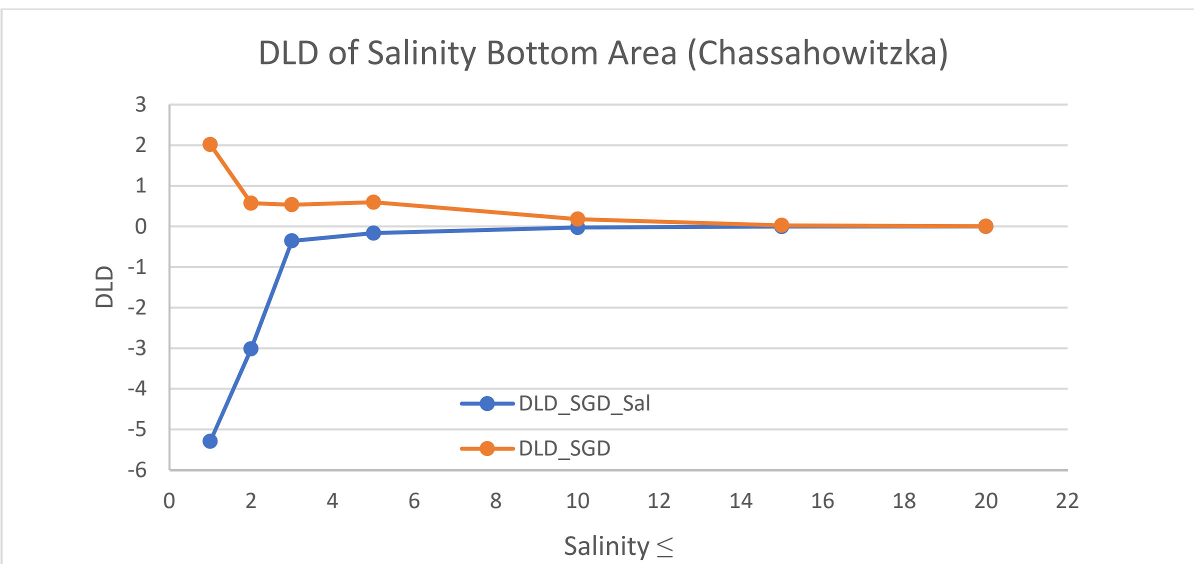

Figure 2. DLDs of bottom areas for salinity ≤ 1, 2, 3, 5, 10, and 15 psu with respect to SGD (orange) and SGD salinity (blue) in the Chassahowitzka River.

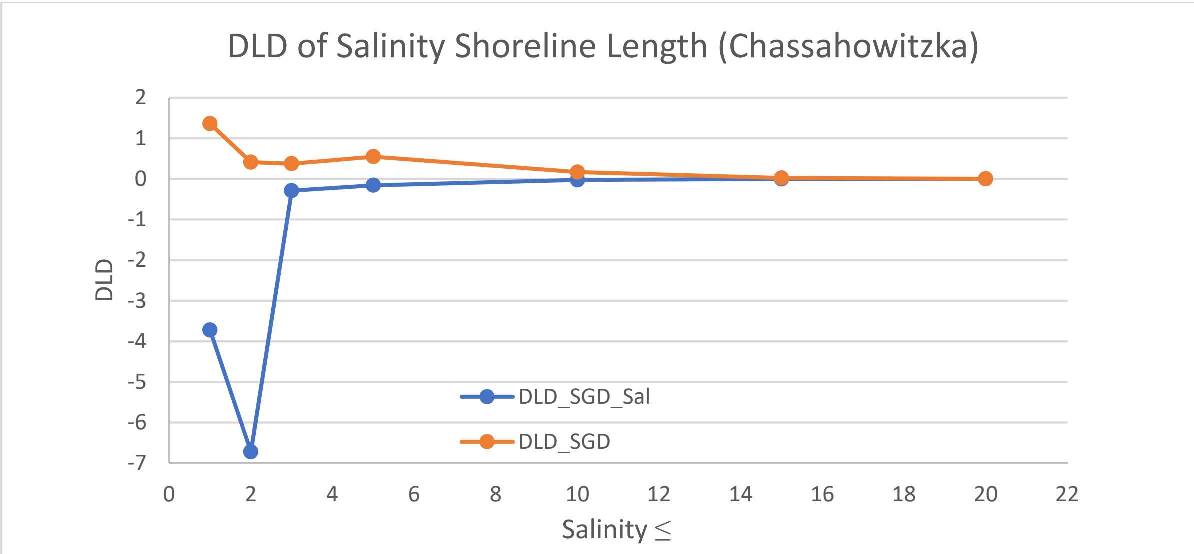

Figure 3. DLDs of shoreline lengths for salinity ≤ 1, 2, 3, 5, 10, and 15 psu with respect to SGD (orange) and SGD salinity (blue) in the Chassahowitzka River.

