Appendix A

HSW Engineering, Inc. 2011. A modeling study of the relationships of freshwater flow with the salinity and thermal characteristics of the Homosassa River. Tampa, Florida. Prepared for the Southwest Florida Water Management District. Brooksville, Florida.

Note: *This 2011 report replaces an earlier version of that was prepared in 2010.*

A MODELING STUDY OF THE RELATIONSHIPS OF FRESHWATER FLOW WITH THE SALINITY AND THERMAL CHARACTERISTICS OF THE HOMOSASSA RIVER

February 2011

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Southwest Florida Water Management District

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1.0 INTRODUCTION

The Homosassa River is one of several spring fed rivers within the Springs Coast Watershed and is home to both fresh and saltwater species of fish. While the endangered manatee can be found in the river year round, the spring areas serve as winter refuge and the headsprings area serves as a refuge for injured or orphaned manatee. Manatees are sensitive to the temperature regime and the various aquatic and benthic species that inhabit the system are sensitive, to varying degrees, to salinity. For this reason, it is important to understand the influence that spring discharge has on the thermal and salinity regime within the river system.

HSW Engineering, Inc., (HSW) was contracted by the Southwest Florida Water Management District (SWFWMD, or the District) to conduct a thermal and salinity evaluation of the Homosassa River. This evaluation is based on a calibrated hydrodynamic model of the Homosassa River system using the public domain three-dimensional hydrodynamic code known as the Environmental Fluid Dynamics Code (EFDC). The model was used to evaluate loss of salinity and thermal habitat resulting from specified reductions in flow from the headwaters of the Homosassa River. In addition, statistical models were developed that can be used to estimate salinity as a function of freshwater discharge and location. The statistical models were also used to evaluate salinity habitat loss associated with specified flow reductions, and these loss estimates were compared with values derived from the hydrodynamic modeling results.

This analysis supports an ongoing Minimum Flows and Levels (MFL) program being conducted for the Homosassa River by the District. The MFLs Program is based on Chapter 373.042, *Florida Statutes*, which requires that either a water management district or the Florida Department of Environmental Protection establish minimum flows for surface watercourses and minimum levels for surface waters of the state. The statutory description of a minimum flow is "the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area" (Ch. 373.042 (1) (a), *FS*). The statutory description of a minimum level, as applies to Florida‟s surface water bodies, is "the level of surface water at which further withdrawals would be significantly harmful to the water resources of the area" (Ch. 373.042 (1) (b), *FS*).

The main tasks conducted by HSW include:

- screening data for the purpose of identifying data gaps, inconsistencies, or anomalous readings and advising the District as to findings
- characterizing flows from the Homosassa River head springs and Halls River
- characterizing salinity in the Homosassa and Halls Rivers
- developing empirical salinity models as a function of freshwater flow, tide stage, and location
- using empirical models to estimate changes in area and volume of salinity zones as a function flow and tide stage
- recommending simulation periods and „worst-case" scenario criteria to the District
- developing, calibrating, and validating the EFDC model, and
- determining habitat (thermal and salinity) under existing and reduced flow scenarios based on EFDC model results.

This report provides an overview of the methodology used to calibrate and validate the model, as well as the results from various flow reduction scenarios. The characterization of flows and salinity regression models are provided in Section 2.4 of this report.

Reference

Title XXVIII, Ch. 373.042 (1) (a) and (b), Florida Statutes. http://www.flsenate.gov/Statutes/index.cfm?App_mode=Display_Statute&Search_String=&URL=Ch0373/Sec042.HTM.

2.0 SITE LOCATION AND CHARACTERIZATION

2.1 Site Location

The Homosassa River is located in Citrus County, FL, approximately 100 miles north of Tampa and 100 miles southwest of Ocala. The river is part of the Gulf Coast Spring complex and is bounded by the Chassahowitzka River watershed to the south and Crystal River watershed to the north (Figure 2-1). The river is approximately 12.5 km long and varies from about 100 meters wide with a 1.5 meter deep channel near the head springs to 300 meters wide with a maximum depth of about 6 meters near the Gulf (Yobbi & Knochenmus 1989). There are a series of freshwater and brackish water springs at the headwaters of the Homosassa River and Halls River, which joins the Homosassa River just downstream of its source (Yobbi & Knochenmus 1989). Near its mouth, the river moves through a series of tidal creeks and limestone karst features with natural and manmade channels along its length (Figure 2-2). The entire river is tidally influenced with the normal tidal range less than about 1 meter.

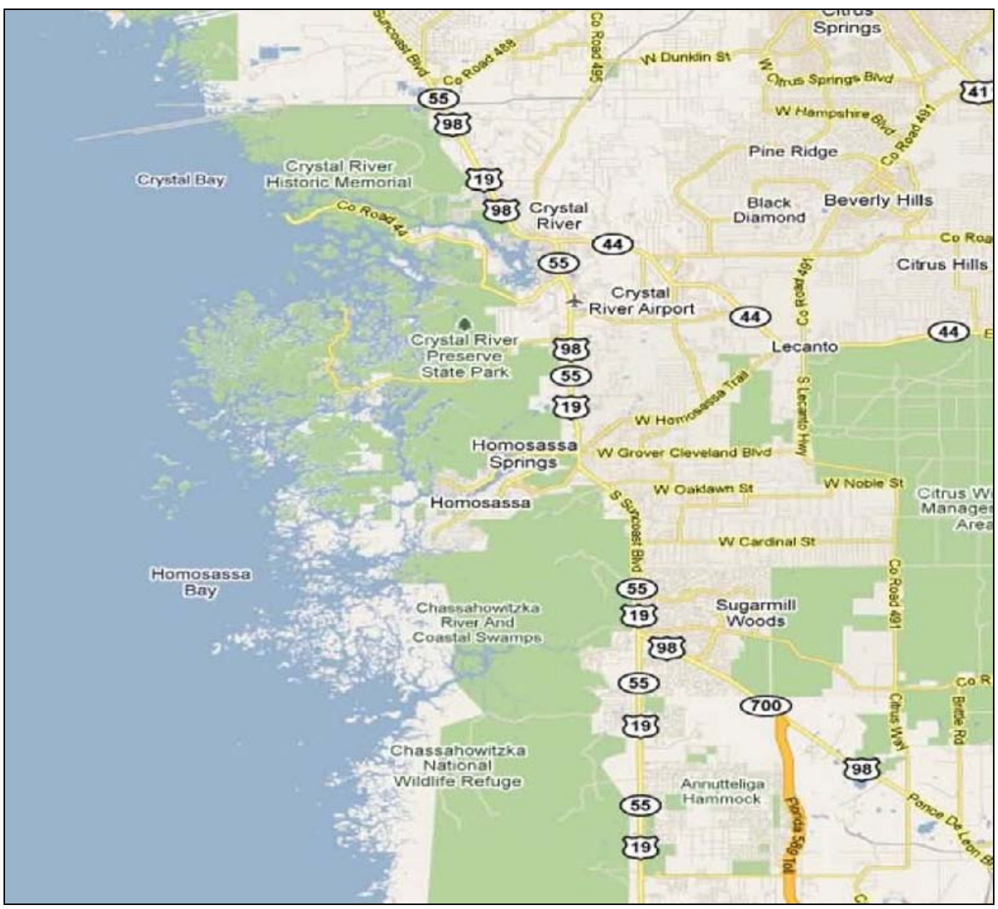

Figure 2-1. Homosassa River vicinity (from google.com)

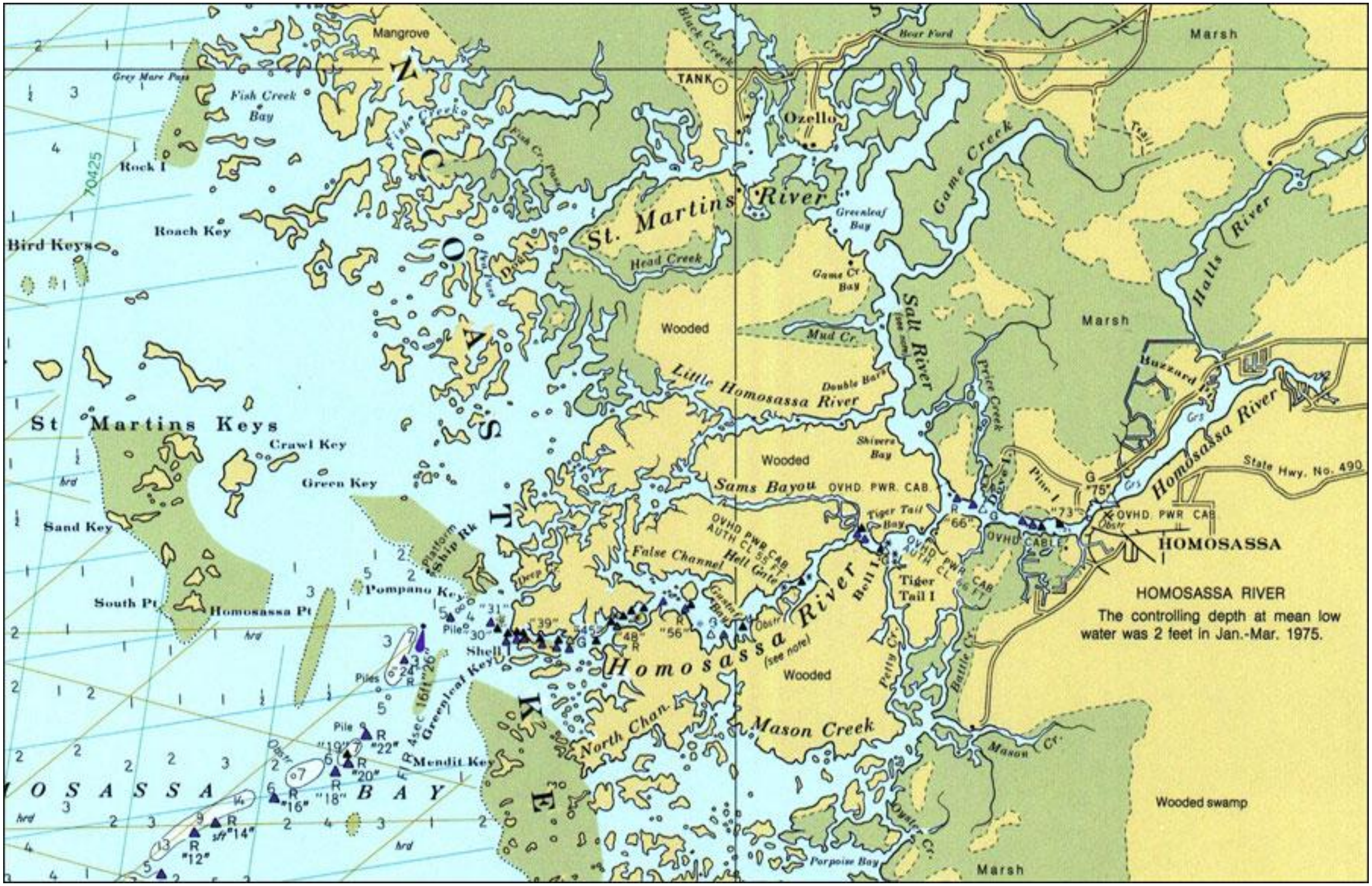

Figure 2-2. Homosassa River geometry (National Oceanic and Atmospheric Administration, *Gulf Coast Survey 1977* Washington, DC)

2.2 Hydrologic and Meteorological Data

Guidance provided in Chapter 373.042, *FS* includes using "best available information" for establishing MFLs. HSW has summarized available hydrologic and meteorological data to identify flow regimes and periods of analysis to evaluate salinity and thermal impacts of withdrawals (Tables A-1 to A-6 in Appendix A). The primary source of river hydrologic data used for model development were from USGS gauges located at Shell Island, the mouth of the Homosassa River (USGS Gauge ID# 02310712), Homosassa Springs (ID# 02310678), SE Fork Homosassa (ID# 02310688), on Halls River (ID# 02310690) near the confluence with the Homosassa River, and on the Homosassa River near the town of Homosassa (ID # 02310700) (Figure 2-3, Figure 3-1, Figure A-1). This USGS gauge convention is used throughout the report. A detailed analysis of the hydrologic data is provided in Section 2.4 and a discussion of gauge datum corrections and river and springs flow calculations are in Appendix B.

2.3 Area and Volume Characterization

Reach-based and elevation-based river volume and bottom area were calculated as a function of centerline river kilometer (RKM) within the main river channel domain (Figure 2-4) based on bathymetry surveyed and reported by University of South Florida (Wang 2007). A triangular irregular network (TIN) was created using 3-D Analyst in ArcGIS 9.2, which also was used to extract necessary information to calculate bottom area and volume. The method and procedure for calculating river volume and bottom area and associated tables and figures is provided in Appendix C. The reference datum is NAVD88 throughout this report unless noted.

Reach-based bottom areas and volumes (Figure 2-5) were calculated for specified river reaches, exclusive of Halls River, in a cumulative manner within the domain as a function of centerline RKM in 0.5-kilometer increments. Elevation-based bottom areas and volumes (Figure 2-6) were calculated for the Homosassa River (Figure 2-4 exclusive of Halls River), in 0.5-meter increments from zero-elevation to a 6.5 meter depth (-6.5 m water surface elevation). At a 0.0 meter elevation, the bottom area in the main channel of the Homosassa River is 2.76 million square meters and the total volume is 3.68 million cubic meters.

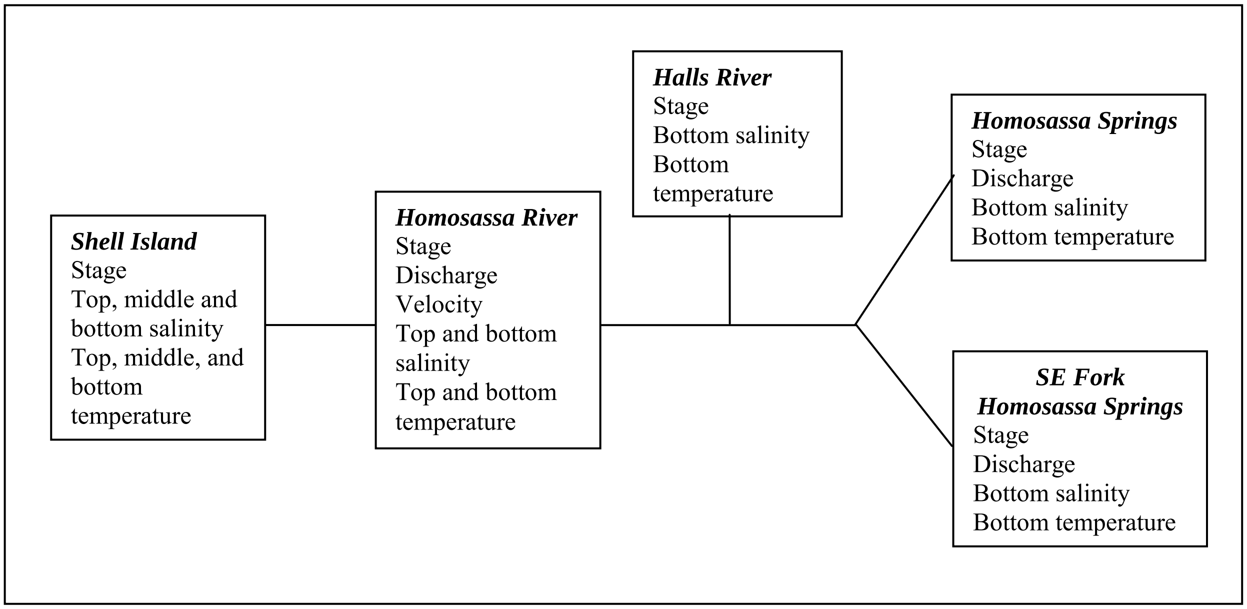

Figure 2-3. Modeling schematic of USGS 15-minute data availability for Homosassa River EFDC Model

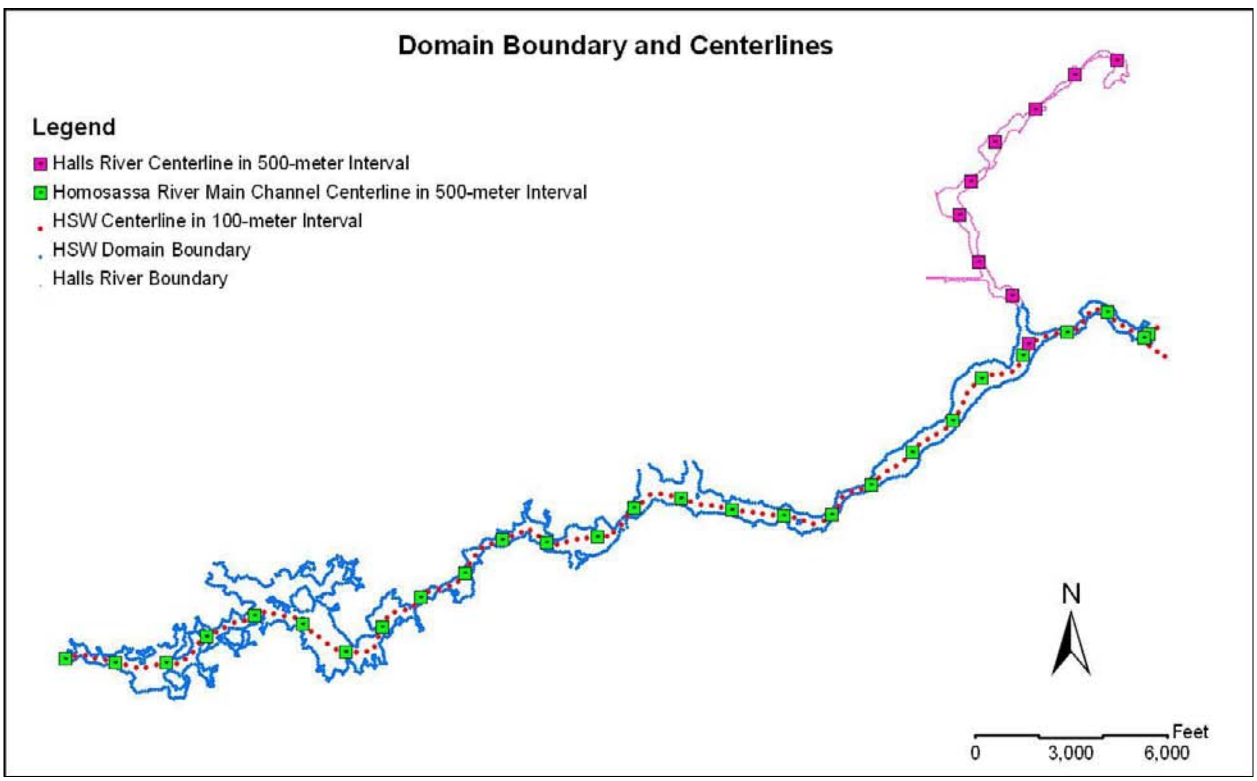

Figure 2-4. Domain boundary for main channel and centerline in specified intervals for the purpose of volume and bottom area calculation

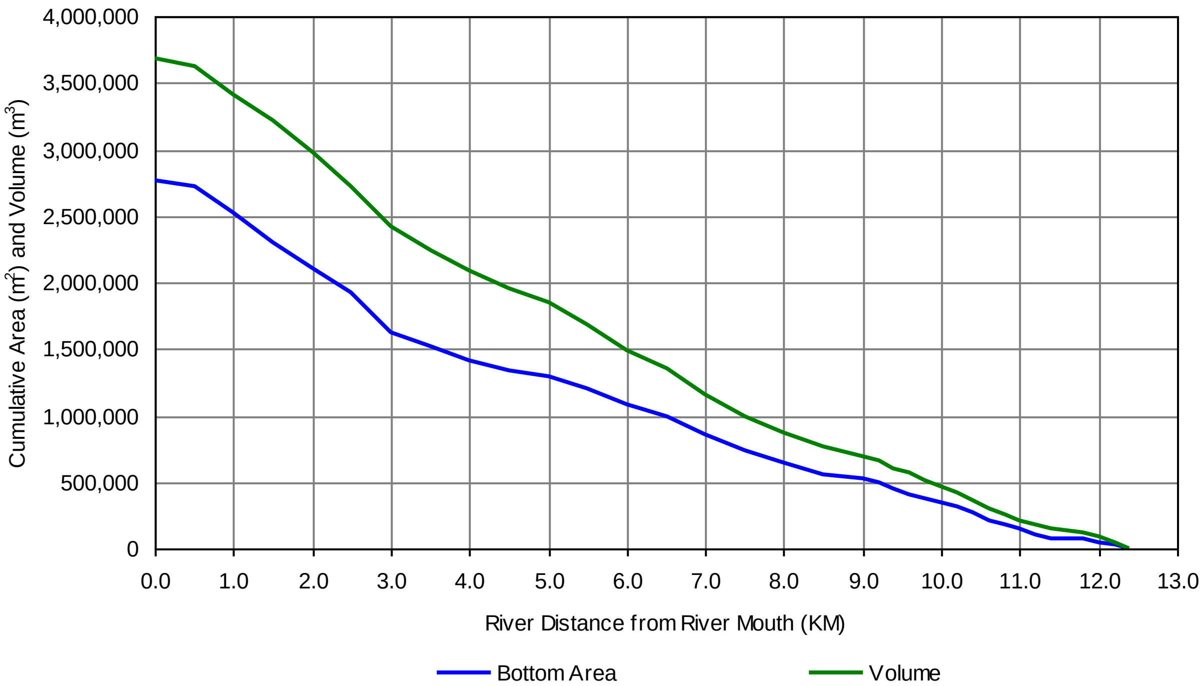

Figure 2-5. Homosassa River main channel reach-based volume and bottom area as a function of river location at a water surface elevation of 0.0 meters