Table 2 Dimensionless local derivatives of salinity habitats with respect to SGDs and SGD salinities in the Homosassa River.

Salinity ≤	1 psu	2 psu	3 psu	5 psu	10 psu	15 psu
	Volume					
SGD Salinity	-4.0574	-2.7596	-0.7893	-0.4193	-0.0532	-0.0143
SGD	0.2326	1.3123	1.1550	0.9286	0.3440	0.1226
	Bottom Area					
SGD Salinity	-2.5849	-2.8600	-0.9171	-0.5034	-0.0498	-0.0129
SGD	0.1458	1.3307	1.1733	0.9382	0.3255	0.1134
	Shoreline Length					
SGD Salinity	-1.4027	-2.0128	-0.9322	-0.5378	-0.0431	-0.0101
SGD	0.1250	0.8783	0.9437	0.8662	0.2887	0.0917

From the tables, it can be seen that lower salinity habitats are generally more sensitive to salinity in the SGD than to SGD itself. For example, water volumes of salinity ≤ 1 psu and ≤ 2 psu could decrease 5.17% and 2.43%, respectively for every percent increase of SGD salinity but only increase 1.88% and 0.64%, respectively for every percent increase of SGD in the Chassahowitzka River. In the Homosassa River, every percent increase of SGD salinity could cause 4.05% and 2.76% decreases of ≤ 1 psu and ≤ 2 psu volumes, respectively, but every 1% of SGD increase only results in 0.23% and 1.31% increases of ≤ 1 psu and ≤ 2 psu volumes.

On the other hand, higher salinity habitats are more sensitive to SGD than to SGD salinity. For example, a 1% increase of SGD salinity causes only 0.003% and 0.014% volume decreases for salinity ≤ 15 psu in Chassahowitzka and Homosassa, respectively. Nevertheless, a 1% decrease of SGD would cause 0.033% and 0.123% decreases of ≤ 15 psu volume in Chassahowitzka and Homosassa, respectively. Although the response of ≤ 15 psu volume to a SGD change is week, it is a order of magnitude stronger than the response of ≤ 15 psu volume to a change in SGD salinity.

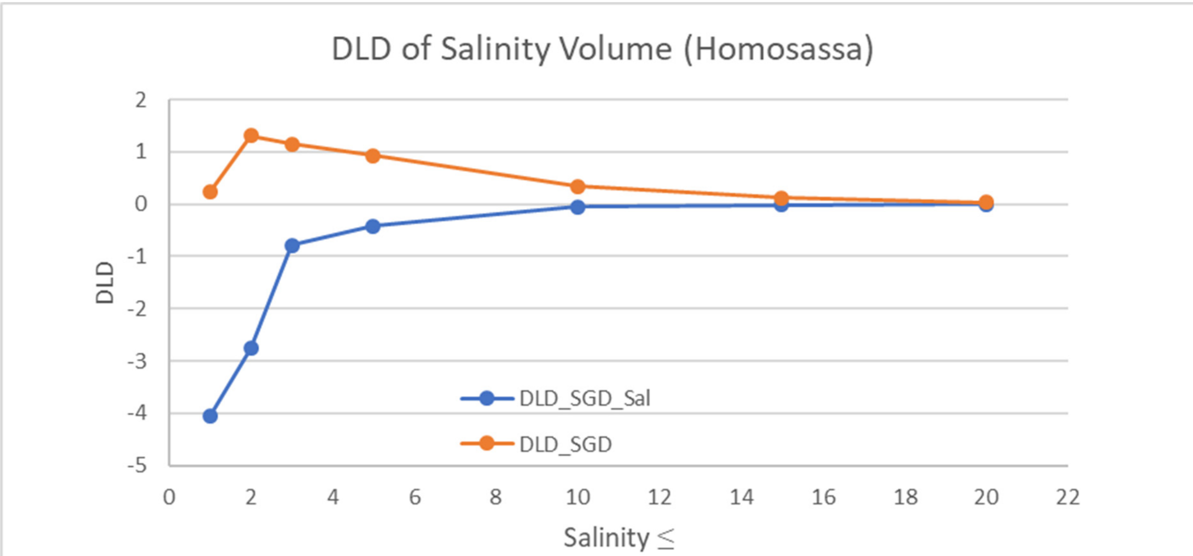

Figure 4. DLDs of water volumes for salinity ≤ 1, 2, 3, 5, 10, and 15 psu with respect to SGD (orange) and SGD salinity (blue) in the Homosassa River.

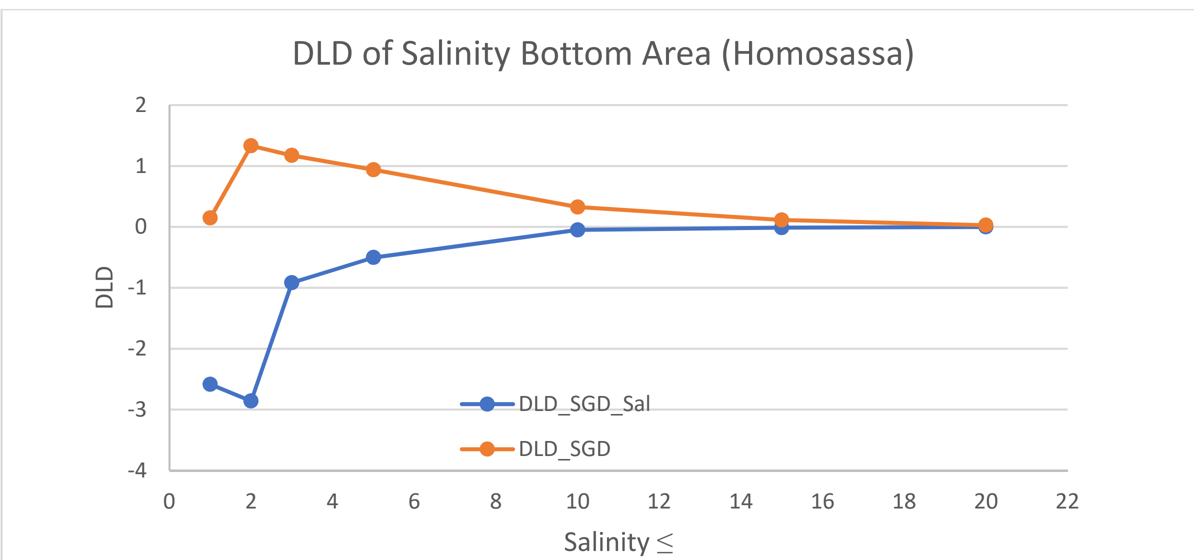

Figure 5. DLDs of bottom areas for salinity ≤ 1, 2, 3, 5, 10, and 15 psu with respect to SGD (orange) and SGD salinity (blue) in the Homosassa River.