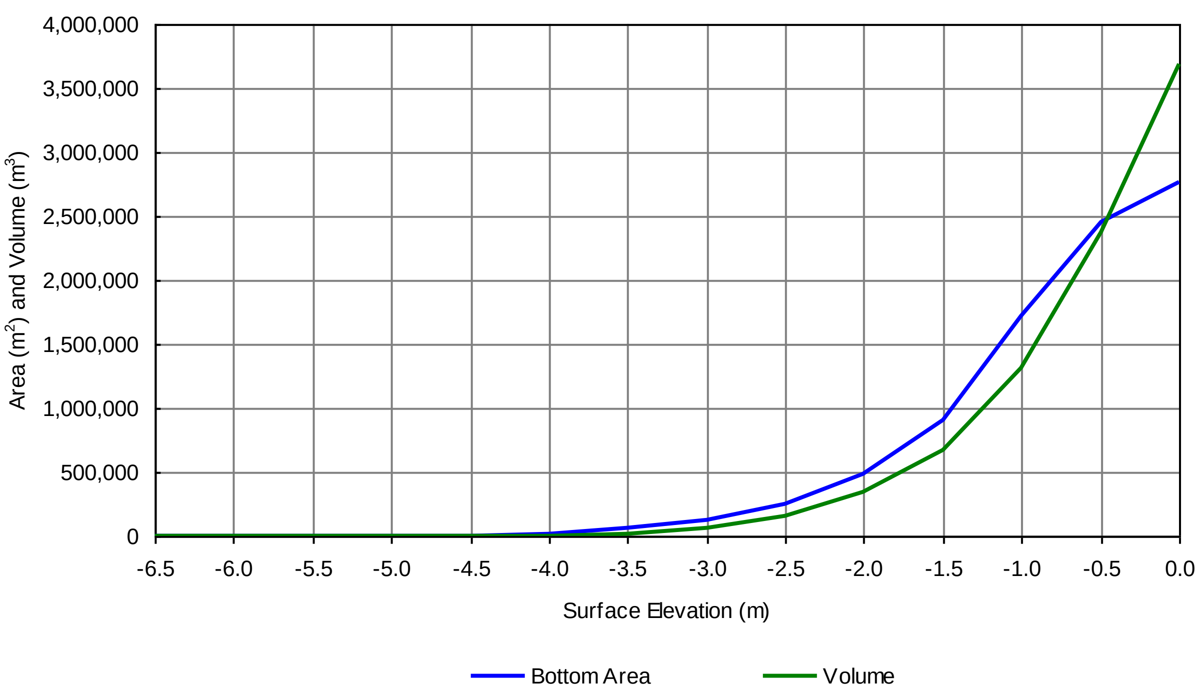

Figure 2-6. Homosassa River main channel water surface elevation-based volume and bottom area

2.4 Data Evaluation and Statistical Modeling

2.4.1 Characterization of Flows from Head Springs and Halls River

The average daily flow in the Homosassa River at Homosassa (USGS Gauge 02310700) is tidally affected and routinely varied between about -200 and 800 (cfs) cubic feet per second from July 2004 through December 2008 (the period for which continuous records exist for USGS Gauge 02310688), with extreme values of about -800 and 2,500 cfs (Table 2-1 and Figure 2-7). Less variability is apparent in the daily records of flow that the USGS post processed using numerical filtering techniques (Appendix B) to reduce, ideally to eliminate, the influence of tide (Figure 2-8).

From January 2004 through December 2008, the discharge of two gauged springs at the headwaters of the Homosassa River varied between about 40 and 100 cfs in SE Fork Homosassa Spring (USGS Gauge 02310688) and between about 60 and 140 cfs in Homosassa Springs (USGS Gauge 02310678) (Figure 2-9). An average decline in spring discharge of about 20 cfs during the 4-year period is apparent in the discharge hydrographs for these springs.

The stream-gauging method used by the USGS to calculate discharge at the Homosassa River, Homosassa Springs and SE Fork Homosassa Spring gauging stations is described in Appendix B. Spring discharges are based on the Floridan aquifer potentiometric surface at the USGS Weeki Wachee well (Figure A-1) and river stage measured at the springs. Spring discharge is calculated every 15 minutes so values will oscillate in a sinusoidal pattern throughout the day in an inverse pattern with respect to tide. Seasonal flow patterns also occur as rainy months are associated with greater potentiometric elevations at the Weeki Wachee well (i.e., greater flow) and winter months are associated with stronger tide signals (i.e., greater amplitude in the daily flow pattern). The river discharge at Homosassa is based on gauge height and water velocity measured using an acoustic velocity meter (AVM) at the gauge.

Table 2-1. Summary statistics for daily flow for the period of October 27, 2000, to February 3, 2009 (in cubic feet per second) [1]

Statistic	Homosassa Gauge (unfiltered)	Homosassa Gauge (filtered)	Homosassa Spring	SE Fork	Halls River (filtered)	Spring Total [2]
Minimum	(837)	(636)	34	23	(765)	57
Maximum	2,520	2,090	141	100	1,995	240
Average	279	279	90	62	133	152
Median	267	258	88	61	112	149
Standard Deviation	216	189	14	11	188	25
Standard Error	0.78	0.68	0.16	0.18	1.41	0.16
Skewness	1.81	2.10	0.41	0.45	2.34	0.41

1. Number of data values will vary by gauge
2. Sum of Homosassa Springs and SE Fork flows

Halls River discharge was estimated by subtracting the combined spring discharge from the filtered discharge reported for the Homosassa River gauge. Although referred to as Halls River discharge, it actually represents ungauged freshwater runoff and spring discharge upstream from the gauge and likely includes some tidal influence that remains after filtering the raw AVM record for the Homosassa gauge. Based on the average daily data, spring flow and Halls River flow are about 53 and 47 percent of the total flow at the Homosassa gauge.

Halls River discharge is much more variable than the gauged spring flows (Figure 2-10 and Table 2-1). The relatively high variability of the gauged flow at Homosassa (filtered flow) supports a hypothesis that at least a component of the filtered flow is not spring flow but rather event associated runoff. In addition, the filtering technique may only partially filter the tide signal.

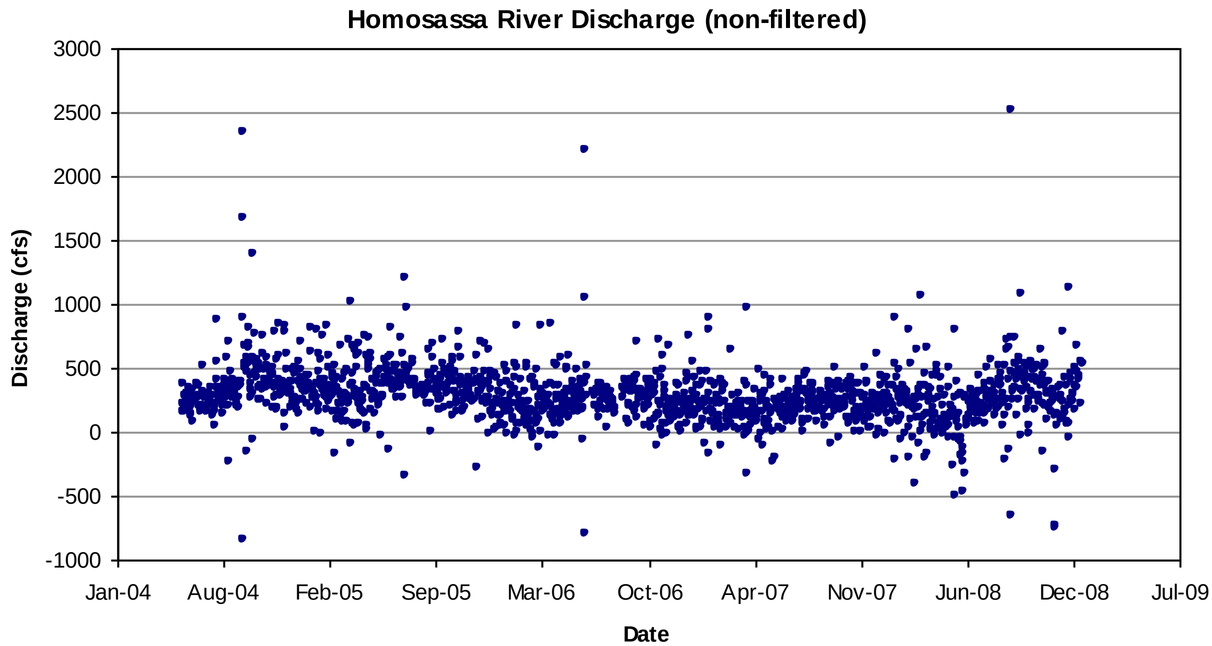

Figure 2-7. Time series of average daily non-filtered flow for Homosassa River gauge

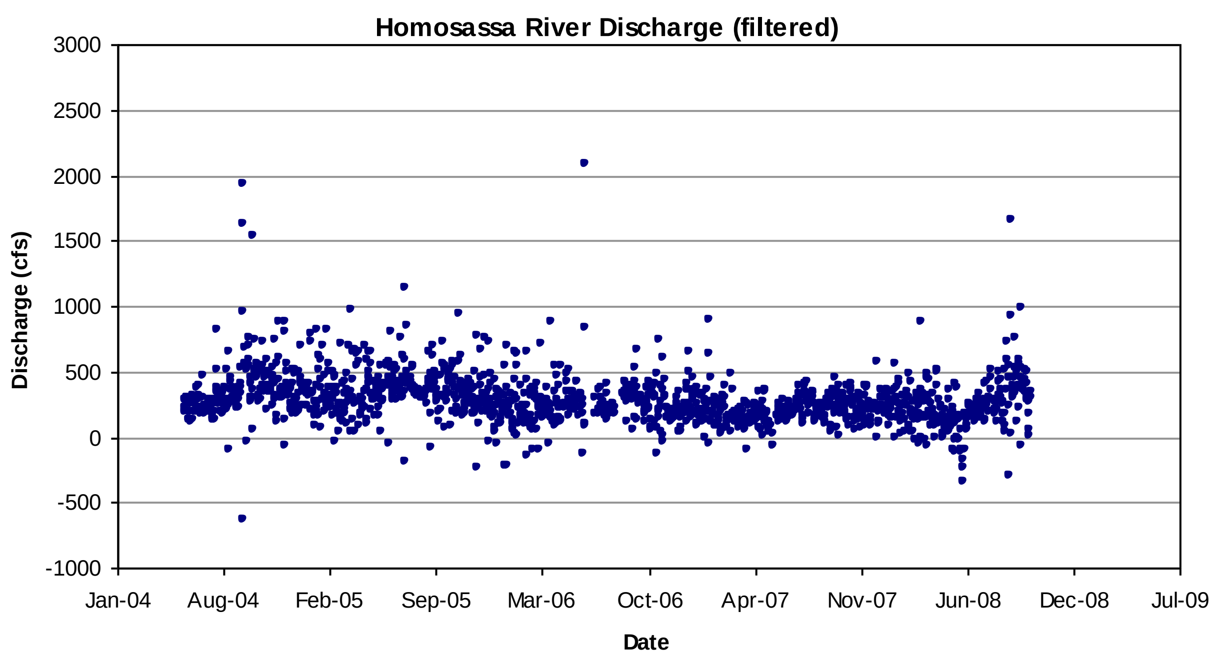

Figure 2-8. Time series of average daily filtered flow for Homosassa River gauge

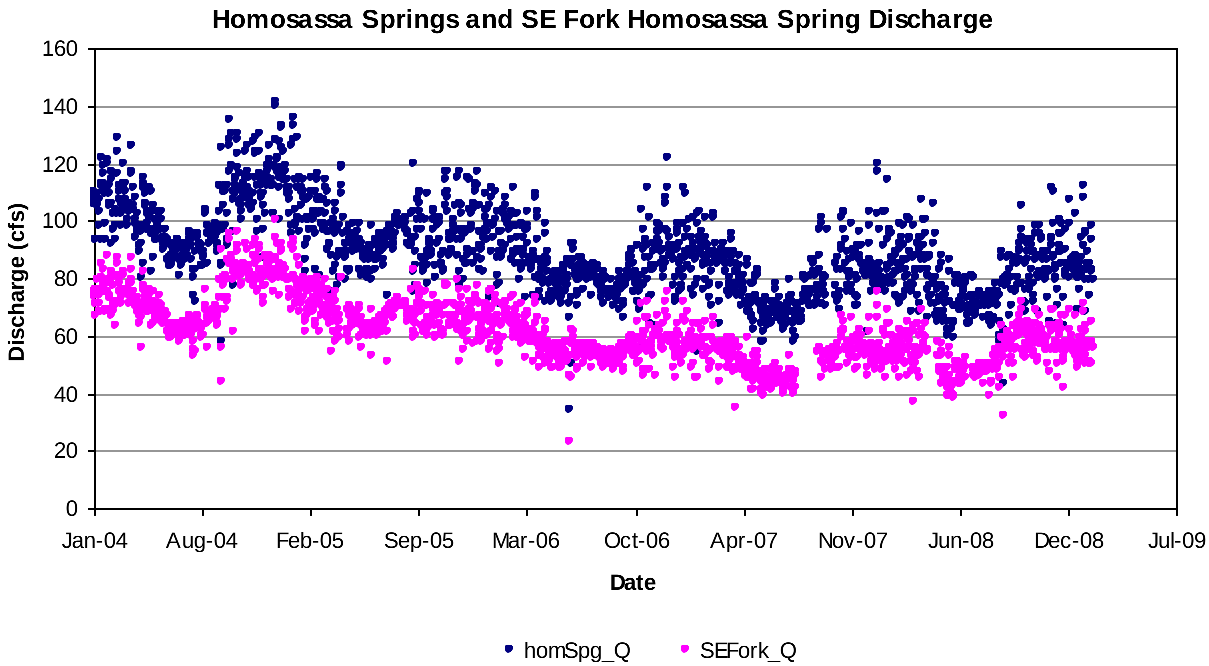

Figure 2-9. Time series of average daily flow for Homosassa Springs and SE Fork Homosassa Spring gauges

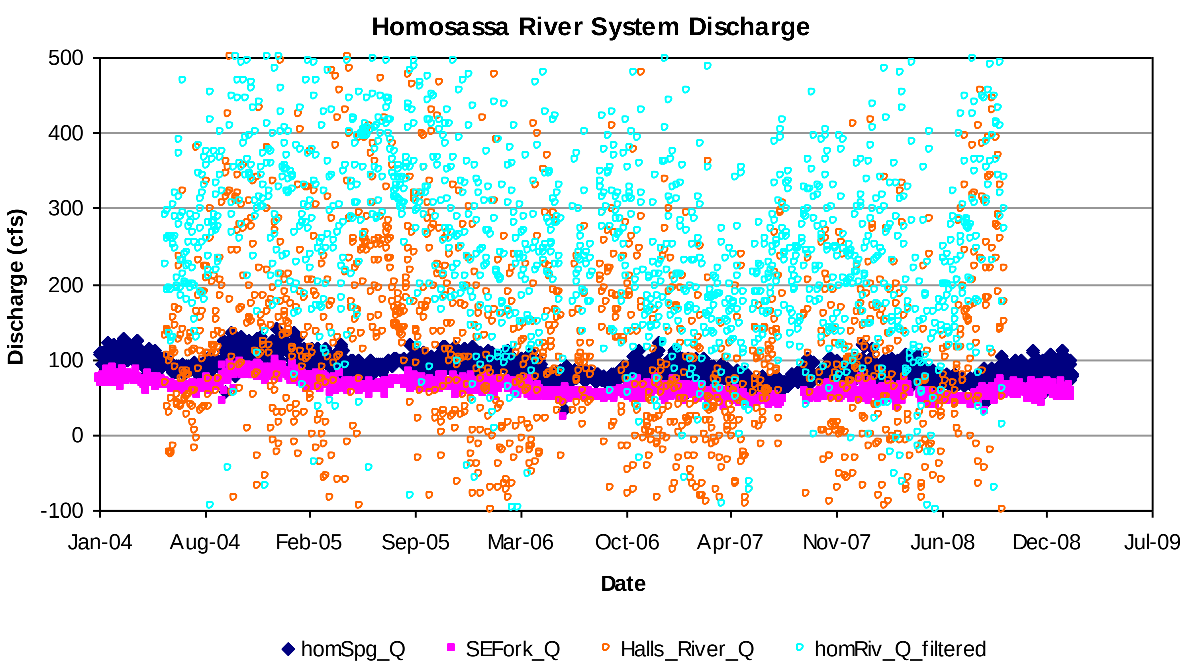

Figure 2-10. Concurrent average daily flows for Homosassa Springs, SE Fork Homosassa Spring, Halls River, and Homosassa River gauges

Daily high and low tide values recorded at Shell Island, Homosassa River, SE Fork Spring and Homosassa Springs gauges are strongly associated across the range of data for both Shell Island and SE Fork USGS gauges (Figures 2-11 to 2-16). Similarly, 15-minute gauge heights at Shell Island and the springs (lagged 2 hours and 15 minutes) also are correlated although considerably more scatter is apparent in the 15-minute data (Figures 2-17 and 2-18). Gauge heights at the two springs are highly correlated (Figure 2-19).

Gauge height at Shell Island also varies by time of year (Figure 2-20). Higher low and median tides occur during the summer, which tend to reduce springflow due to greater pressure over the spring vents. Lower tides in the winter tend to result in increased springflow, with the highest seasonal flows often observed in the early winter. Extreme high tides occur in late winter, which results in lower minimum daily spring flows.