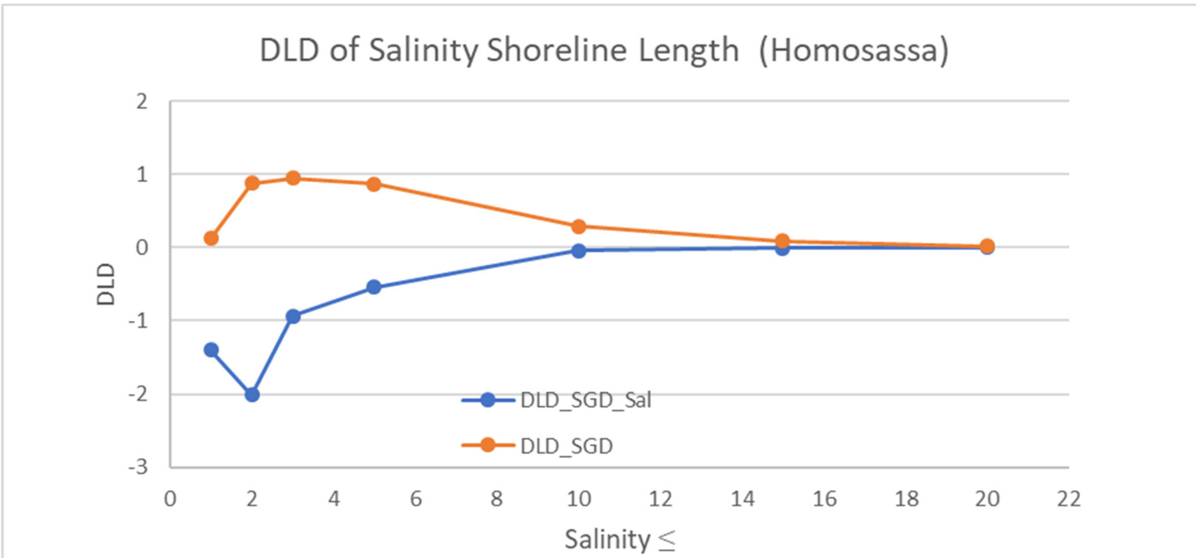

Figure 6. DLDs of shoreline lengths for salinity ≤ 1, 2, 3, 5, 10, and 15 psu with respect to SGD (orange) and SGD salinity (blue) in the Chassahowitzka River.

Figures 7, 8, and 9 respectively show averages of water volumes, bottom areas, and shoreline lengths for salinity ≤ 1, 2, 3, and 5 psu under various flow reduction conditions in the Chassahowitzka River. Similar graphs for the Homosassa are plotted in Figures 10 – 12. As can be seen in Figures 7 – 12, salinity habitat – SGD relationships are normally close to linear or at least weakly non-linear in both the Chassahowitzka and Homosassa Rivers.

Graphically, the DLDs with respect to SGD shown in Tables 1 and 2 are twice the slopes at the "Existing" point in the figures (Figs. 7 - 12.) Please note that the spacing between "Baseline" and "2.5%" is two times of the spacing between any other two neighboring flow reduction scenarios. As such, the slope at "Existing" is one half of the DLD.

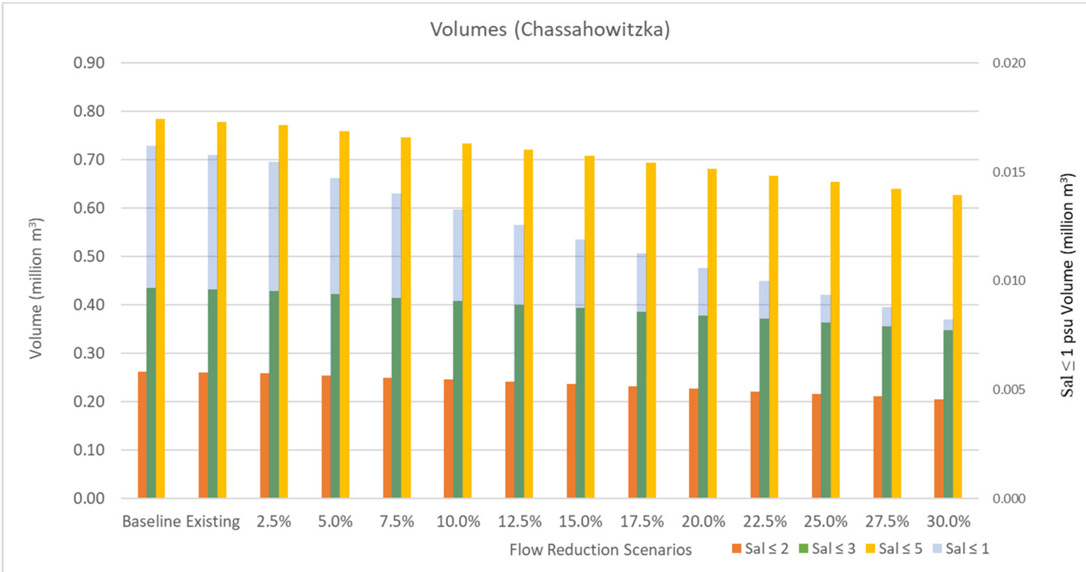

Figure 7. Average water volumes of salinity ≤ 1, 2, 3, and 5 psu for various flow reduction scenarios in the Chassahowitzka River.

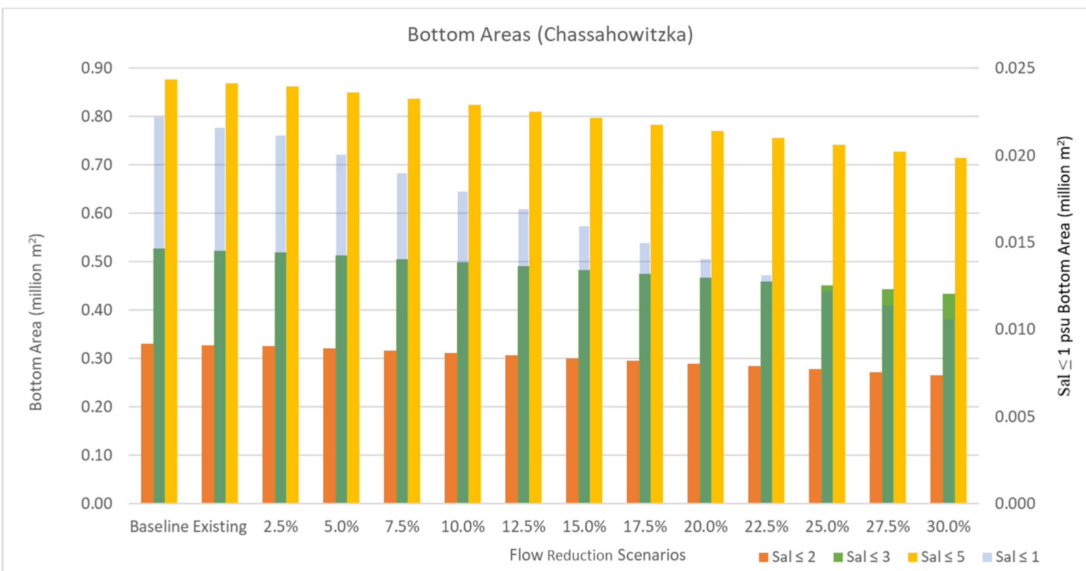

Figure 8. Average bottom areas of salinity ≤ 1, 2, 3, and 5 psu for various flow reduction scenarios in the Chassahowitzka River.

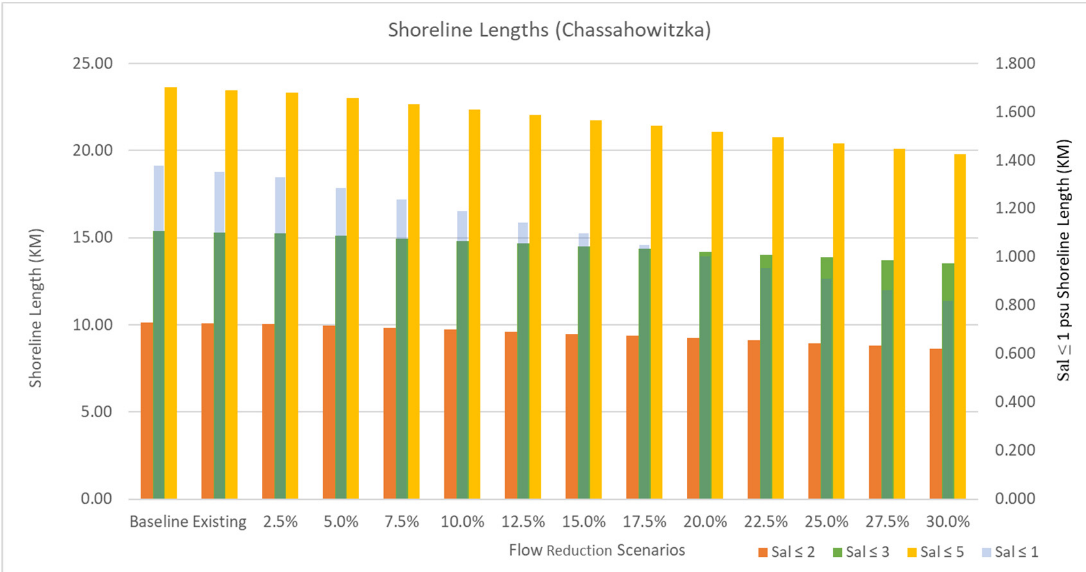

Figure 9 Average shoreline lengths of salinity ≤ 1, 2, 3, and 5 psu for various flow reduction scenarios in the Chassahowitzka River.