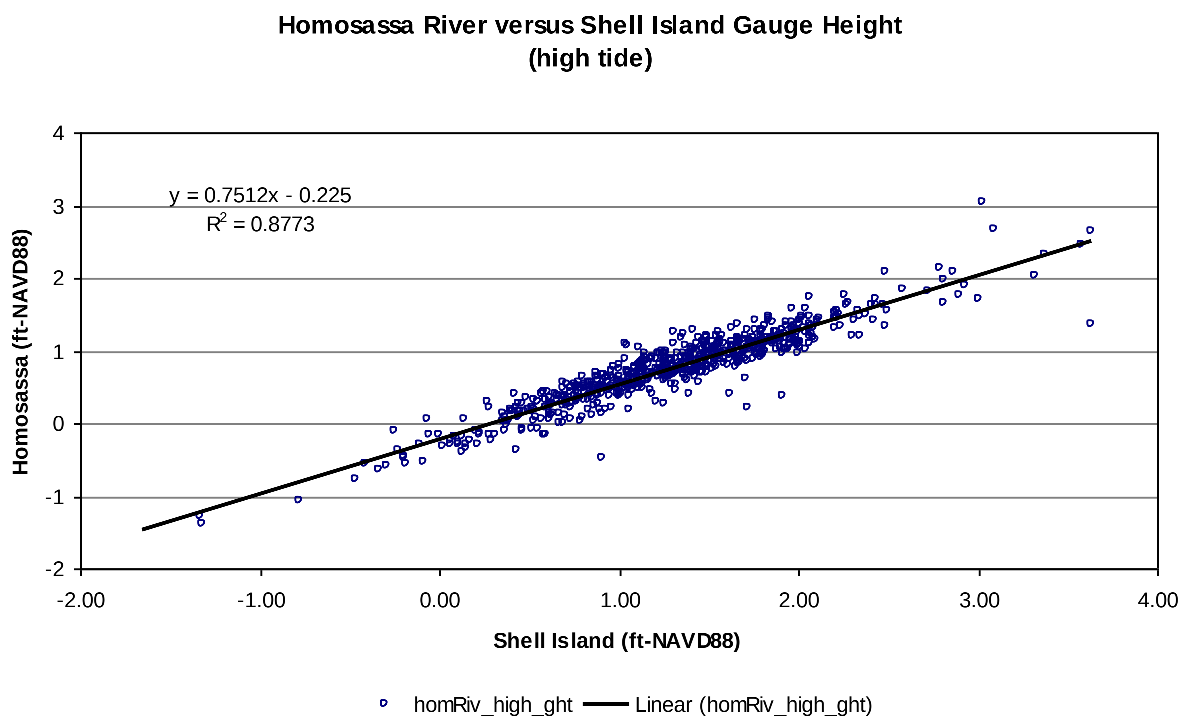

Figure 2-11. Observed daily gauge height at Homosassa River gauge versus observed daily gauge height at Shell Island gauge during high tide

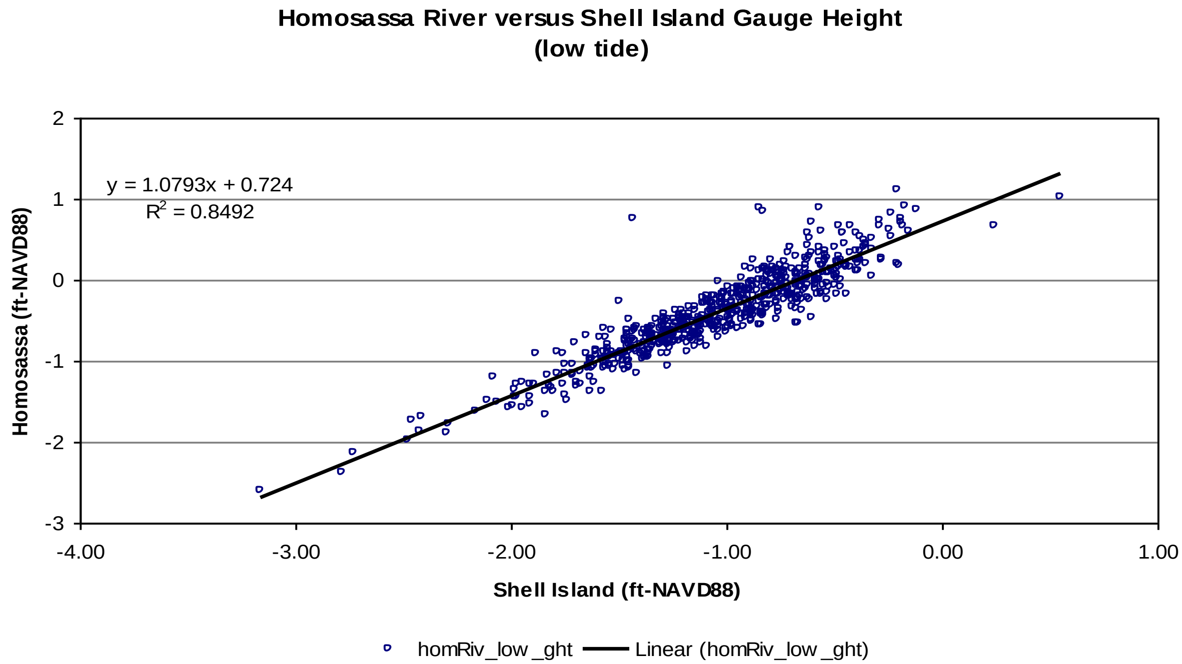

Figure 2-12. Observed daily gauge height at Homosassa River gauge versus observed daily gauge height at Shell Island gauge during low tide

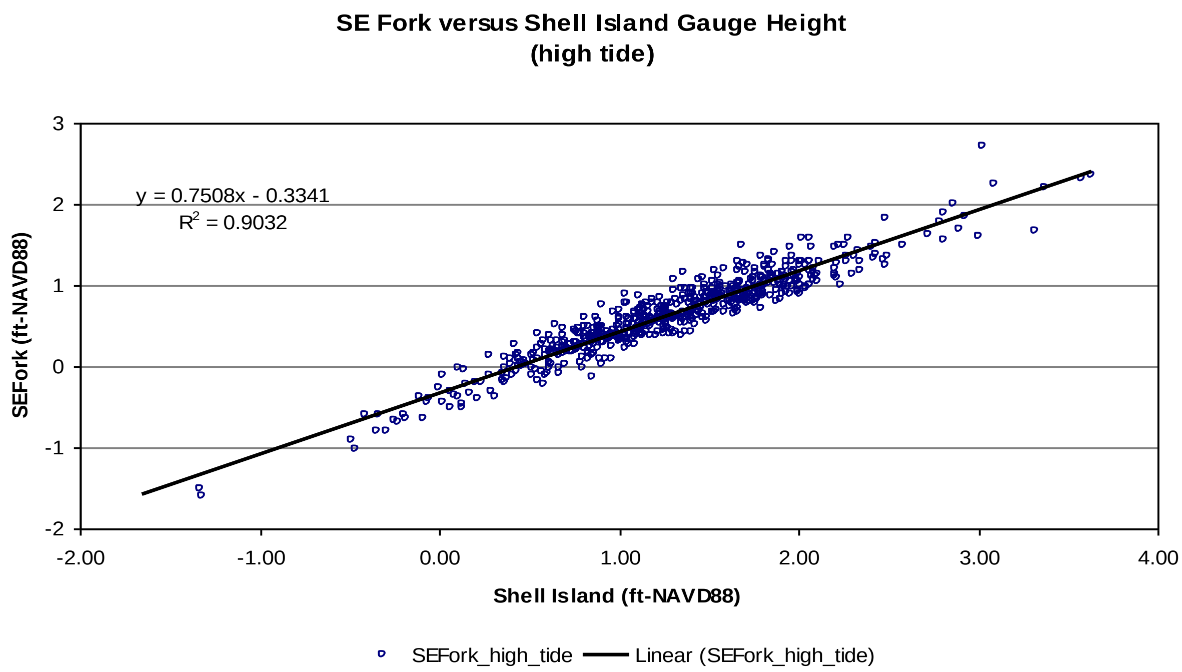

Figure 2-13. Observed daily gauge height at SE Fork Homosassa Spring gauge versus observed daily gauge height at Shell Island gauge during high tide

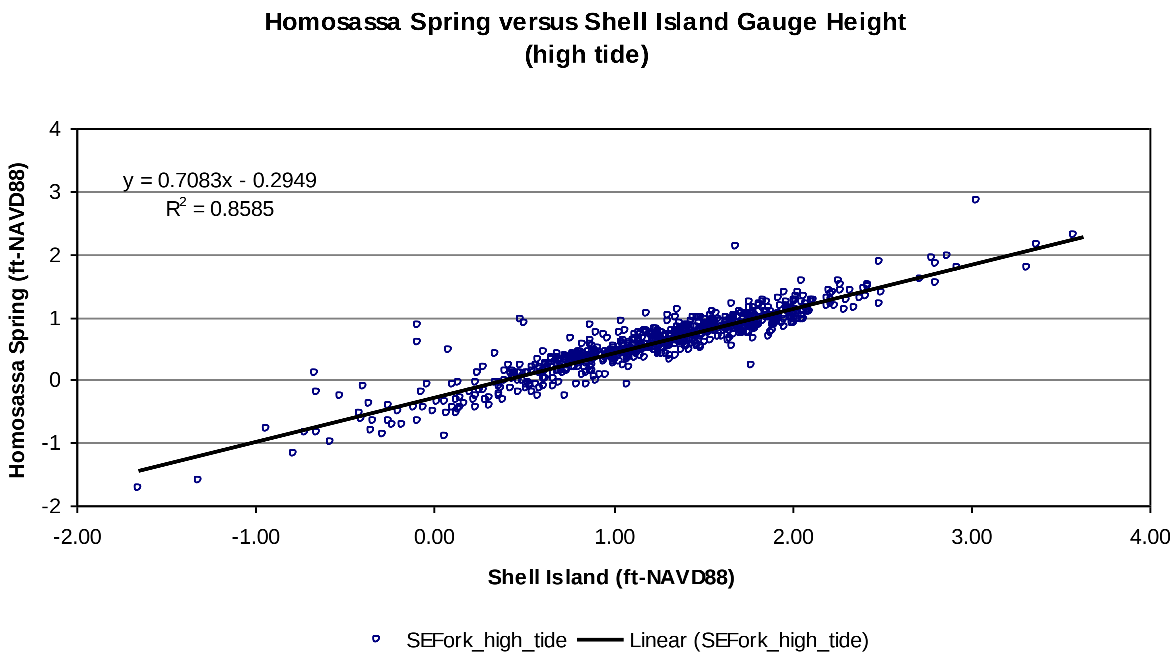

Figure 2-14. Observed daily gauge height at Homosassa Springs gauge versus observed daily gauge height at Shell Island gauge during high tide

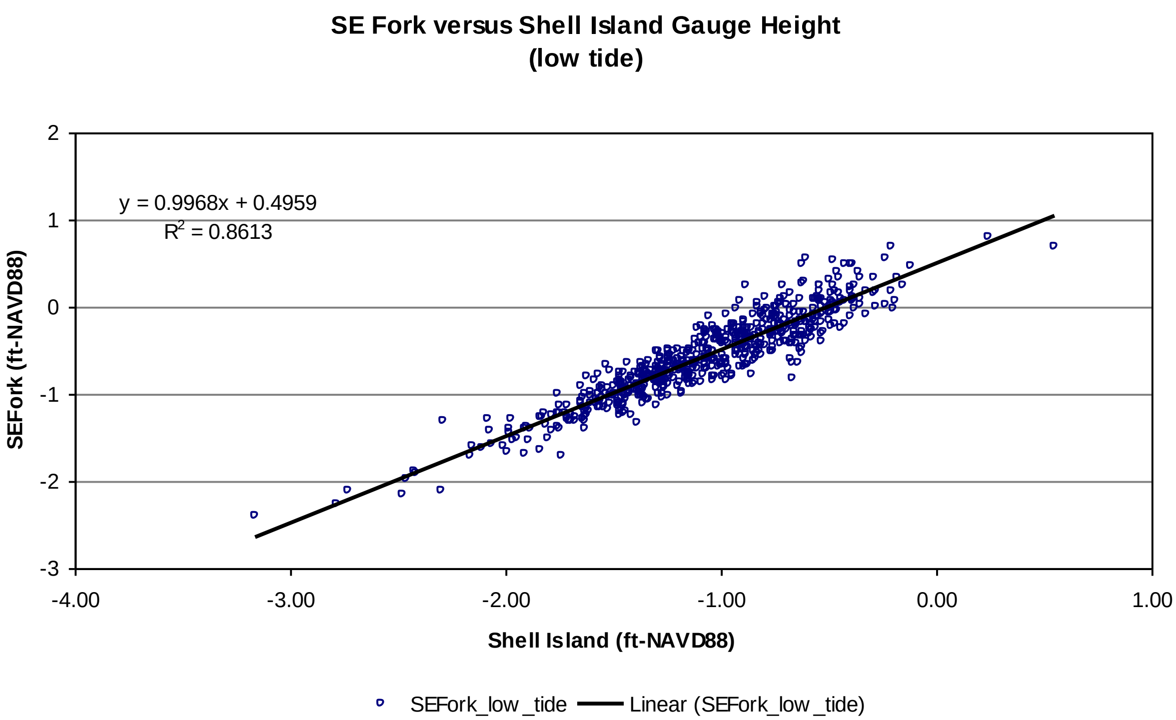

Figure 2-15. Observed daily gauge height at SE Fork Homosassa Spring gauge versus observed daily gauge height at Shell Island gauge during low tide

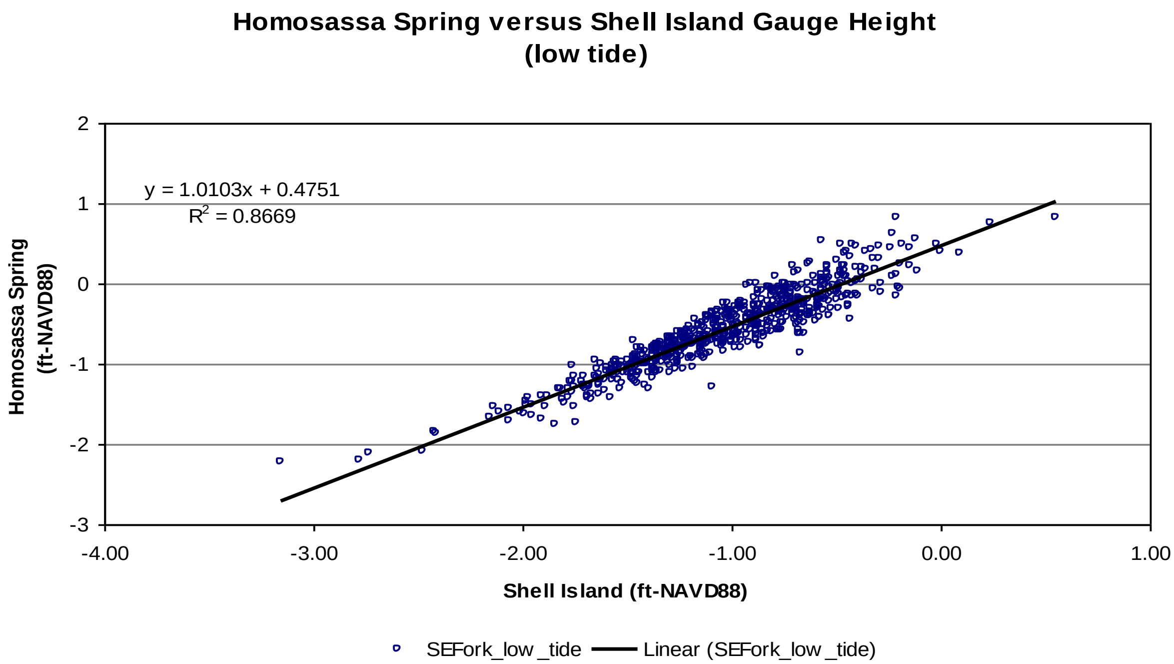

Figure 2-16. Observed daily gauge height at Homosassa Springs gauge versus observed daily gauge height at Shell Island gauge during low tide

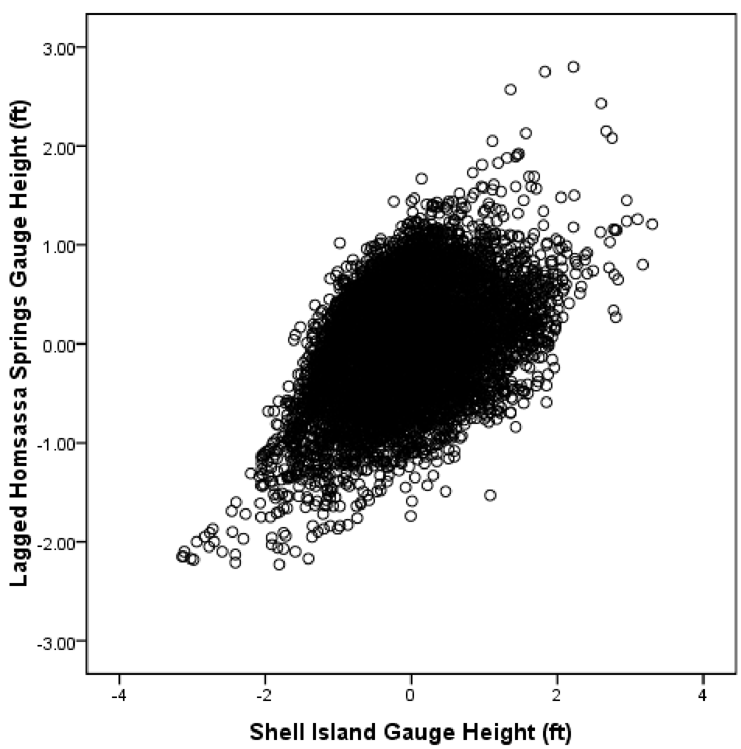

Figure 2-17. Observed 15-minute gauge height at Homosassa Springs gauge lagged 2.25 hours versus observed 15-minute gauge height at Shell Island gauge

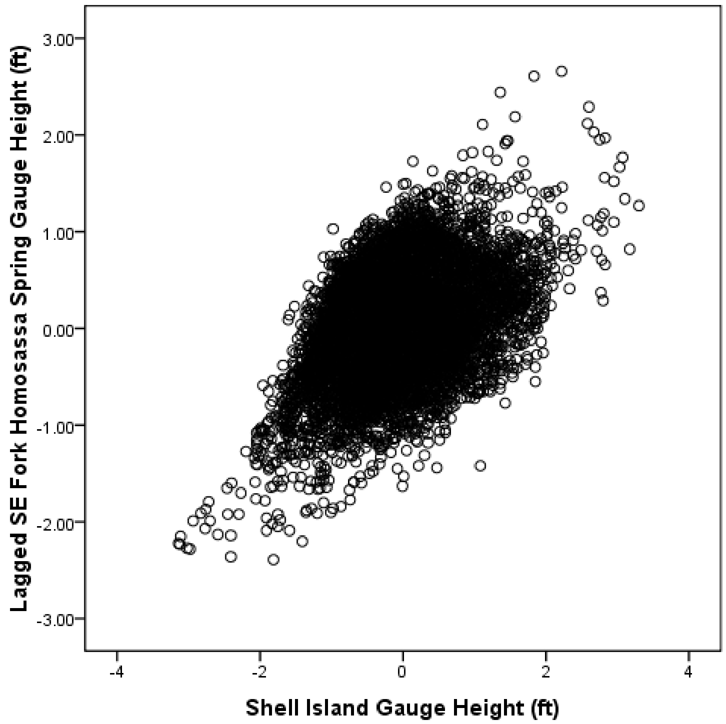

Figure 2-18. Observed 15-minute gauge height at SE Fork Homosassa Spring gauge lagged 2.25 hours versus observed 15-minute gauge height at Shell Island gauge

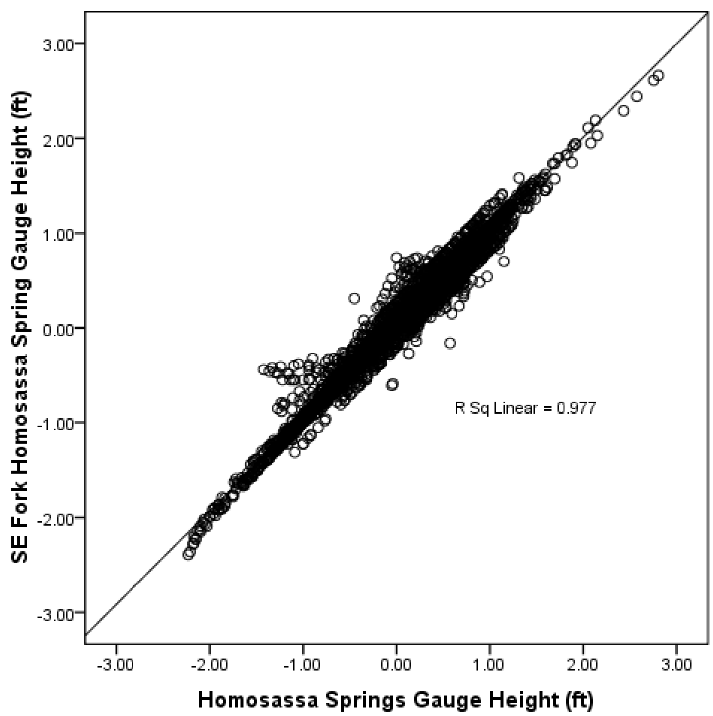

Figure 2-19. Observed 15-minute gauge height at SE Fork Homosassa Spring gauge versus observed 15-minute gauge height at Homosassa Springs gauge

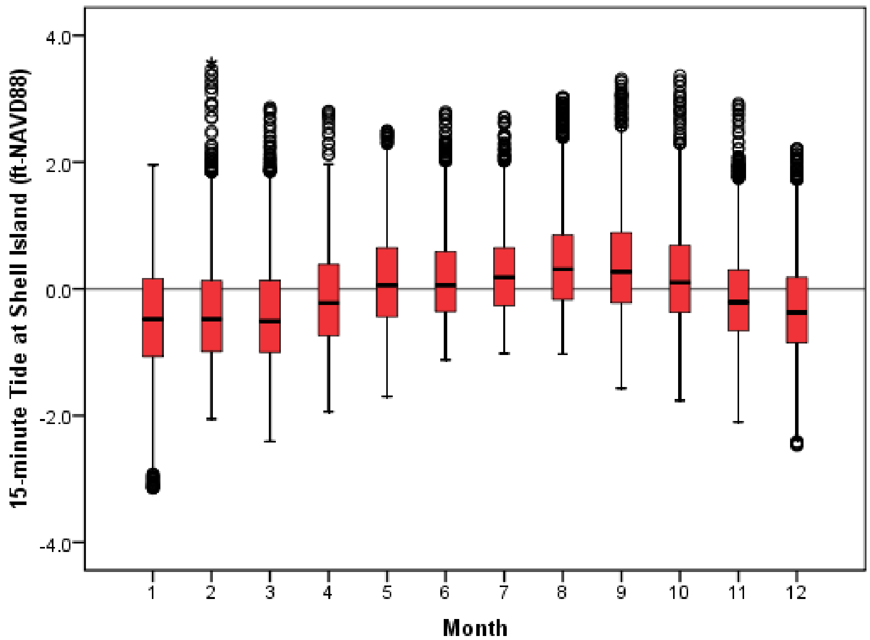

Figure 2-20. Box plot of 15-minute tidal stage at Shell Island from January (Month 1) through December (Month 12)

Cross-correlation plots were developed for various lag times and 30-day average daily spring flow, Weeki Wachee well stage, and rainfall for a gauge in Inglis (Figures 2-21 to 2-23). A cross correlation plot is a graphical representation of the correlation between two variables with one of the variables lagged in time with respect to the other. Zero lag is the correlation of two variables at a common time. Lag one is the correlation between one variable and the other variable at a lag of one time unit (in this case one day). A 30-day averaging period was used because at averaging periods less than 30 days it was difficult to visually discern a pattern in the filtered flow data at Homosassa (Figures D-1 to D-6 in Appendix D). Spring flow is most highly correlated with Weeki Wachee well stage at zero lag as expected since the Weeki Wachee well stage is used, along with river stage, to compute spring flow (Figure 2-20). Halls River flow lags rainfall by 3 to 30 days (Figure 2-21) suggesting that the response to rainfall occurs over some period of time. The relatively quick response could be interpreted as runoff and the lagged response might be more associated with ungauged spring flow. The Weeki Wachee well water levels lag rainfall between about 40 and 70 days (Figure 2-23).