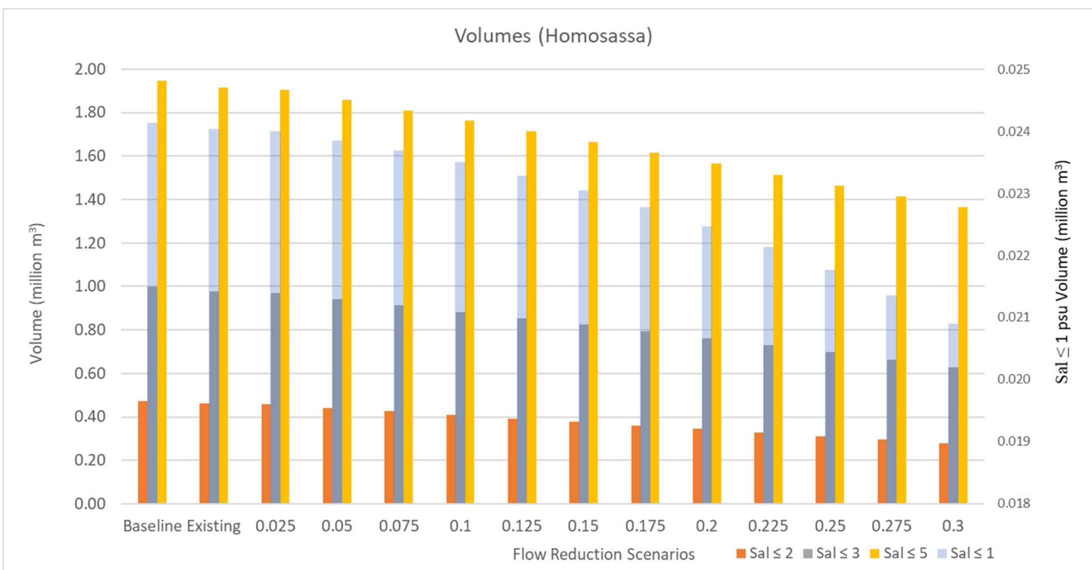

Figure 10. Average water volumes of salinity ≤ 1, 2, 3, and 5 psu for various flow reduction scenarios in the Homosassa River.

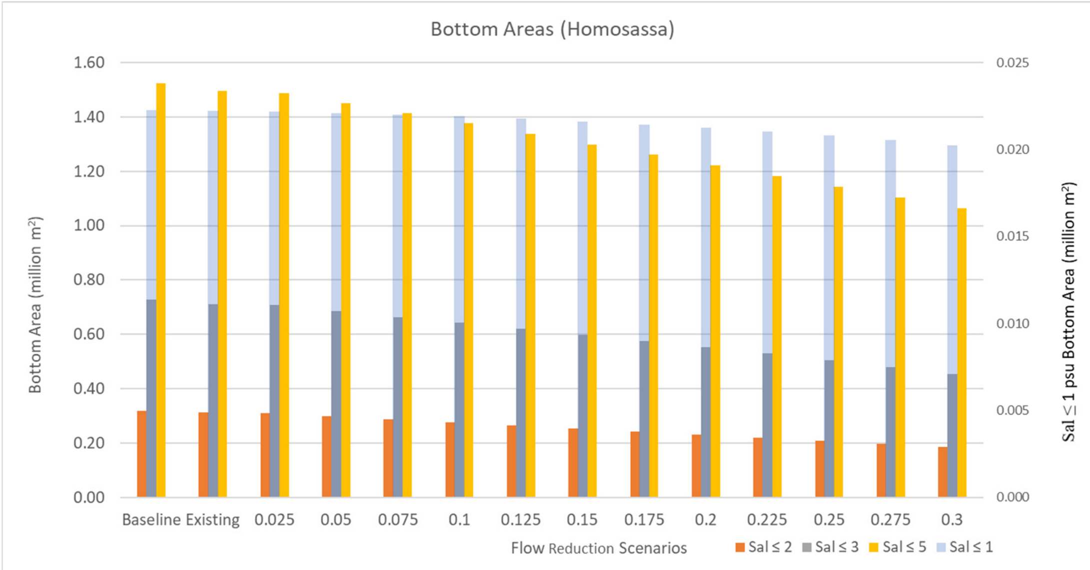

Figure 11. Average bottom areas of salinity ≤ 1, 2, 3, and 5 psu for various flow reduction scenarios in the Homosassa River.