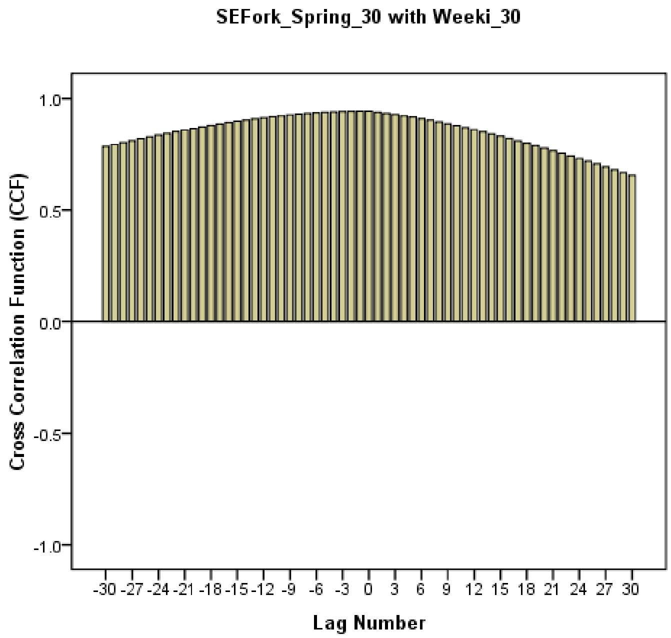

Figure 2-21. Cross-correlation plot between 30-day average daily flow of SE Fork Homosassa Spring gauge and 30-day average daily stage of Weeki Wachee well near Weeki Wachee FL (gauge ID = 02883201082315601)

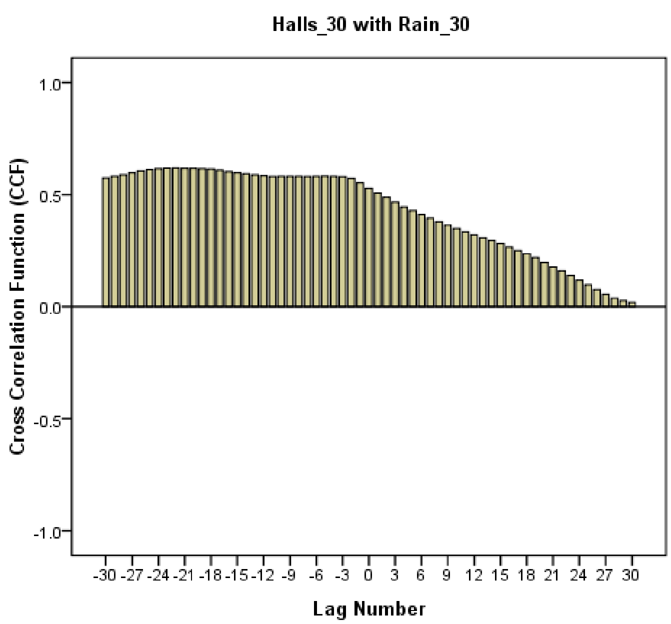

Figure 2-22. Cross-correlation plot between 30-day average daily flow of Halls River gauge and 30-day average rainfall of Inglis, FL

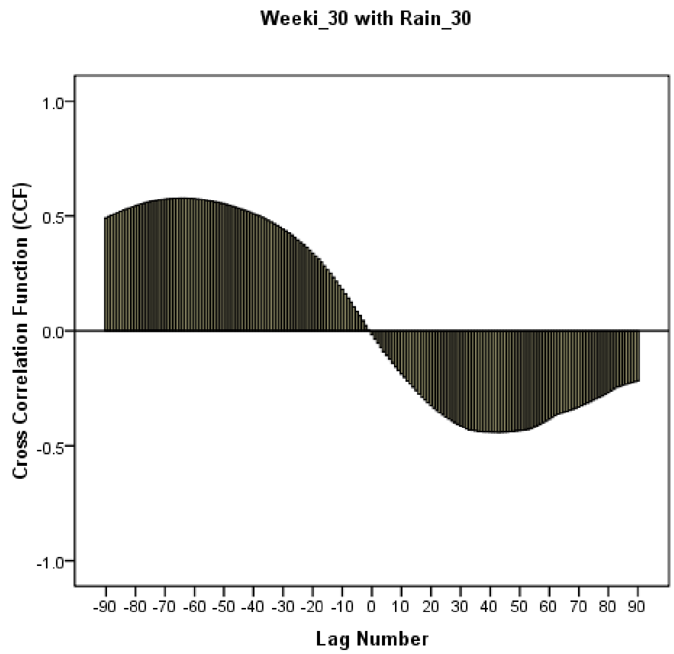

Figure 2-23. Cross-correlation plot between 30-day average daily rainfall of Inglis and 30-day average daily stage of Weeki Wachee well near Weeki Wachee FL (gauge ID = 028832010823156 01)

An attempt was made to use a mass balance approach to calculate the contribution of flow from Halls River to the total flow recorded at the Homosassa River at Homosassa gauge. The governing equation is:

$$Q_{tot}*S_{tot} = Q_{Halls}*S_{Halls} + Q_{Hom\_sp}*S_{Hom\_sp} + Q_{SEFork\_sp}*S_{SEFork\_sp}$$

in which the variables S_{tot} and Q_{tot} are the salinity and filtered flow measured during low tide at the Homosassa River gauge, Q_{Hom_sp} and Q_{SEFork_sp} are Homosassa Springs and SE Fork Springs flow, and S_{Hom_sp} and S_{SEFork_sp} are their corresponding salinity, and Q_{Halls} and S_{Halls} are the flow to be estimated and salinity measured at low tide at Halls River.

The primary issue is that the daily minimum salinity at the Homosassa River gauge, often (and on average) is greater than either the salinity at the springs and Halls River (Figure 2-24). The average daily minimum salinity values for USGS gauges at Homosassa Springs, SE Fork Spring, Halls River, and Homosassa River are 1.55, 0.35, 2.02 and 2.37 psu, respectively. That is only possible if there is residual salinity from the preceding tide cycles impacting the salinity at the USGS gauge.

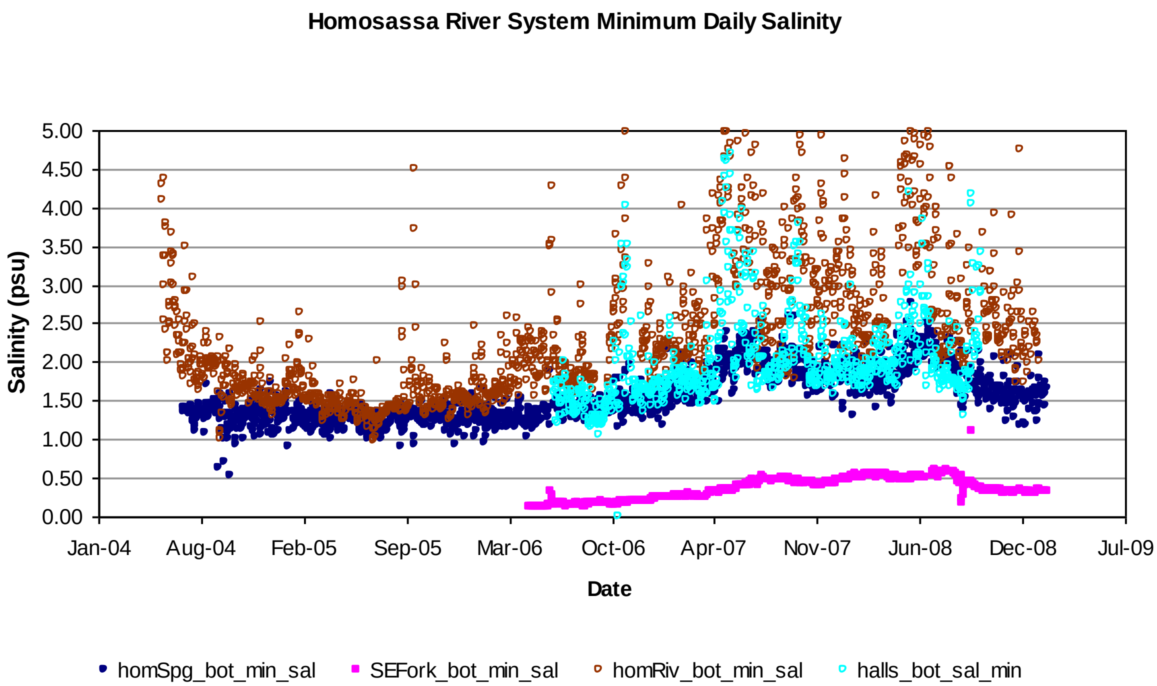

Figure 2-24. Daily minimum salinity at Homosassa Springs, SE Fork Homosassa Spring, Halls River, and Homosassa River gauges

2.4.2 Characterization of Salinity in Homosassa and Halls Rivers

Specific conductance values are reported in daily (maximum and minimum) and 15-minute intervals at the USGS gauges at Homosassa River, Halls River, Homosassa Springs and SE Fork Springs, and Shell Island (Tables A-4 and A-5, and Figure A-1 in Appendix A). Shell Island is located at the mouth of the river, the gauge at Homosassa is located about 9 km upstream of the mouth and the Halls River gauge is located immediately upstream of the confluence of Halls River with Homosassa River. Salinity values were calculated from the specific conductance data using the Cox polynomial method (Cox 1967). An algorithm for the conversion was supplied to HSW by SWFWMD (Michael S. Flannery, December 2006).

The 15-minute bottom salinity values for the two springs and Halls River were plotted versus flow and stage measured or calculated at the same gauge (Appendix E). Halls River flow was calculated as the difference between filtered flow at the USGS gauge at Homosassa and total spring flow. However, spring flow is a calculated value that includes stage as an independent variable (Appendix B); therefore flow and stage are functionally and inversely related for the springs.

Although obscured by many data values, it appears that salinity generally tends to decrease with flow at the Homosassa Springs and SE Fork Springs whereas there is no discernible relationship for Halls River (Figure E-1). At the SE Fork Spring, salinity becomes nearly constant at high flow whereas salinity at the more downstream Homosassa Springs is more varied at high flow. In contrast, there is a discernible relationship between salinity and stage at the Halls River gauge in which higher salinities are associated with higher stages. Farther upstream the relationship is less apparent at the Homosassa Springs gauge where salinity values are lower. At the SE Fork Springs site, low salinity values occur at low tides (stages below about 0.2 ft) and higher salinity values occurred when stages were higher. Halls River salinity also was plotted against total spring flow and this appears to be a better association than Halls River salinity and calculated Halls River flow (not shown).

Time series of mean salinity values were prepared using the 15-minute data values to evaluate relative and temporal trends (Figures 2-25 and 2-26). A slight increase in salinity appears to have occurred at the springs and Halls River over the short period of record, particularly since the beginning of 2006 (Figure 2-25). The increase may be attributed to a decline in spring flow over that time period and is apparent when viewing the relationship of salinity to flow at the various gauges (Figures 2-27 to 2-31), although the association between salinity and flow for Halls River and the SE Fork Homosassa Spring gauge sites is less clear.

Scatter (Figure 2-32) and box plots (Figure 2-33) illustrate the range of data and that the frequency distributions become progressively skewed upstream as the lower limit of salinity approaches that of the combined spring flow. The median salinity of about 20 psu and broad range in salinity at Shell Island illustrates the influence of freshwater inflows at this location.

As expected, greater salinities at a particular gauge are associated with higher tide measured at the same gauge location (Figure 2-34). The association diminishes upstream from the Shell Island gauge to the progressively farther upstream gauges at Homosassa and Halls River.

The salinity at a particular location is inversely proportional to the combined discharge from the SE Fork and Homosassa Springs (Figure 2-35). A nearly linear, albeit variable, relationship is evident at Shell Island. During periods of low spring discharge of about 60 cfs, the salinity has ranged between about 26 and 32 psu, while during periods of high spring discharge of about 190 cfs salinity has ranged between about 10 and 14 psu. The relationships between salinity and flow for the upstream stations at Homosassa and Halls River reflect a decreasing tidal influence.

Mean daily salinity for the Shell Island, Homosassa River, and Halls River gauges was regressed against combined spring flow and mean tide at the Homosassa gauge (Table 2-2 and Appendix I-1). The regression result for the Shell Island data is linear with respect to flow, (Figure 2-36). Similar results were obtained for the gauge at Homosassa but in this case a piecewise (in flow) regression was used (Figures 2-37). The inflection point (i.e., knot) is a flow value that defines a change in the linear relationship between flow and salinity (e.g., 127.1 cfs at the Homosassa gauge). For flow values greater than this inflection point, the reduction in salinity as a function of flow decreases. The regression result for the Halls River data is not as good as the models associated with the two other gauges (as observed graphically [Figures 2-38] and with respect to R-square) probably due to the influence of the ungauged flow associated with Halls River. The apparent increase in salinity at the Halls River gauge at higher flows may be due to backwater influences of spring flow at the junction of Homosassa and Halls Rivers during periods of relatively high spring flow. It also is important to recognize that river stage as measured at the springs is a variable used in calculating spring flow and therefore the independent variables spring flow and tide are related.

Table 2-2. Summary of mean daily salinity prediction equations and statistics for Homosassa River USGS gauges at Shell Island, Homosassa River, and Halls River

Period of Record	Location	Coefficients					R^2	Number of Observations
		a_0	a_1	a_2	a_3	$knot_1$		
2000 - 2009	Shell Island	47.302	-0.199	-2.277	—	—	0.60	618
	Homosassa	30.598	-0.207	-0.739	0.144	127.1	0.65	682
	Halls River	13.130	-0.087	0.198	0.104	125.0	0.34	724

Equation forms:

$S = a_0 + a_1*Q + a_2*T + a_3*(Q-knot_1)$ for $Q >= knot_1$

$S = a_0 + a_1*Q + a_2*T$ for $Q < knot_1$

for which

S = Mean daily salinity at the Shell Island, Homosassa River and Halls River USGS gauge in psu

Q = total combined flow of Homosassa Springs and SE Fork Homosassa Spring, in cfs

T = mean tide at Homosassa in ft NAVD88

knot1 = inflection Q values in the piecewise regression models

— = the variable was not included in the model

In addition to salinity values at gauge locations, synoptic sampling has been conducted by various agencies. From 2006 to 2008, the SWFWMD and the University of South Florida collected near-surface and near-bottom salinity measurements. Longitudinal salinity gradients are nearly linear under a wide range of flows (Figures F-1 and F-2 in Appendix F). Steeper gradients in which salinity declines from about 23 psu near the mouth to about 2 psu at a distance 11 km upstream are generally associated with combined spring discharges less than about 125 cfs. Less steep gradients in which salinity declines from about 12 psu at the mouth to 2 psu 11 km upstream were observed when spring discharge was greater than about 145 cfs. Vertical gradients characterized by longitudinal profiles of surface and bottom salinity measured on individual dates illustrate water that is generally well mixed or weakly stratified with bottom salinity several psu higher than the surface salinity (Figure F-3).

The river channel was divided into 200-meter intervals along the river centerline. Between five and twenty surface and bottom salinity observations are available for the majority of these intervals (Figure F-4). In areas with more than 30 observations, surface and bottom salinity versus total spring flow (Figures F-5 to F-17) demonstrate weak associations. Vertical stratification plots also were prepared for areas with more than 30 data points and when both surface and bottom salinity data are available (Figures F-18 to F-20). Stratification is more apparent in the upstream reaches.

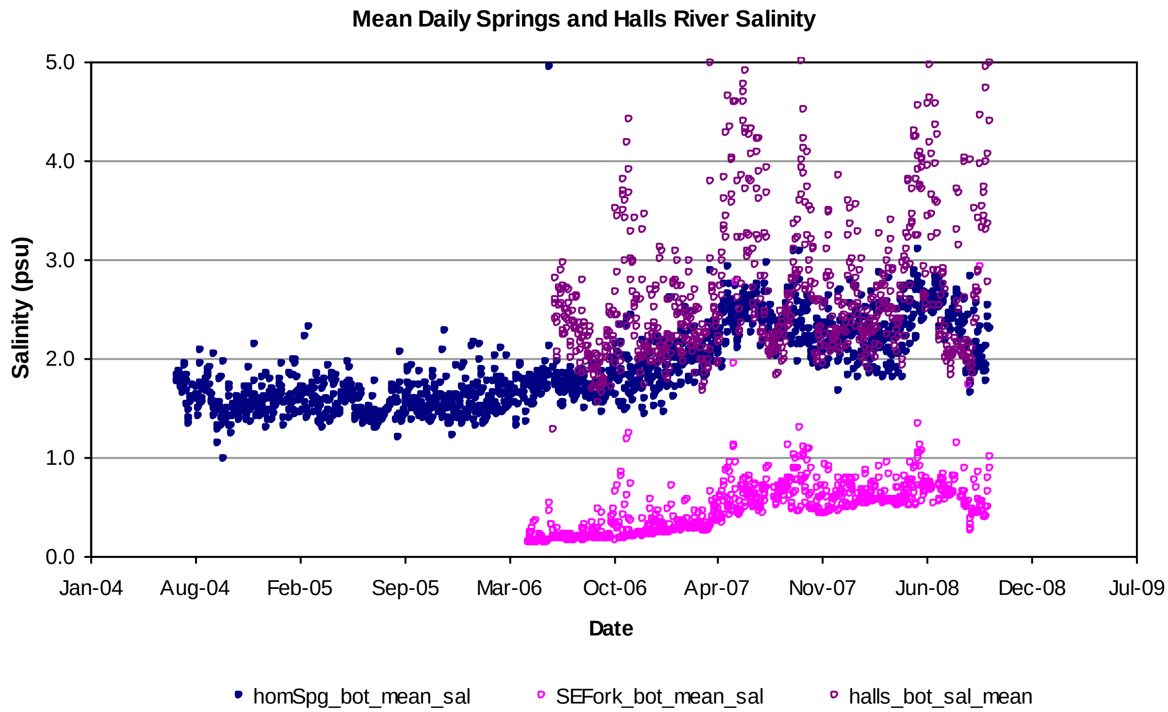

Figure 2-25. Mean daily salinity for Homosassa Springs, SE Fork Homosassa Spring, and Halls River gauges

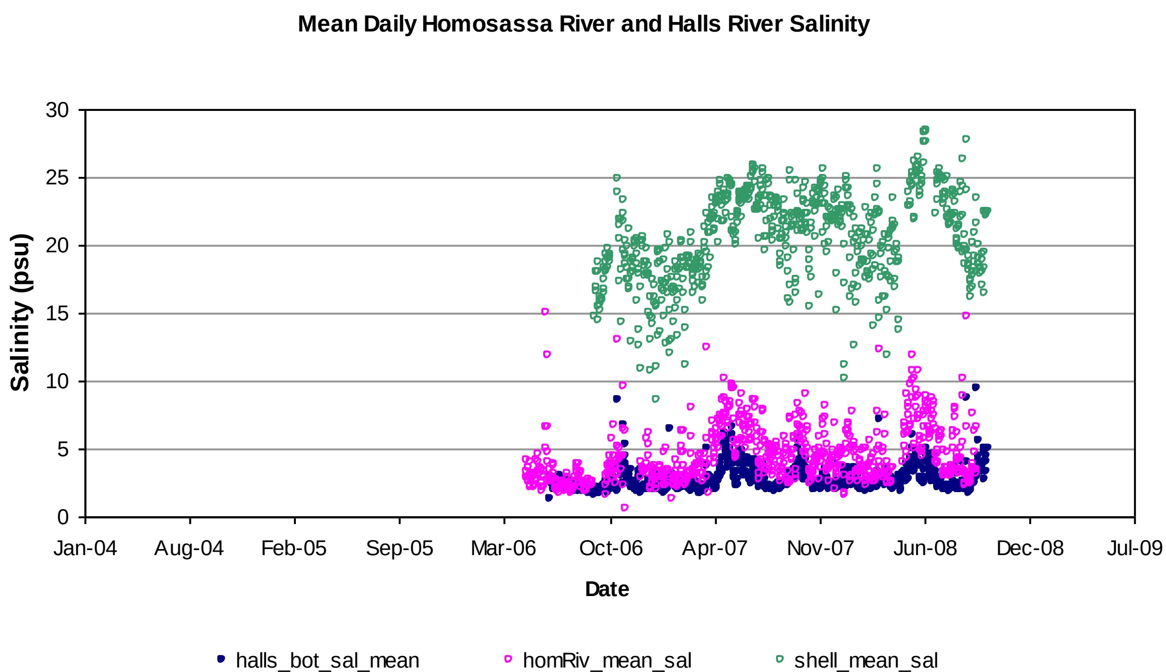

Figure 2-26. Mean daily salinity for Halls River, Homosassa River, and Shell Island gauges

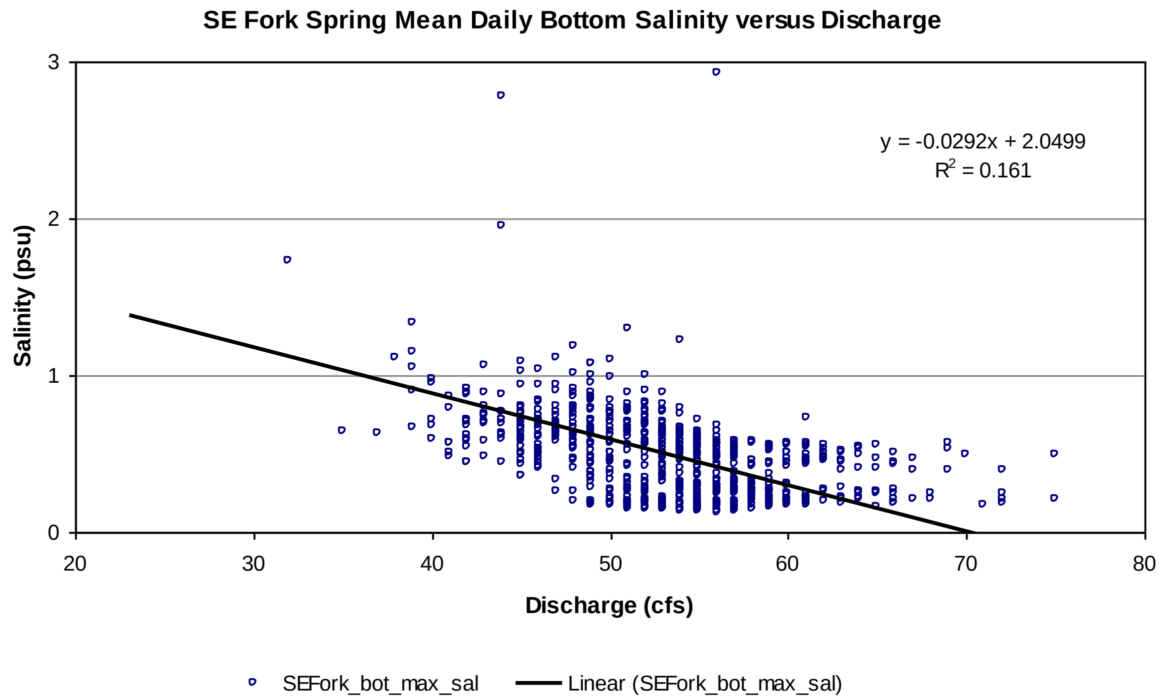

Figure 2-27. Relationship between mean daily bottom salinity and SE Fork Homosassa Spring discharge

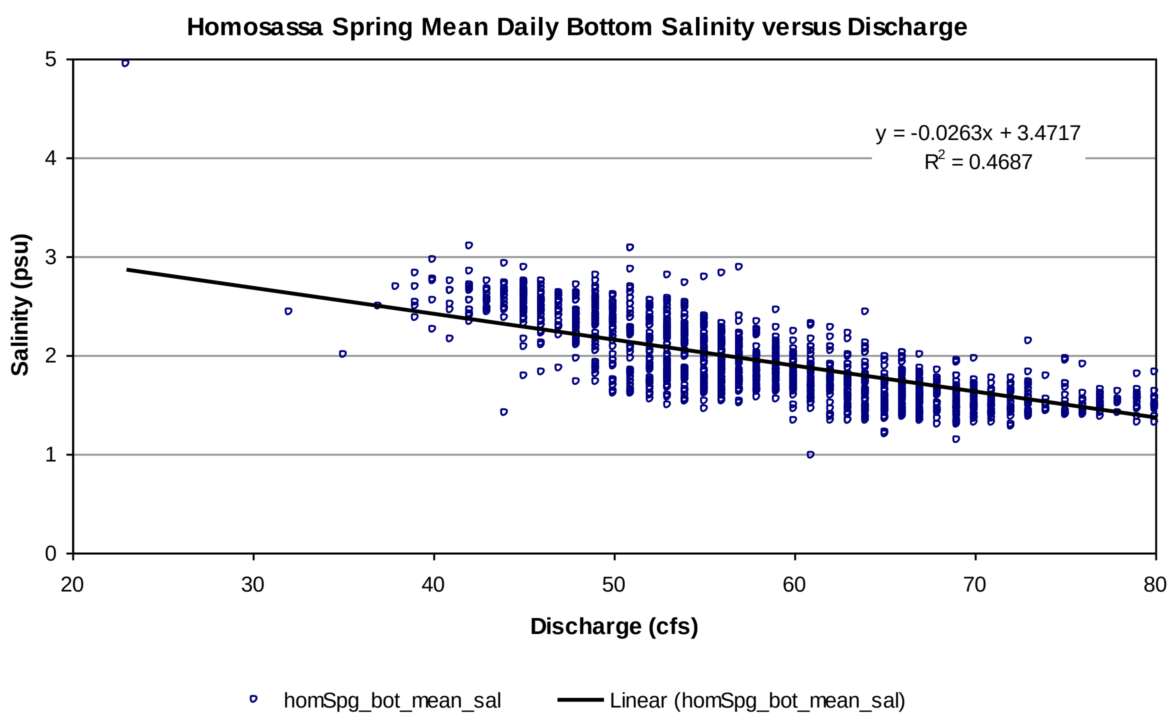

Figure 2-28. Relationship between mean daily bottom salinity and Homosassa Springs discharge

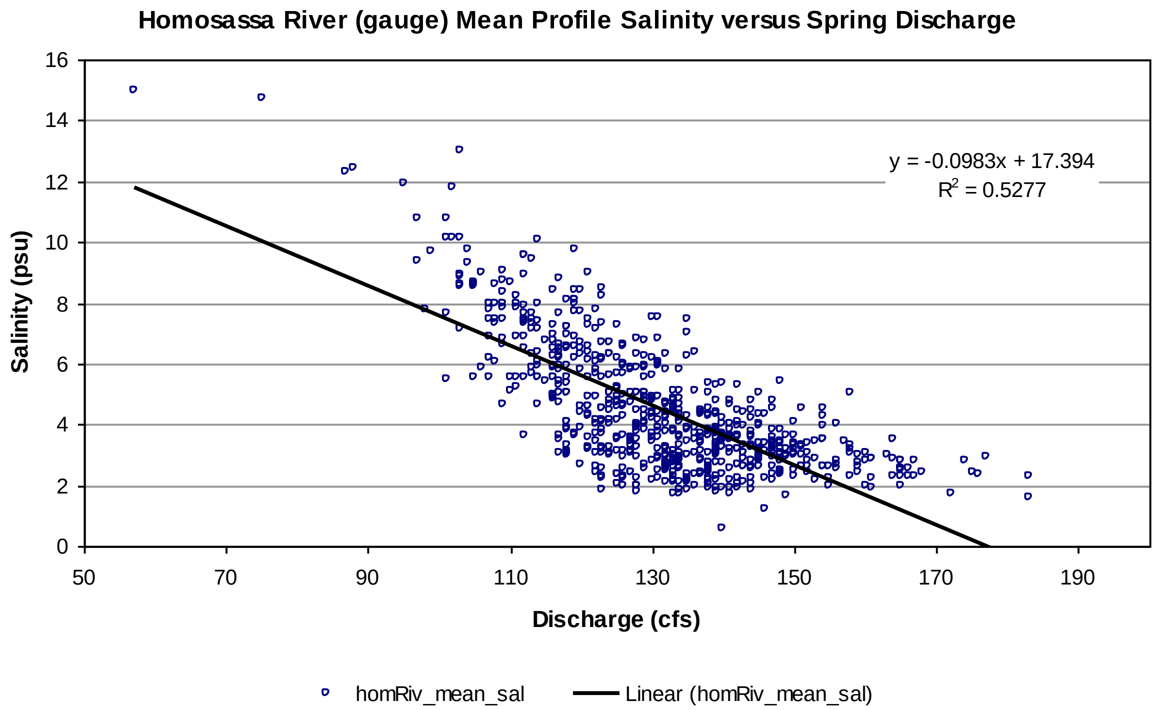

Figure 2-29. Relationship between mean profile salinity and river discharge at Homosassa

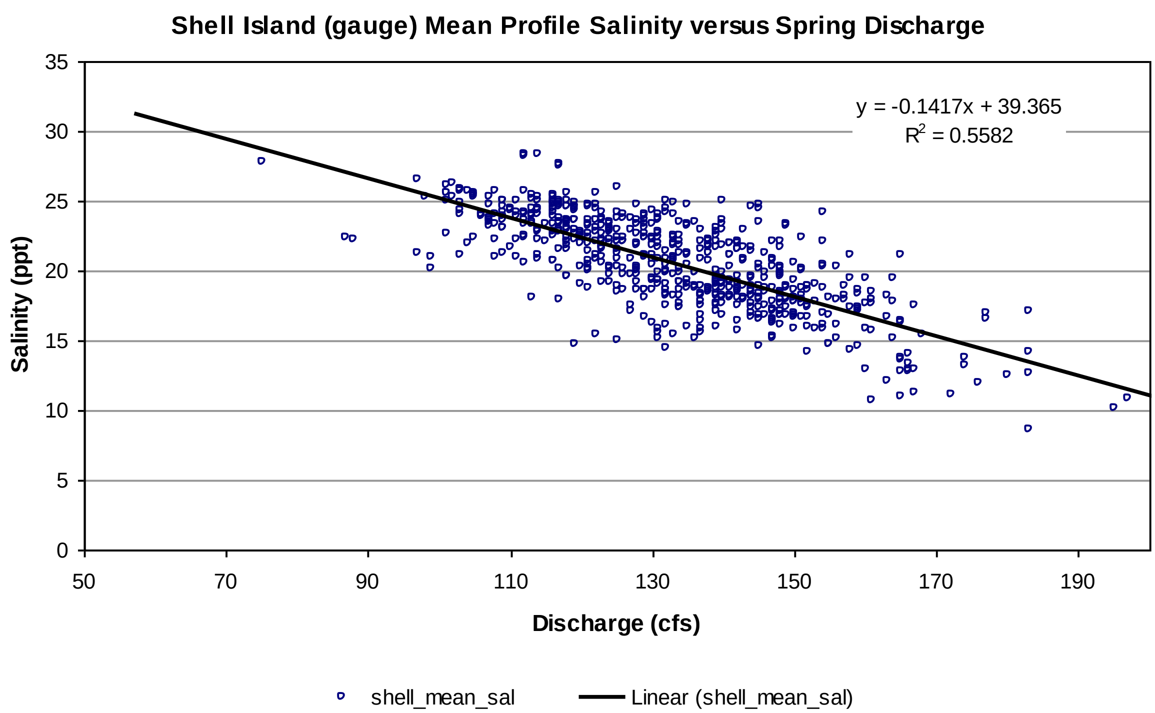

Figure 2-30. Relationship between mean profile salinity and river discharge at Shell Island

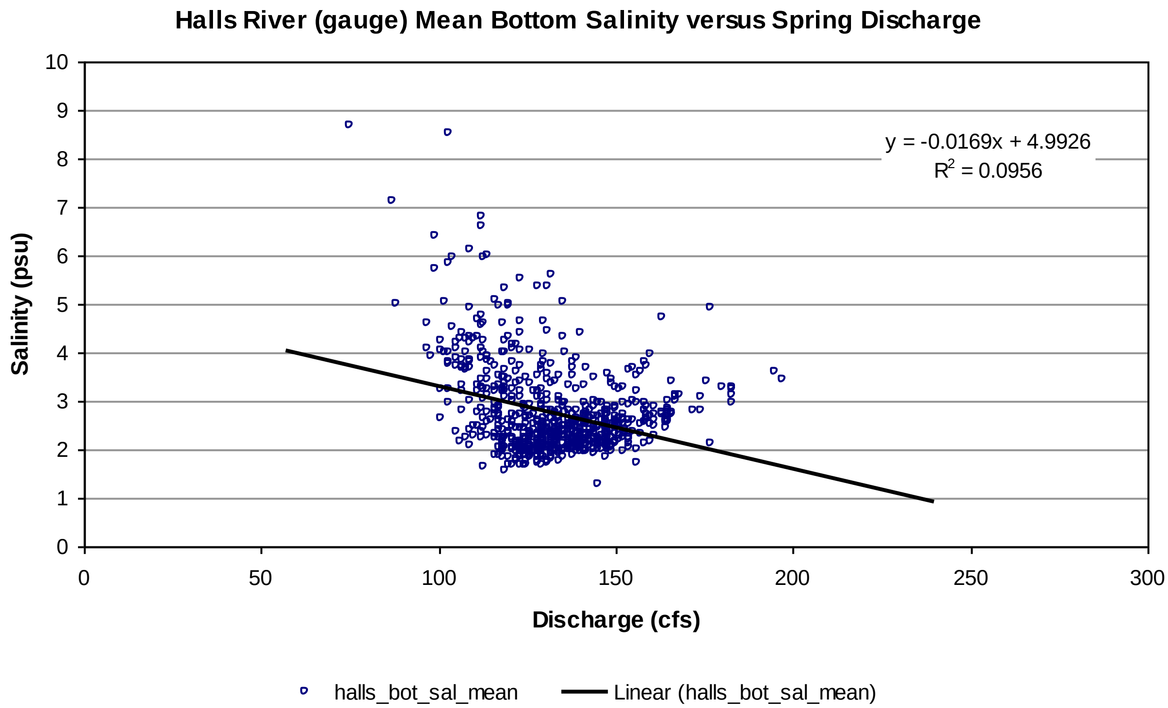

Figure 2-31. Relationship between mean daily bottom salinity at Halls River gauge and combined Homosassa and SE Fork spring discharges

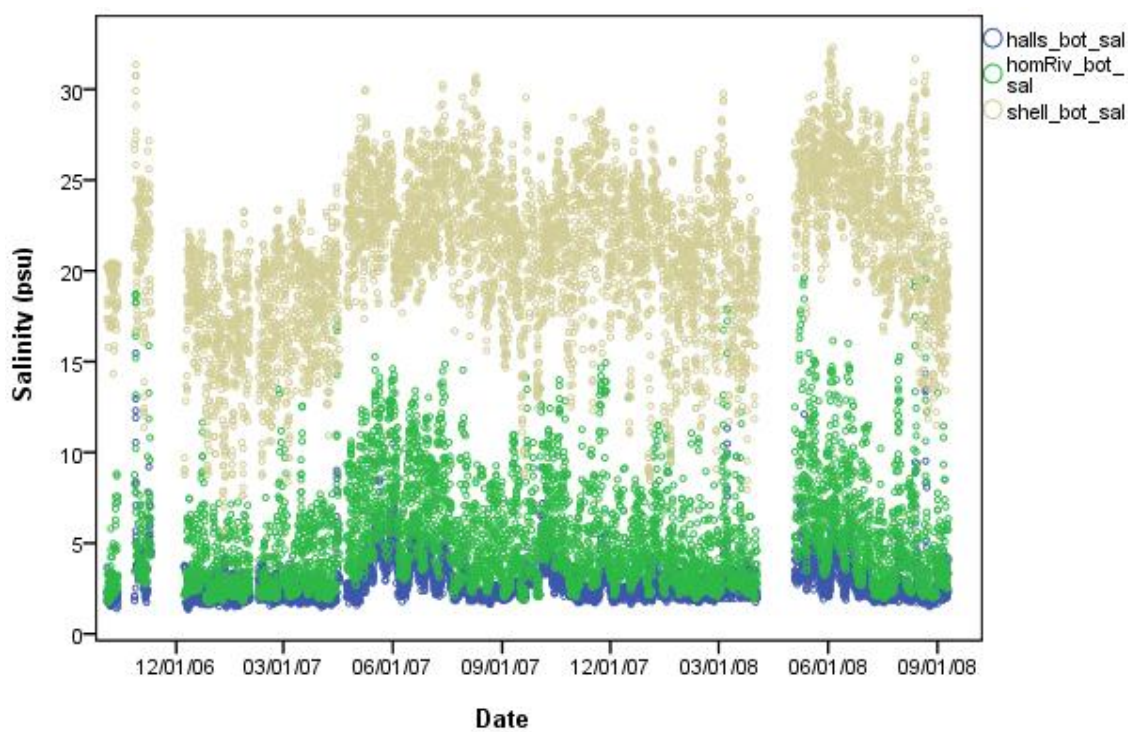

Figure 2-32. Time series of 10% randomly sampled 15-minute bottom salinity data for Halls River, Homosassa River, and Shell Island gauges

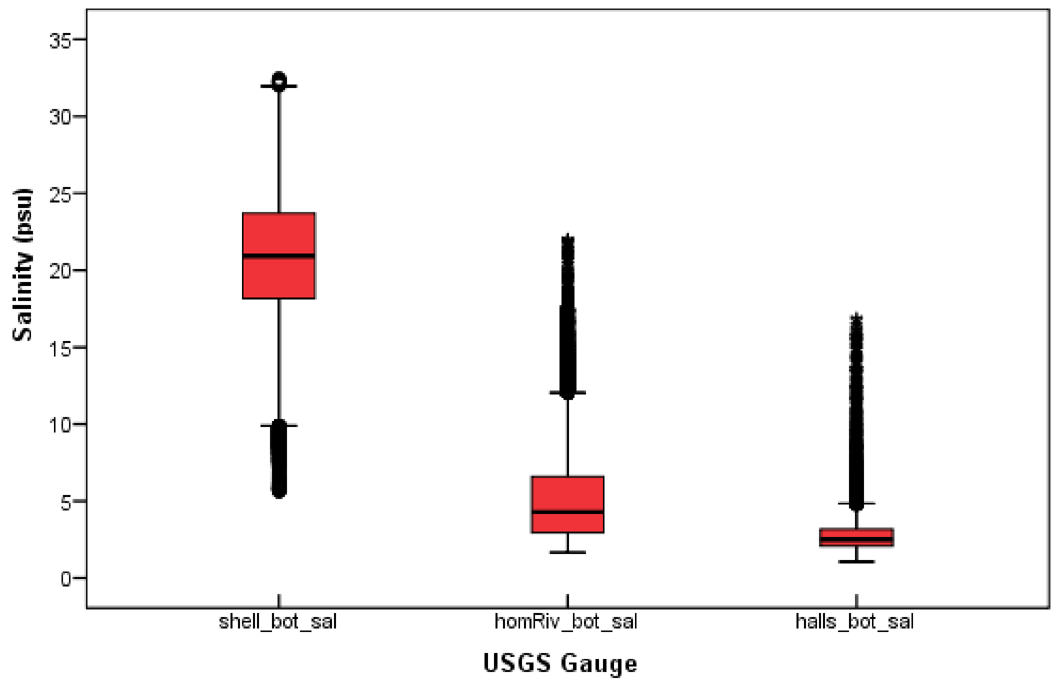

Figure 2-33. Box plot of 15-minute bottom salinity data for Halls River, Homosassa River, and Shell Island gauges

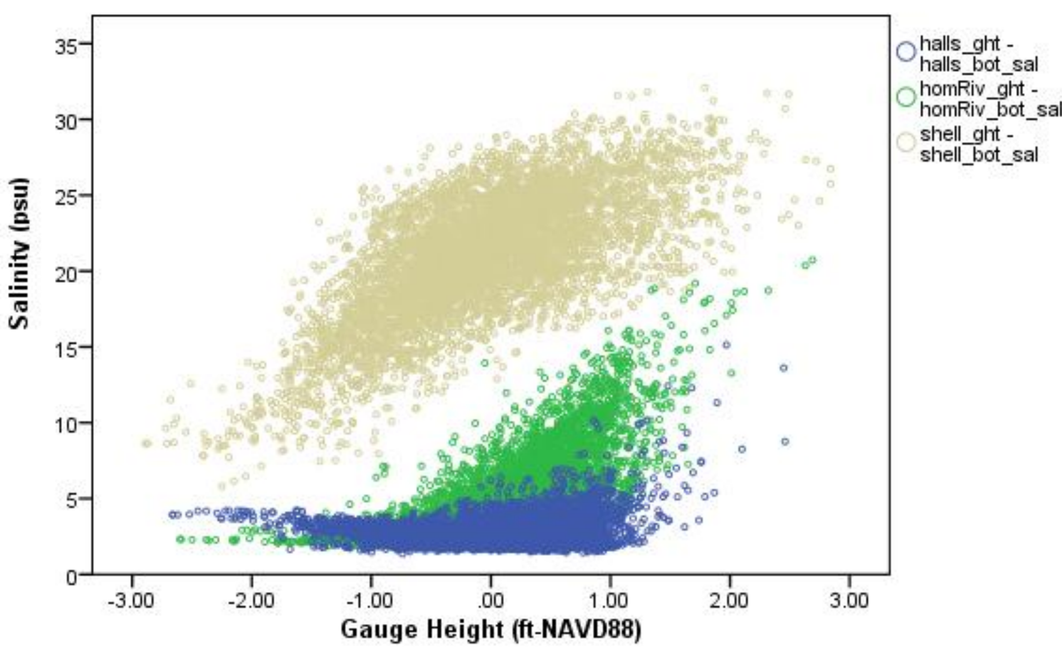

Figure 2-34. 10% randomly sampled 15-minute bottom salinity versus station-specific stage for Halls River, Homosassa River, and Shell Island gauges