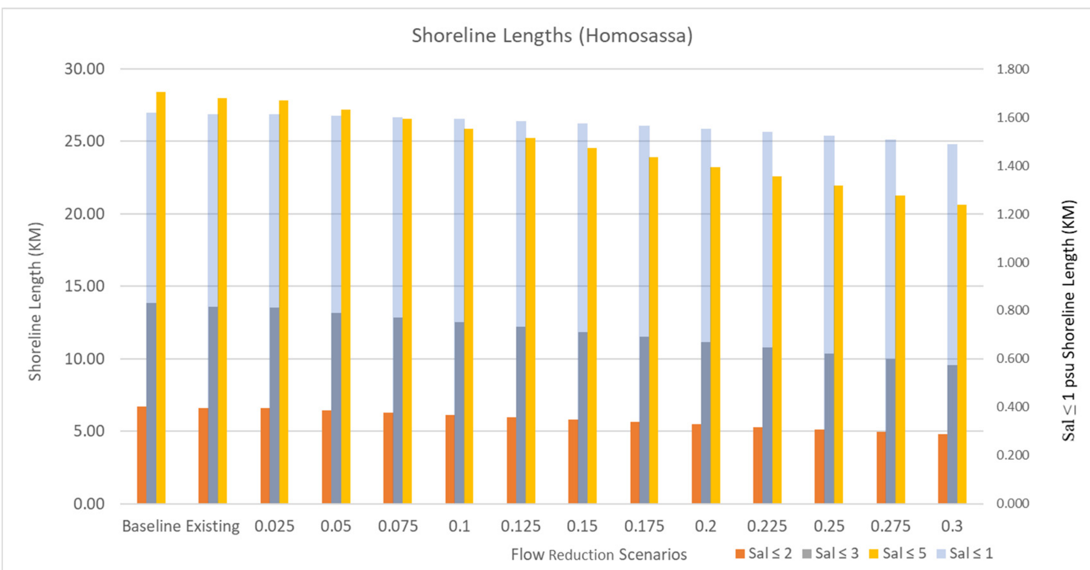

Figure 12. Average shoreline lengths of salinity ≤ 1, 2, 3, and 5 psu for various flow reduction scenarios in the Homosassa River.

Results without Crab Creek Negative Flow

A LAMFE model run was conducted for the Chassahowitzka River, with all the negative SGDs from the Crab Creek being set to zero. Differences of salinity habitats between simulated salinity habitats with and without negative discharges out of the Crab Creek were calculated and relative changes were obtained. Overall, Table 3 shows that without the negative flow, low salinity habitats would increase very slightly, except for the ≤ 2 psu habitats, which have a very small relative decrease of about 0.05 percent. Either way, the relative changes of salinity habitats caused by setting negative Crab Creek flow to zero are all minor.

Table 3. Relative changes of simulated salinity habitats without negative Crab Creek SGD against those with negative Crab Creek SGD.

Salinity ≤	1 psu	2 psu	3 psu	5 psu	10 psu	15 psu
Volume	0.0001	-0.0005	0.0001	0.0001	0.0001	0.0000
Bottom Area	0.0001	-0.0005	0.0001	0.0001	0.0001	0.0000
Shoreline Length	0.0000	-0.0005	0.0000	0.0001	0.0001	0.0000

<u>*References*</u>

Chen, X., 2012. A sensitivity analysis of low salinity habitats simulated by a hydrodynamic model in the Manatee River estuary in Southwest Florida, USA. *Estuarine*, *Coastal and Shelf Science*,104 - 105: 80-90, doi:10.1016/j.ecss.2012.03.023.

Chen, X., 2019 Hydrodynamic Modeling of Effects of Flow Reduction on Salinity and Thermal Habitats in the Homosassa River, Final Draft, Southwest Florida Water Management District, p247.