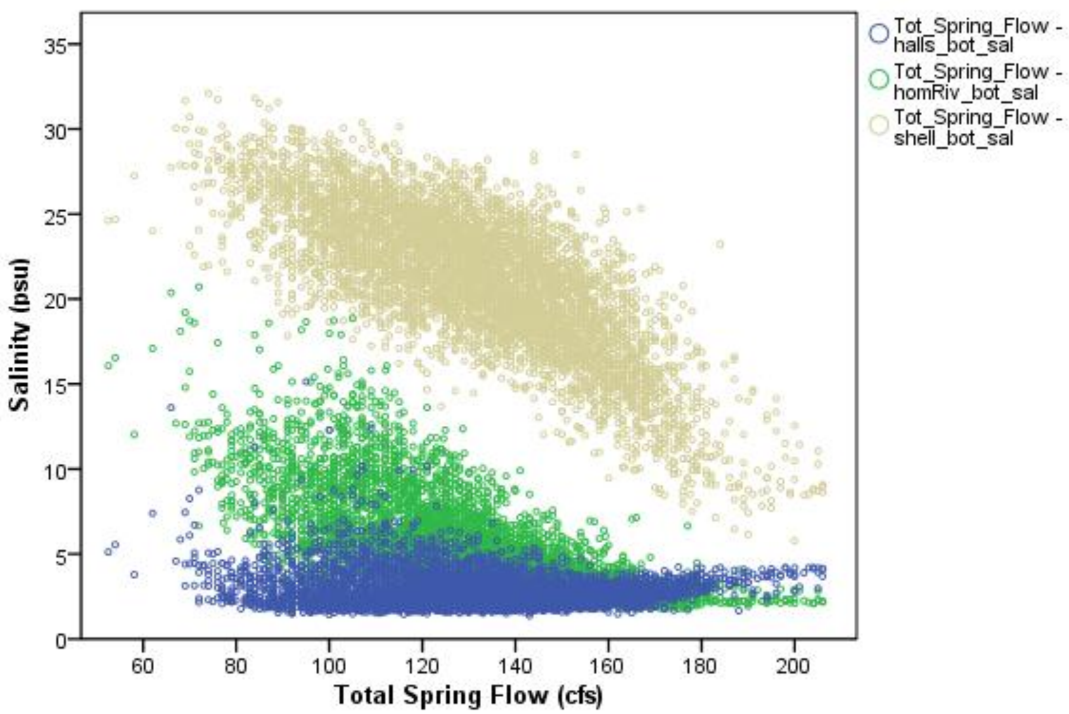

Figure 2-35. 10% randomly sampled 15-minute bottom salinity versus total spring flow for Halls River, Homosassa River, and Shell Island gauges

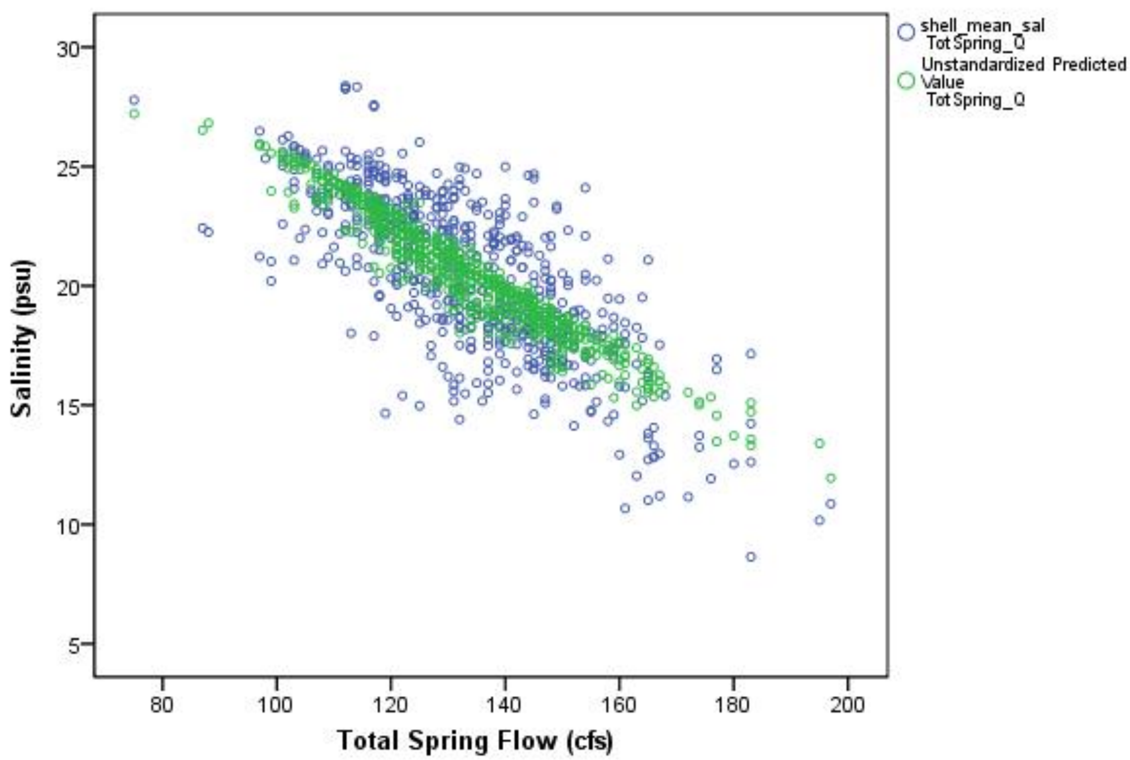

Figure 2-36. Observed and predicted mean salinity versus total spring flow for Shell Island gauge

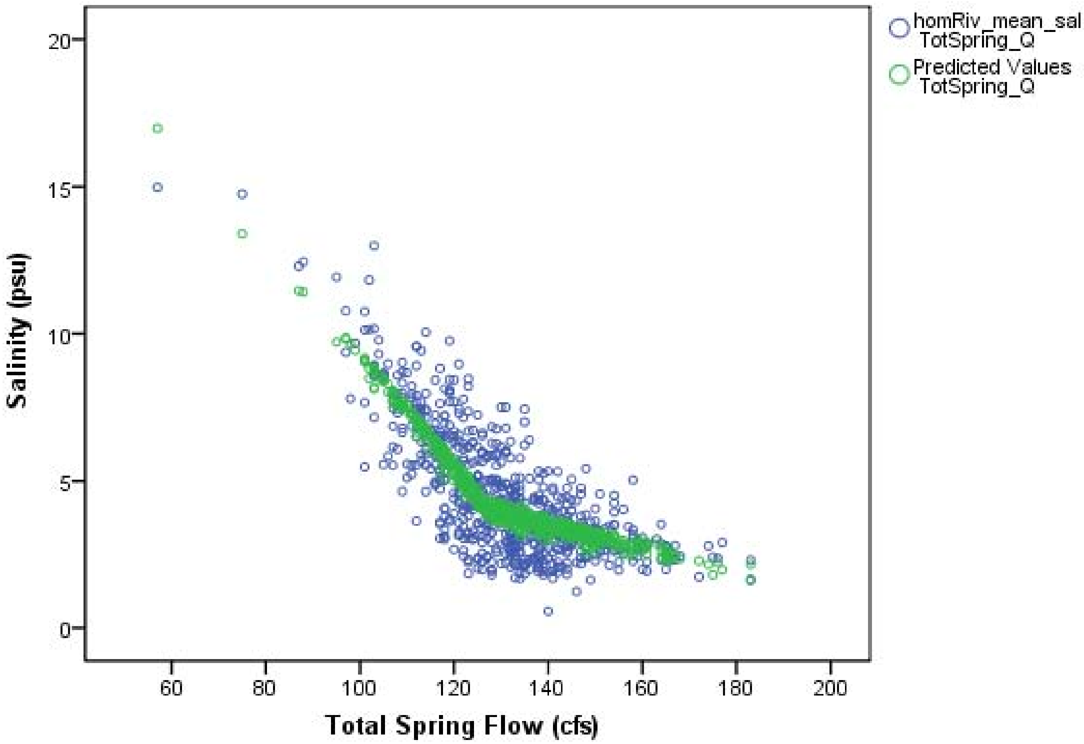

Figure 2-37. Observed and predicted mean salinity versus total spring flow for Homosassa River gauge

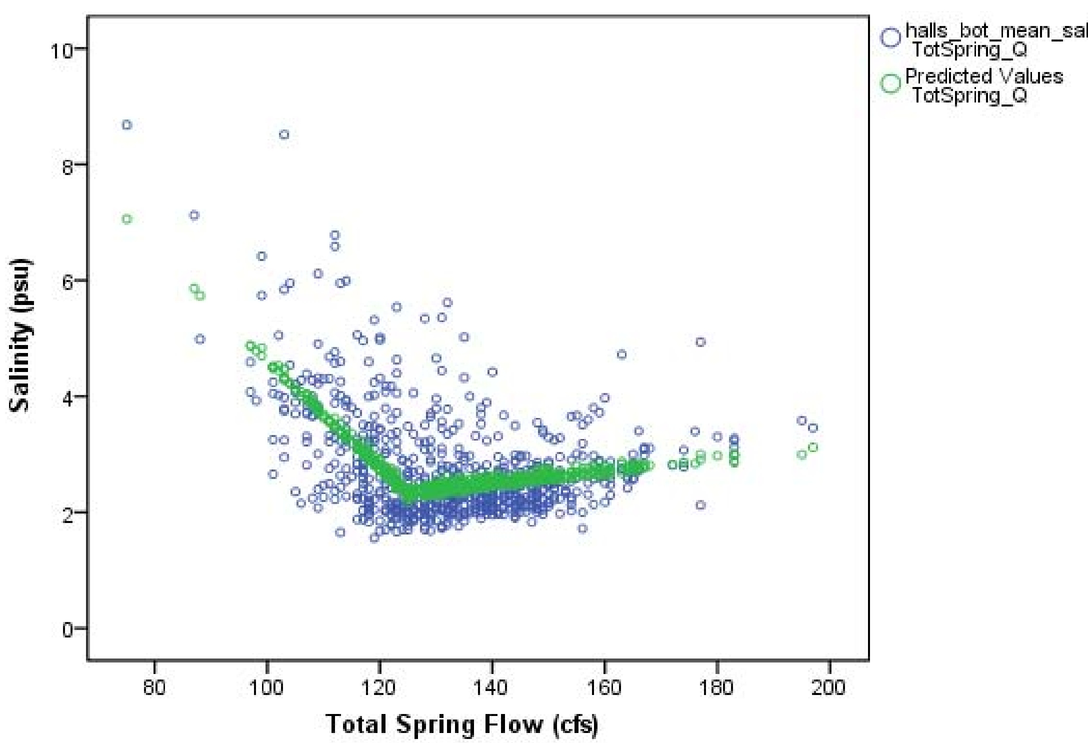

Figure 2-38. Observed and predicted mean salinity versus total spring flow for Halls River gauge

2.4.3 Empirical Salinity Model Development

Mean daily surface and bottom salinity data for the USGS gauge at Homosassa River were regressed against spring flow and mean tide at the gauge (Table 2-3, Figures 2-39 to 2-42, and Appendix I-2) similar to the mean vertically averaged salinity regressions described for Section 2.4.2. At high flows, there is little variation in bottom salinity at the Homosassa gauge and it reflects the salinity of the springs and ungauged flow (Figure 2-40). The number of observations varies according the period of record for the particular gauge and salinity measurement depth locations.

Regression equations also were developed for the Shell Island gauge, which is located near the mouth of the Homosassa River (Table 2-3 and Figures 2-41 and 2-42). The association between salinity and total spring flow is linear throughout the range of flow data.

Table 2-3. Summary of prediction equations and statistics for Homosassa River and Shell Island USGS gauges surface and bottom salinity regression models

Period of Record	Gauge Depth	Coefficients							R^2	Number of Observations
		a_0	a_1	a_2	a_3	a_4	$knot_1$	$knot_2$		
2000 - 2009	Homosassa River Surface	27.247	-0.184	0.141	—	-0.263	127.3	—	0.62	727
	Homosassa River Bottom	30.560	-0.205	0.134	0.063	-0.269	126.8	162.8	0.71	1389
	Shell Island Surface	47.028	-0.198	—	—	-2.251	—	—	0.59	650
	Shell Island Bottom	48.518	-0.207	—	—	-2.415	—	—	0.59	625

Equation forms:

$S = a_0 + a_1*Q + a_2*(Q-knot_1) + a_3*(Q-knot_2) + a_4*T$ for $Q >= knot_2$

$S = a_0 + a_1*Q + a_2*(Q-knot_1) + a_4*T$ for $knot_1 <= Q < knot_2$

$S = a_0 + a_1*Q + a_4*T$ for $Q < knot_1$

in which

S = surface or bottom salinity at Homosassa River or Shell Island USGS gauge, in psu

Q= total combined flow of Homosassa Springs and SE Fork Homosassa Spring, in cfs

$knot_1$ and $knot_2$ = inflection Q values in the piecewise regression models

T = tide at Homosassa gauge

— = the variable was not included in the model

Three isohaline models (3, 5 and 12 psu) were developed for predicting the location of surface and bottom water-column salinity isohalines using synoptic survey data (2005 through 2009). The isohaline models explain about 50% to 60% of the variation in the measurements used to develop the models (Table 2-4 and Appendix I-3). The coefficient associated with flow

(Q) is the displacement of a particular isohaline per unit change in Q. For example, if Q is reduced by 10 cfs, the 5 psu bottom isohaline is predicted to move only about 0.09 km upstream if Q is less than 135 cfs but will move 0.9 km upstream for greater values of Q.

Salinity values within subreaches with sufficient data points (more than 30 observations identified in Section 2.4.2) were evaluated to characterize relationships between surface and/or bottom salinities and Shell Island gauge height and total spring flow (Table 2-5 and Appendix I-4). Similar to the analyses summarized for Section 2.4.2, these models explain less than 60% of the variability in the measurements. No statistically significant model was developed for the two subreaches 11.9 and 12.3 km upstream from the mouth.

Surface and bottom whole river models (Table 2-6 and Appendix I-5) were developed using the synoptic data set for the whole river (i.e., same data set used in Table 2-5) and account for between 79% and 88% of the variability in the measurements used to develop the models (Table 2-6). Models were developed using all of the salinity data and using only the salinity data with concentrations greater than 3 psu. A salinity of 3 psu is near the salinity of the spring water and below 3 psu the salinity is poorly correlated to spring flow. The root mean square error (RMSE) of all models, a measure of predictive accuracy, ranges between 2.47 and 3.01 psu.

Table 2-4. Summary of prediction equations and statistics for Homosassa River isohaline location (kilometers) regression models (2000 to 2009)

Isohaline (psu)	Type	Coefficients					R^2	Number of Observations
		a_0	a_1	a_2	a_3	$knot_1$		
3	Surface	11.936	-0.017	-0.029	0.427	128.0	0.54	59
	Bottom	14.259	-0.026	-0.054	0.443	135.0	0.57	61
5	Surface	10.991	-0.020	-0.030	0.511	135.0	0.59	69
	Bottom	10.874	-0.009	-0.081	0.664	135.0	0.53	65
12	Surface	5.397	0.002	-0.072	1.250	121.6	0.59	70
	Bottom	9.630	-0.029	-0.060	1.070	131.2	0.54	49

Equation forms:

$RKM = a_0 + a_1*Q + a_2* (Q-knot_1) +a_3*T$ for $Q >= knot_1$ or

$RKM = a_0 + a_1*Q +a_3*T$ for $Q < knot_1$

in which

RKM = distance to the salinity isohaline (in psu) upstream from river mouth, in kilometers

Q = total flow of Homosassa Springs and SE Fork Homosassa Spring USGS gauges, in cfs

$knot_1$ = inflection Q value in piecewise model

T = tide at Homosassa River USGS gauge, in ft-NAVD88, at the time of water quality sampling

Table 2-5. Summary of prediction equations and statistics for Homosassa River fixed location surface and bottom salinity regression models (1998 to 2009)

Location (km) (vertical)	Coefficients			RMSE (psu)	R^2	Number of Observations
	a_0	a_1	a_2			
0.1 (surface)	26.683	-0.044	2.692	2.61	0.50	72
0.1 (bottom)	26.514	-0.040	2.813	2.69	0.49	70
7.3 (surface)	20.121	-0.097	—	2.03	0.41	26
7.3 (bottom)	25.442	-0.117	—	2.67	0.58	37
9.1 (surface)	10.763	-0.051	—	1.76	0.32	179
9.1 (bottom)	13.683	-0.065	1.303	2.06	0.46	72

Equation form:

$S = a_0 + a_1 * Q + a_2 * T$

in which

S = surface or bottom salinity at indicated location, in psu

Q = total flow of Homosassa Springs and SE Fork Homosassa Spring USGS gauges, in cfs

T = tide at Shell Island USGS gauge, in ft-NAVD88, at the time of water quality sampling

— = not significant

Table 2-6. Summary of prediction equations and statistics for Homosassa River whole river surface and bottom salinity regression models (1998 to 2009)

Type	Coefficients			RMSE (psu)	R^2	Number of Observations
	a_0	a_1	a_2			
Surface[a]	29.696	-1.611	-0.075	2.47	0.88	806
Surface[b]	33.232	-1.767	-0.097	2.62	0.85	492
Bottom[a]	30.766	-1.400	-0.087	2.80	0.85	1001
Bottom[b]	37.811	-1.595	-0.129	3.01	0.79	524

Equation form:

$S = a_0 + a_1 * KM + a_2 * Q$

in which

S = surface or bottom salinity, in psu

KM = distance in kilometers upstream from river mouth, and

Q = total flow of Homosassa Springs and SE Fork Homosassa Spring USGS gauges, in cfs

[a] All data points were included in the model

[b] Data points with salinity value greater than 3 psu were included in the model

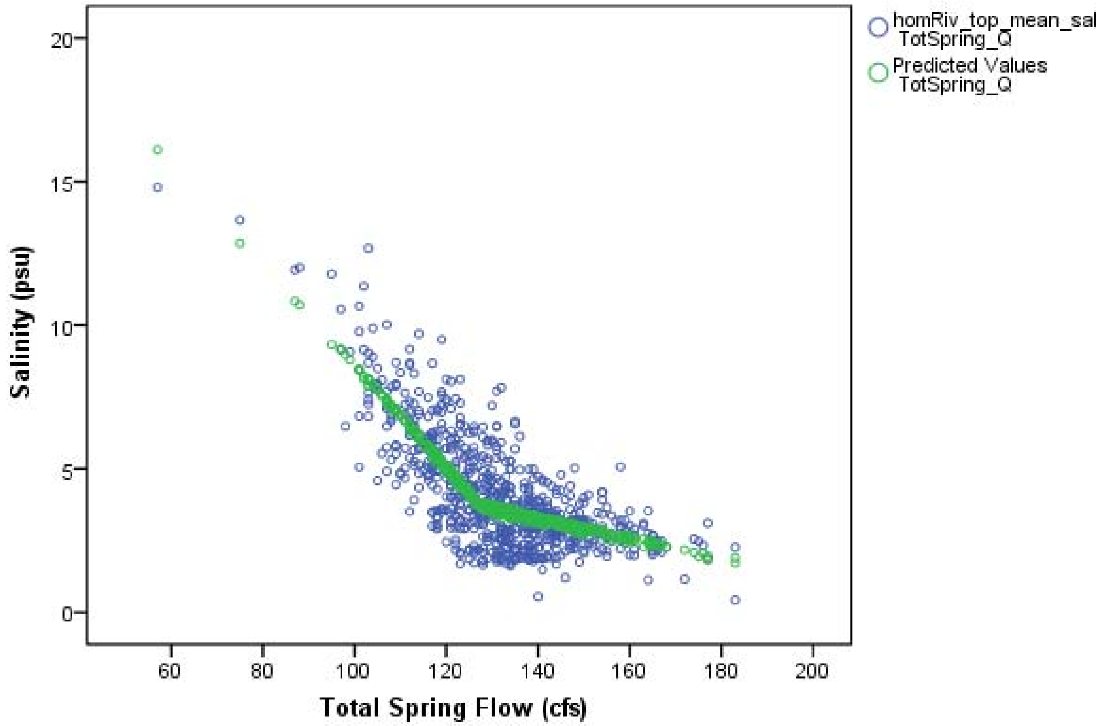

Figure 2-39. Observed and predicted surface mean salinity versus total spring flow for Homosassa River gauge

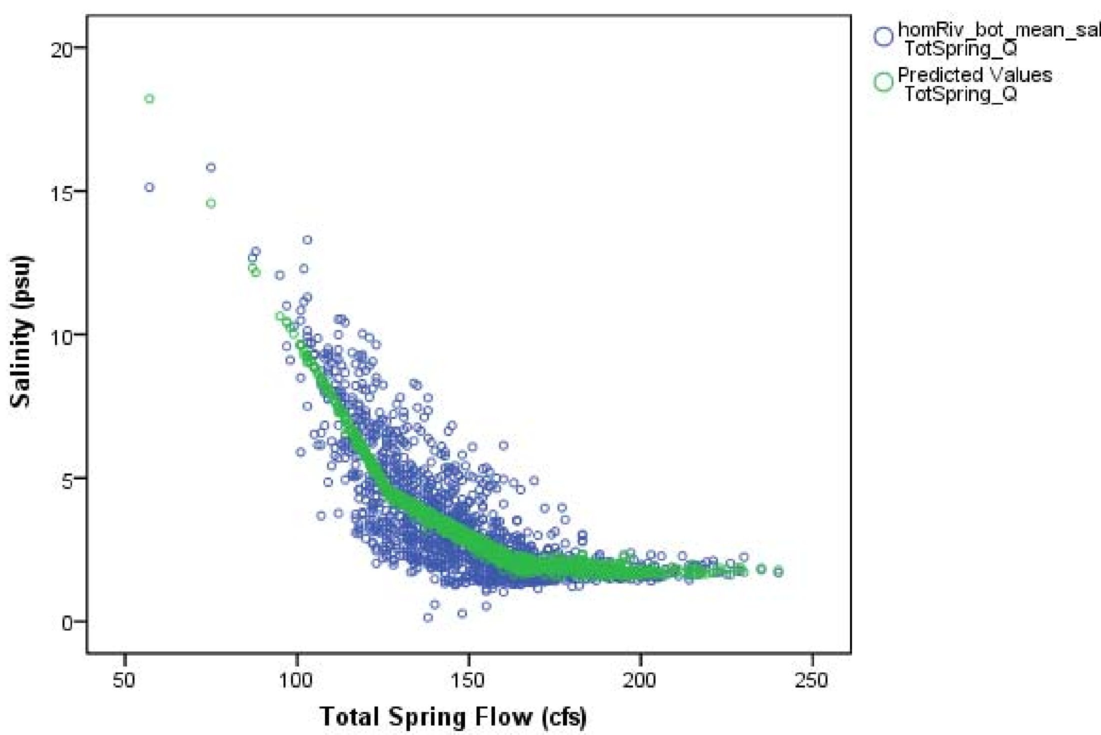

Figure 2-40. Observed and predicted bottom mean salinity versus total spring flow for Homosassa River gauge

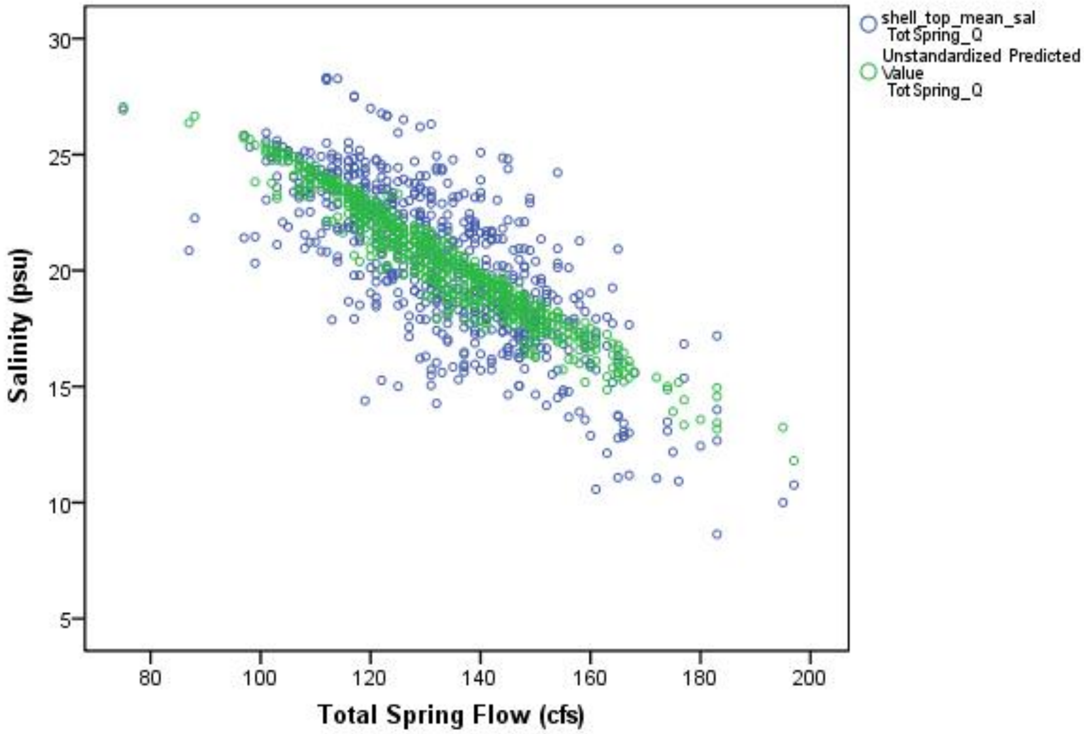

Figure 2-41. Observed and predicted surface mean salinity versus total spring flow for Shell Island gauge

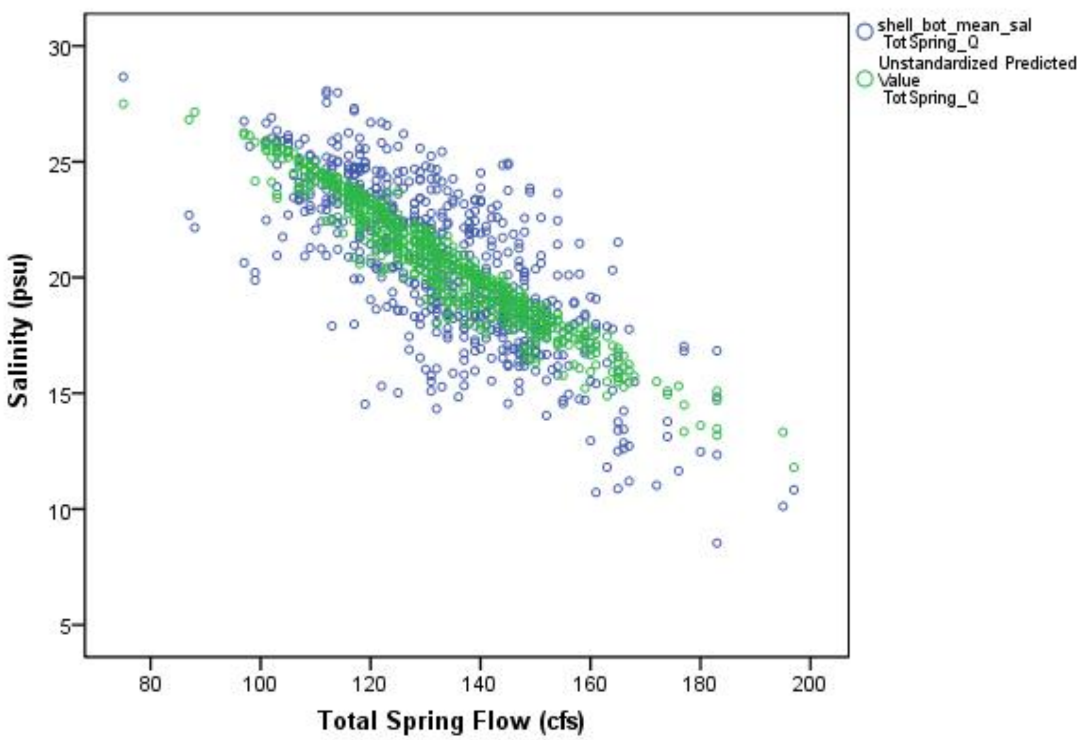

Figure 2-42. Observed and predicted bottom mean salinity versus total spring flow for Shell Island gauge

References

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Wang, P. April 2007. Shoreline Mapping and Bathymetric Survey for the Homosassa River Systems. Submitted by Department of Geology, University of South Florida. Submitted to Southwest Florida Water Management District, 7601 Highway 301 North, Tampa, FL 33637

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3.0 HYDRODYNAMIC MODEL DEVELOPMENT AND CALIBRATION

3.1 Introduction

The Environmental Fluid Dynamics Code (EFDC) has been applied to numerous estuaries (Shen et al. 1999; Wool et al. 2003; Moustafa and Hamrick 1994) including several in Florida (Dynamic Solutions 2008; Huang & Liu 2007; Janicki & ATM 2007). The EFDC solves the Reynolds-averaged equations of motion for a free-surface flow (Hamrick 2001). It uses a sigma vertical coordinate to deal with the bottom variation and the free surface. Horizontal coordinates can be either Cartesian or curvilinear orthogonal. The solution scheme is dynamically coupled with transport equations for turbulent kinetic energy, turbulent length scale, salinity and temperature. The model incorporates a second-order turbulence closure sub-model (Mellor and Yamada, 1982) that provides eddy viscosity and diffusivity for the vertical mixing.

The specific version of EFDC used in this application was formulated at Florida State University (Liu 2007), and includes a modified horizontal diffusion equation for modeling of salinity in a shallow tidal river and an alternative algorithm for reducing numerical error near steep topography. This version of the EFDC code was used in a previous MFL related study of the Little Manatee River (Huang & Liu 2007). The general equations and numerical solution schemes used in the EFDC model are given in Hamrick (1996, 2001) and are very similar to those of the Princeton Ocean Model of Blumberg and Mellor (1987). The modified solution schemes are provided in Liu (2007) and Huang and Liu (2007).

3.2 Model Domain Development

For this application, a three dimensional curvilinear orthogonal grid was developed with three proportionally equal vertical layers, depending on the water depth in each cell. The model grid domain was created using the Delft3D-RGFGrid program (DHS 2008). Output from Delft3D-RGFGrid was then translated into EFDC input files using the postprocessing program in EFDC (GEDFC) and HSW developed FORTRAN codes. Finally, ArcGIS was used to overlay the grid system onto an aerial photograph (Figure 3-1).

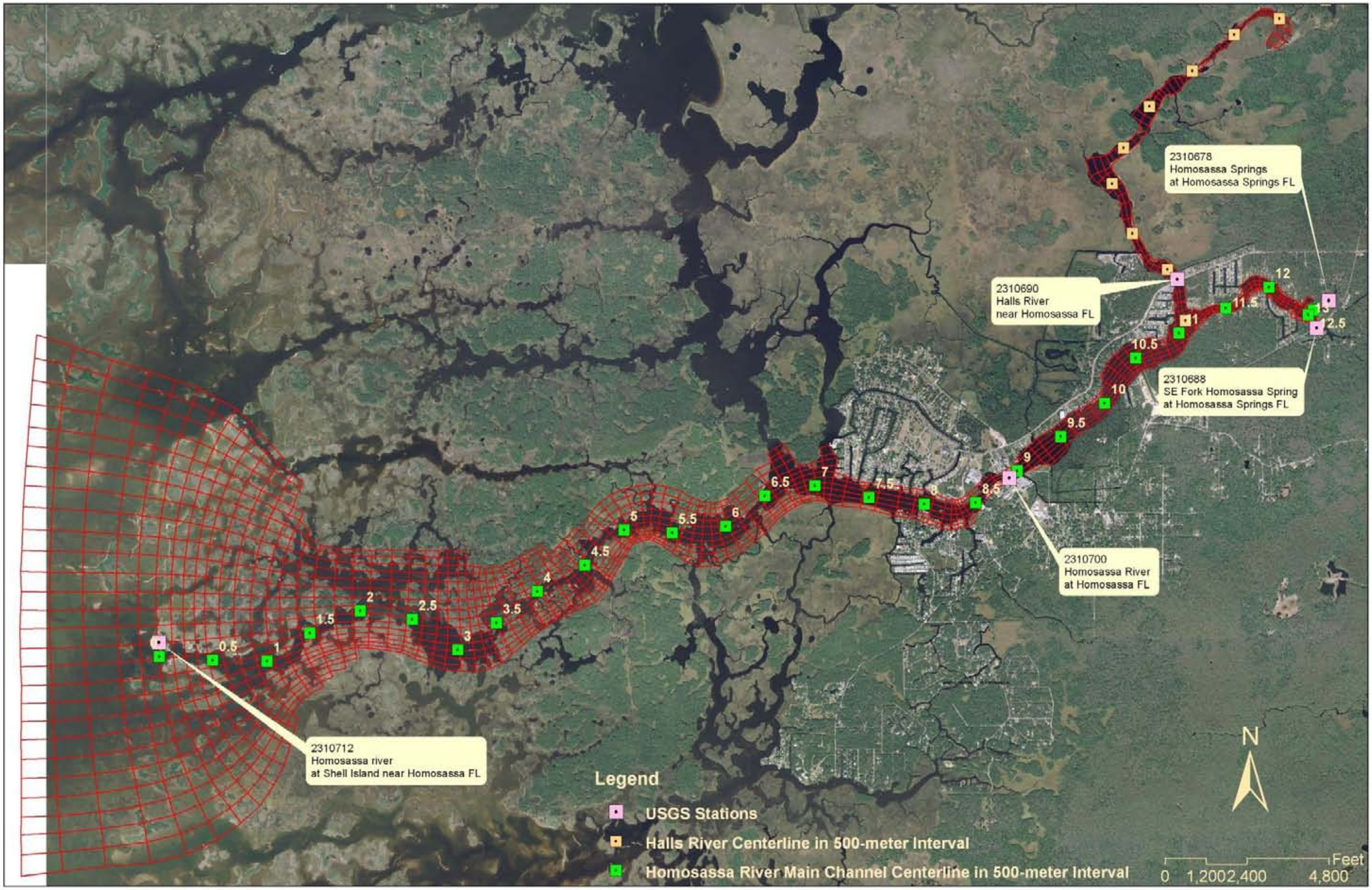

Figure 3-1. Curvilinear-orthogonal grid system for Homosassa River EFDC Model Domain

Near its mouth, the river discharges through a series of tidal creeks and limestone karst features with natural and manmade channels along its length (Figures 2-2 and 3-1). With the exception of the main channel, bathymetry information extending to the Gulf is not available. Additionally, the precise area/volume of the channels and embayments downstream of the town of Homosassa where tidal exchange with the Homosassa River occurs is unknown.

The Homosassa River estuary was modeled in two phases. During the first phase, a simplified conceptual model was developed on the basis of available data. The initial EFDC model boundary upstream of Shell Island only encompassed the main channel of the Homosassa River and excluded the numerous channels and embayments present along the main channel, the interconnected estuary to the north of the main channel at approximately river kilometer (RKM) 7, and Halls River. This model boundary was based on the assumption that excluding interconnected waterways would not significantly impact model results in the area of interest, which is generally upstream of about RKM 7 and to the headwater springs. Of specific note, the larger embayment to the north of RKM 7 (labeled Salt River in Figure 2-2) connects to additional channels to the north and west. These channels provide additional connections to the Gulf, which have not been surveyed and for which hydrodynamic data are unavailable. It is not clear where the tidal divide is located between the Homosassa River and Crystal River to the north and the Chassahowitzka River system to the south (Figure 2-1). Finally, Halls River was initially excluded because data for Halls River are limited to stage and salinity with no direct measurements of discharge, although estimates have been made. Survey data with field verification indicate that Halls River is shallow and not part of the manatee refuge area. This initial attempt to simplify the model domain failed to accurately represent salinity and temperature.

During the second phase, the conceptual site model was revised to consider more features for which data are lacking. The complex geometry of the dendritic tributary network of channels in the lower estuary was represented by a geometric funnel for the mouth and upstream to about river kilometer 7 (Figure 3-1). This approach was necessary to simplify the true physical setting to obtain reasonable model results in the region of interest.

As part of the model calibration process, the model domain and grid were adjusted to create a larger offshore boundary condition in the Gulf and to encompass some of the channels upstream of Shell Island. Since the primary objective is to simulate temperature and salinity upstream of the Homosassa River gauge, the funneled grid system and the extent of the funnel upstream is a reasonable approximation of the contributing volume. The grid geometry near and upstream of the mouth allows water and salt to enter the channelized portion of the river along the lateral river boundary without quantitative knowledge (e.g., bathymetric data) of the estuarine system. This adjustment of the model domain near the mouth was necessary to accurately depict the manatee refuge upstream of about RKM 9. The hypothetical initial depth prescribed for the simulations ranges from about 0.9 meter to 2.5 meter in the funnel area, with grid cells along the main channel deeper than those along the edges of the funnel, and change is gradual. The funnel domain was enlarged and the salinity boundary values increased as part of the calibration process. The final domain is shown in Figure 3-1.

There is evidence that Halls River may provide on the order of 40% of the measured discharge at Homosassa River gauge and an additional 25% of the total discharge at the mouth of the Homosassa River may come from ungauged areas below the confluence with Halls River (Yobbi & Knochenmus 1989). In addition, the salinity measured during ebb tide in Halls River near its mouth is typically about 2-5 psu indicating that the head springs are discharging brackish water and that Halls River represents a source of salinity to the Homosassa River (Knochenmus & Yobbi, 2001). Therefore, it was necessary to estimate discharge for Halls River for the period of interest using statistical correlations from the other USGS gauges (see section 2.4). In addition, the salinity associated with the Halls River inflow is based on historical salinity measurements.

3.3 Boundary Conditions

The boundary conditions for the hydrodynamic model were set offshore of Shell Island, and at the headwaters of Halls River and Homosassa River. For the downstream boundary, stage, salinity, and temperature were as reported for the Shell Island gauge. Downstream boundary salinity was adjusted during the calibration process to achieve good estimates of the salinity at Shell Island. Upstream boundary conditions at the SE Fork Homosassa Spring and Homosassa Springs are as reported and include discharge, temperature, and salinity. The boundary conditions at Halls River were developed based on comparisons made between the spring gauge data and the Homosassa gauge data (see section 2.4). Halls River discharge was set at 88% of the combined SE Fork and Homosassa Springs discharge, temperature was set as a constant of 23.2 °C, and salinity was set as a ratio of Homosassa Springs salinity. The ratio was calculated using salinity data for Homosassa Springs and upstream locations of Halls River. Distributed inflow from surface runoff and groundwater downstream of the Homosassa gauge were not considered because insufficient data are available to characterize these potential inflow sources.

3.4 Calibration, Validation, and Sensitivity Analysis

Calibration is an iterative procedure of parameter evaluation and refinement, as a result of comparing simulated and observed values of interest. Model validation is in reality an extension of the calibration process. Its purpose is to assure that the calibrated model properly assesses the variables and conditions that can affect model results, and demonstrate the ability of the model to predict field observations for periods separate from the calibration effort. Model performance and calibration/validation are evaluated through qualitative and quantitative measures, involving both graphical comparisons and statistical tests.

The following timeframes were used for different phases of the hydrodynamic modeling effort:

- Model Calibration 9/15/06 – 12/31/06
- Model Validation 1/1/07 – 6/30/07
- Sensitivity Analysis 1/1/07 – 6/30/07
- Thermal Model 10/1/07 – 3/31/08 (with a three-day critically cold period from 1/2/08 to 1/4/08 as described in Section 4.2)
- Salinity Model 1/1/07 – 12/31/07

The datasets that were used as part of the modeling process are identified in Table 3-1. The timeframes considered are based on the availability of data for the domain (Table A-1 and Table A-2). The boundary conditions were data within the same timeframes. Flow duration curves were calculated for both Homosassa Springs and the SE Fork of Homosassa Springs for four time periods with data availability (period of record, 10/1/06 – 3/31/08, 10/1/06 – 3/31/07, 10/1/07 – 3/31/08, and 2007 Calendar Year). From the flow duration curves, it is clear that the model time frame represents a lower than average spring flow condition (Figures 3-2 and 3-3).

Table 3-1. Data source summary for Homosassa hydrodynamic modeling

Modeling Location	**Data Requirements**
Upstream Boundary Condition	USGS Gauges @ Homosassa Springs & SE Fork Homosassa • Discharge • Salinity • Temperature Halls River (Statistically Modeled) • Discharge • Salinity • Temperature
Downstream Boundary Condition	Shell Island Gauge • Stage • Salinity (modified through calibration) • Temperature
Meteorological Inputs	FAWN-IFAS Station at Brooksville • Wind speed & direction • Air temperature (2 m)
Calibration & Validation	USGS Gauge @ Homosassa River • Water Surface Elevation • Surface & Bottom Salinity • Surface & Bottom Temperature Halls River USGS Gauge • Water Surface Elevation • Bottom Salinity • Bottom Temperature USGS Gauge @ Shell Island • Water Surface Elevation • Surface, Middle, & Bottom Salinity • Surface, Middle, & Bottom Temperature

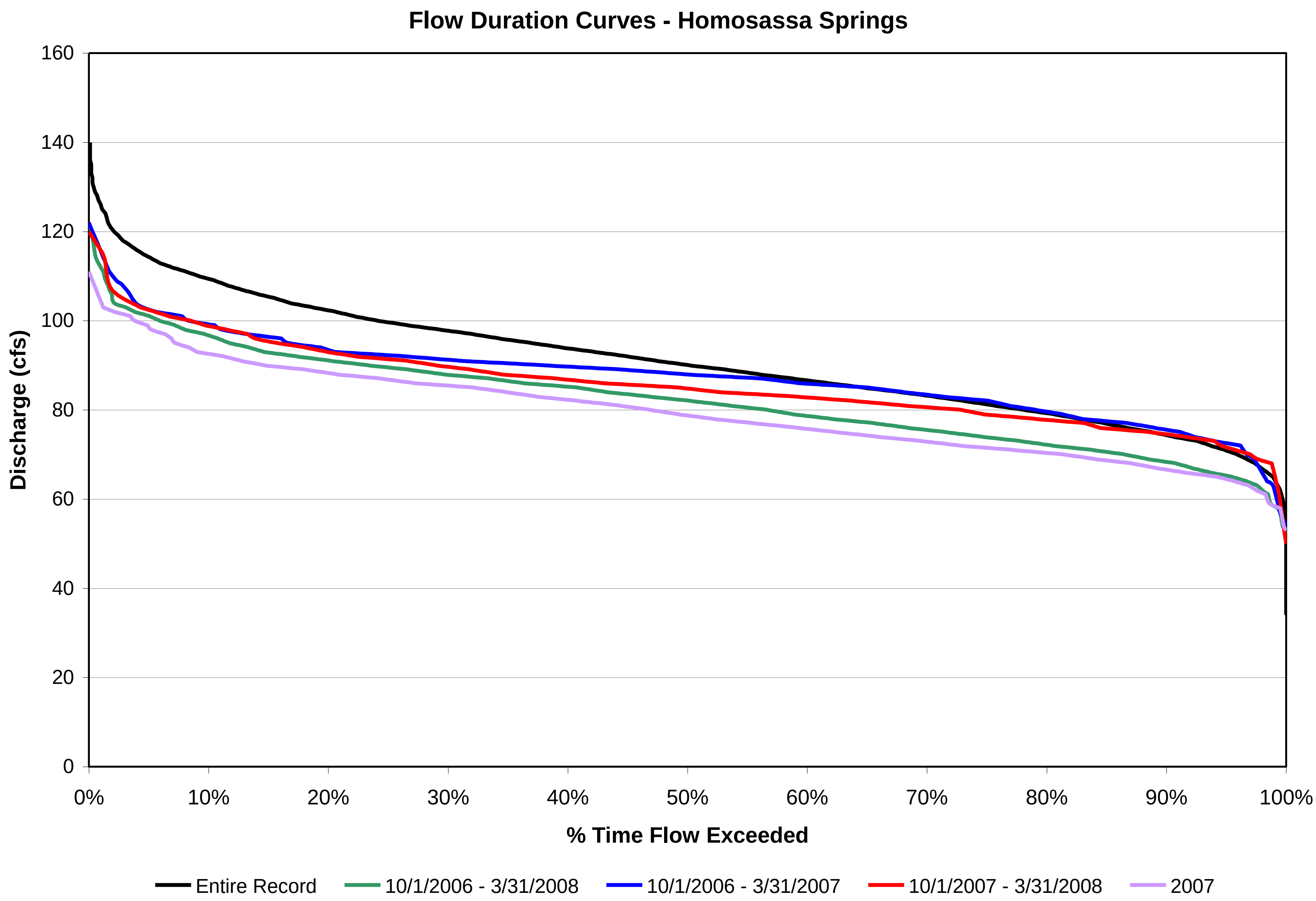

Figure 3-2. Homosassa Springs flow duration curves for selected periods including 2007, the year selected for hydrodynamic modeling

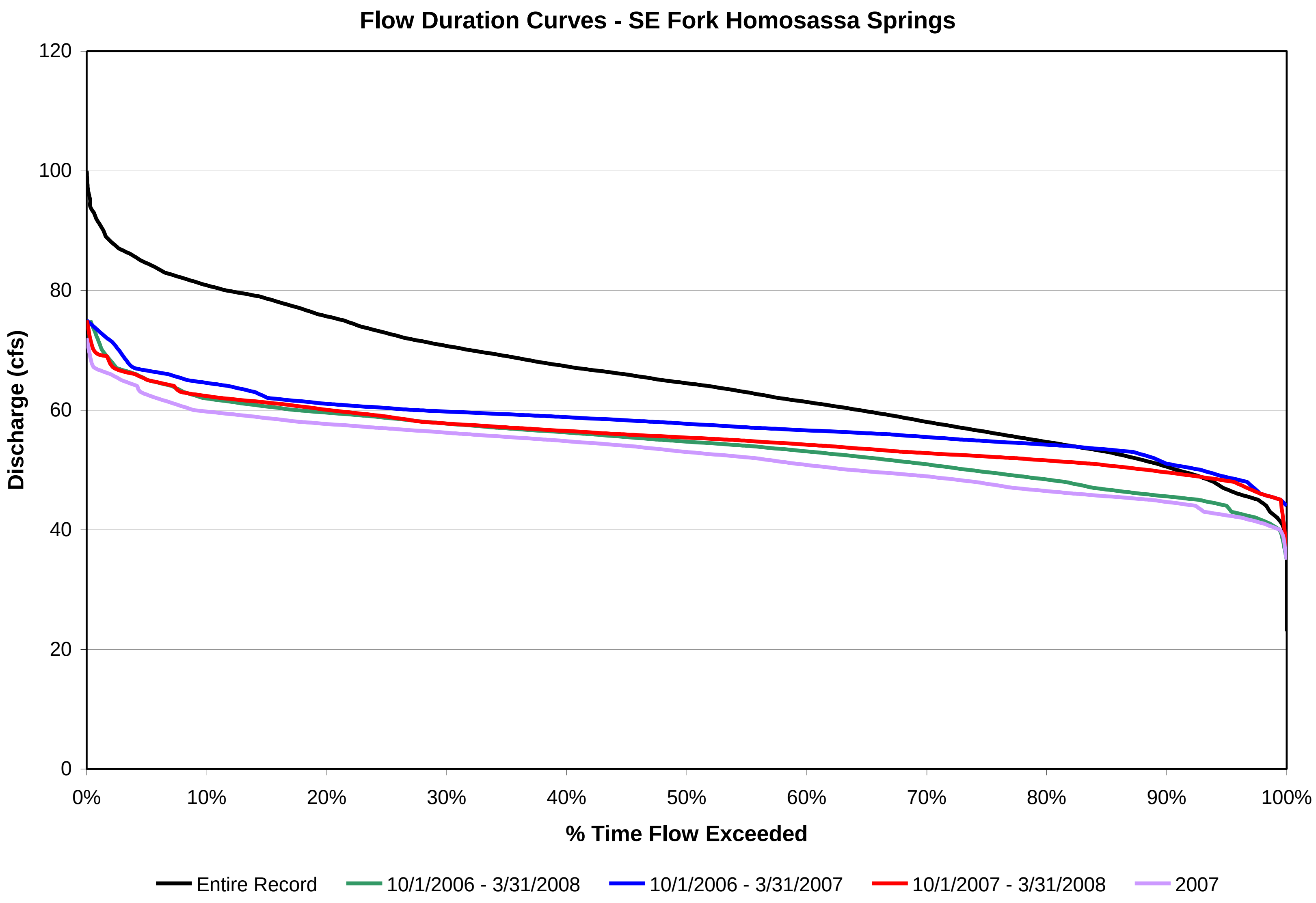

Figure 3-3. SE Fork Spring flow duration curves for selected periods including 2007, the year selected for hydrodynamic modeling

The key target for calibration and validation is the ability of the model to recreate measured parameters at three USGS gauges (Table 3-1). In particular, calibration to the Homosassa River gauge was emphasized as the Shell Island gauge is nearest to the downstream boundary and little influenced by river hydrodynamics and the Halls River gauge is outside of the area of interest based on field surveys that indicate that Halls River is not a manatee refuge area. Analysis included graphical representation of the parameters to determine the model‟s ability to temporally recreate variation in temperature, salinity, and water level as well as tabular representation and comparisons of model results and observed values.

Primary input parameters used to calibrate the model include time step, depth smoothing factors, roughness height, and horizontal diffusion coefficient (Table 3-2). The time step and depth smoothing factors are mostly associated with model stability including using a smaller time step to avoid premature model termination. The depth smoothing algorithm also was helpful in enhancing model stability (Tetra Tech 2007). The roughness height and horizontal diffusion coefficient are two parameters adjusted during model calibration for stage, salinity, and temperature. The calibrated model parameters are kept unchanged for validation and MFL withdrawal scenarios.

The Homosassa model is based on an EFDC code version that was modified and applied to the Little Manatee River (see Section 3.1 for details). In this model version, the enhanced Smagoringsky equation is decoupled so that the horizontal diffusion and eddy viscosity can be represented by different equations. The benefit is that mean salinity is better estimated while maintaining the model stability. Additionally, the horizontal diffusion coefficient can vary spatially (Liu 2007).

The first calibration target is the tide signal at the three calibration gauges (Table 3-3). The bottom roughness height was adjusted in an attempt to attenuate the tide signal amplitude, but little tide attenuation was achievable at the Homosassa River gauge (Figure 3-4 and Appendix E). Widening the river channel grid system beyond the natural boundary resulted in less modeled tide signal attenuation. The roughness height coefficient was increased to a maximum of 0.02 meters with little improvement observed. Model instability prevented further adjustments to the roughness coefficient and the roughness used is towards the high end of what might be reasonable. A more accurate estimation of the tide signal attenuation may be achievable by accurately depicting the small channels in the downstream portion of the estuarine system, which can be accomplished with additional bathymetry data.

The model was calibrated to salinity and temperature at the three gauges by adjusting the horizontal diffusion coefficient. Root mean square error (RMSE) values for salinity ranged from about 1.4 psu at Shell Island to about 2 psu at Homosassa River gauge (Table 3-4). Average salinity was modeled reasonably well at the three gauges. However the maximum salinities observed at the upstream gauges were not captured by the model (Figures 3-5 and 3-6 and Appendix G). Water temperature RMSE values ranged from 0.42 °C at the Shell Island gauge to 1.63 °C at the Halls River gauge (Table 3-5). Water temperature at the Homosassa gauge was modeled reasonably well throughout the range of temperatures (Figures 3-7 and 3-8 and Appendix G). Water temperature is slightly over predicted during the cold months and under predicted during the warm months, which may indicate that spring flow has a greater predicted impact than observed. This could mean that modeled freshwater inflow is too high or that the temperature of the modeled inflow is not correct. Recall that all of the freshwater inflow is attributable to spring flow (and its associated temperature) while in reality surface runoff and shallow groundwater ungauged flow contributes. In general, the modeled salinity and temperature are reasonable and suitable for the purpose of this study, but model accuracy would improve with additional hydrologic field measures for calibration and validation.

Model validation statistics were calculated for the six month validation period (Tables 3-6 through 3-8 and Appendix H). The results are very similar to those calculated during the calibration process (Tables 3-3 to 3-5). In particular, the mean patterns of salinity and temperature are simulated well (Figures 3-9 to 3-13).

Table 3-2. Model parameters used in the model calibration

Parameter	Unit	Value
Roughness height	meter	0.01
Horizontal diffusion coefficient	$meter^2$/second	33 (<= rkm 8.85) and 30 (> rkm 8.85)
Time step	second	10
Number of depth smoothing passes	—	10
Depth smoothing weight	—	0.20

— = not applicable

Table 3-3. Water surface elevation (meter) calibration statistics*

Station ID	Shell Island Gauge		Homosassa River Gauge		Halls River Gauge	
	Observed	Simulated	Observed	Simulated	Observed	Simulated
Layer/Type	Surface		Surface		Surface	
# of pairs	8,832		8,832		8,832	
Average	-0.03	-0.03	0.01	-0.03	-0.04	-0.02
Maximum	1.03	1.03	0.71	1.12	0.64	1.12
Minimum	-0.76	-0.76	-0.60	-0.77	-0.69	-0.66
5thpercentile	-0.40	-0.40	-0.30	-0.41	-0.34	-0.40
50thpercentile	-0.05	-0.05	0.00	-0.05	-0.04	-0.04
95thpercentile	0.42	0.42	0.31	0.43	0.27	0.44
STDEV**	0.25	0.25	0.20	0.26	0.20	0.26
R**	1.00		0.71		0.75	
RMSE**	0.00		0.19		0.17	

* 15-minute interval for both observed and simulated data was used. Periods of missing record are excluded from the statistic calculations. Statistics are based on data during the period 10/1/2006 through 12/31/2006 (day 16 through day 108); the warm-up period (9/15/06 through 9/30/06) is excluded.
** R is the Pearson Coefficient, STDEV is the standard deviation, and RMSE is the root mean square error.

Table 3-4. Salinity (psu) calibration statistics*

Station ID	Shell Island Gauge						Homosassa River Gauge				Halls River Gauge	
	Observed	Simulated	Observed	Simulated	Observed	Simulated	Observed	Simulated	Observed	Simulated	Observed	Simulated
Layer/Type	Surface		Middle		Bottom		Surface		Bottom		Bottom	
# of pairs	8,832		8,832		8,832		5,756		5,785		8,716	
Average	18.54	18.27	18.44	18.55	18.73	18.86	3.75	3.99	4.21	4.13	2.68	2.52
Maximum	30.13	28.02	29.34	28.02	31.37	28.13	19.13	9.60	18.79	9.70	16.07	4.12
Minimum	7.20	8.98	7.14	9.00	7.20	9.22	1.65	1.66	1.66	1.66	1.32	1.54
5thpercentile	11.90	12.95	12.03	13.19	12.03	13.32	1.75	2.19	1.94	2.00	1.63	1.97
50thpercentile	19.13	18.46	19.06	18.86	19.27	19.22	3.13	3.77	3.46	3.98	2.39	2.51
95thpercentile	23.08	22.48	22.73	22.59	23.85	22.93	7.38	6.64	8.63	6.89	4.24	3.06
STDEV**	3.36	2.77	3.26	2.81	3.49	2.85	2.18	1.35	2.41	1.50	1.21	0.34
R**	0.91		0.90		0.90		0.50		0.55		0.35	
RMSE**	1.43		1.44		1.44		2.08		2.02		1.15	

* 15-minute interval for both observed and simulated data was used. Periods of missing record are excluded from the statistic calculations. Statistics are based on data during the period 10/1/2006 through 12/31/2006 (day 16 through day 108); the warm-up period (9/15/06 through 9/30/06) is excluded.
** R is the Pearson Coefficient, STDEV is the standard deviation, and RMSE is the root mean square error.

Table 3-5. Water temperature (ºC) calibration statistics*

Station ID	Shell Island Gauge						Homosassa River Gauge				Halls River Gauge	
	Observed	Simulated	Observed	Simulated	Observed	Simulated	Observed	Simulated	Observed	Simulated	Observed	Simulated
Layer/Type	Surface		Middle		Bottom		Surface		Bottom		Bottom	
# of pairs	8,832		8,832		8,832		5,774		6,114		8,832	
Average	20.80	20.87	20.83	20.85	20.82	20.82	22.69	22.60	22.45	22.46	21.70	22.30
Maximum	28.70	28.24	28.7	28.24	28.69	28.23	28.10	26.92	28.20	26.91	28.10	25.93
Minimum	10.90	11.78	11.1	11.73	11.20	11.65	15.00	16.38	13.60	16.32	10.50	16.90
5th percentile	13.8	13.99	13.9	13.9	13.90	13.85	18.30	19.26	17.40	18.71	16.62	18.64
50th percentile	20.80	20.72	20.8	20.7	20.80	20.70	22.15	22.55	22.00	22.45	21.80	22.60
95th percentile	27.30	27.08	27.4	27.16	27.40	27.18	27.00	25.70	27.10	25.64	26.20	24.91
STDEV**	3.85	3.71	3.85	3.74	3.85	3.77	2.63	1.88	2.88	1.98	2.82	1.81
R**	0.99		0.99		0.99		0.89		0.89		0.87	
RMSE**	0.44		0.43		0.45		1.28		1.42		1.63	

* 15-minute interval for both observed and simulated data was used. Periods of missing record are excluded from the statistic calculations. Statistics are based on data during the period 10/1/2006 through 12/31/2006 (day 16 through day 108); the warm-up period (9/15/06 through 9/30/06) is excluded.

** R is the Pearson Coefficient, STDEV is the standard deviation, and RMSE is the root mean square error

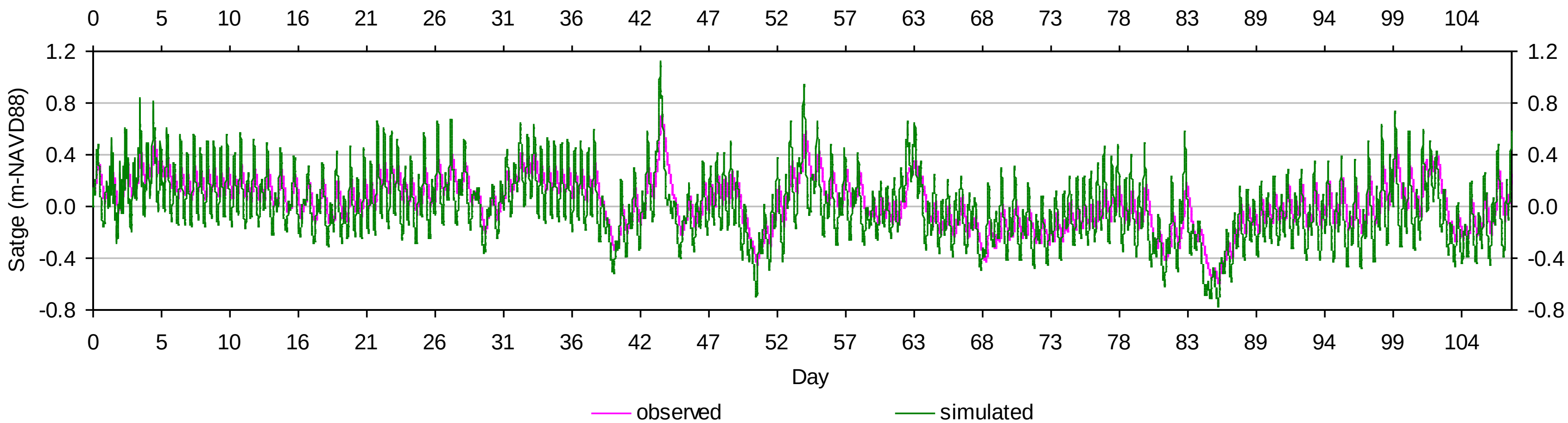

Figure 3-4. Observed and simulated tidal stages at Homosassa River gauge (9/15/2006 – 12/31/2006)

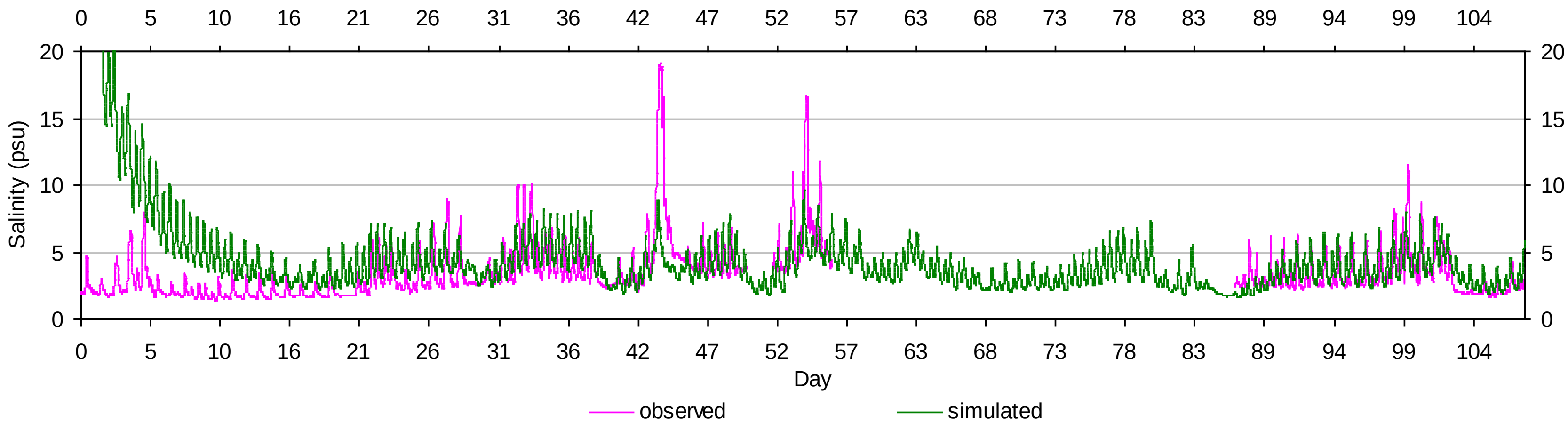

Figure 3-5. Observed and simulated surface salinities at Homosassa River gauge (9/15/2006 – 12/31/2006)

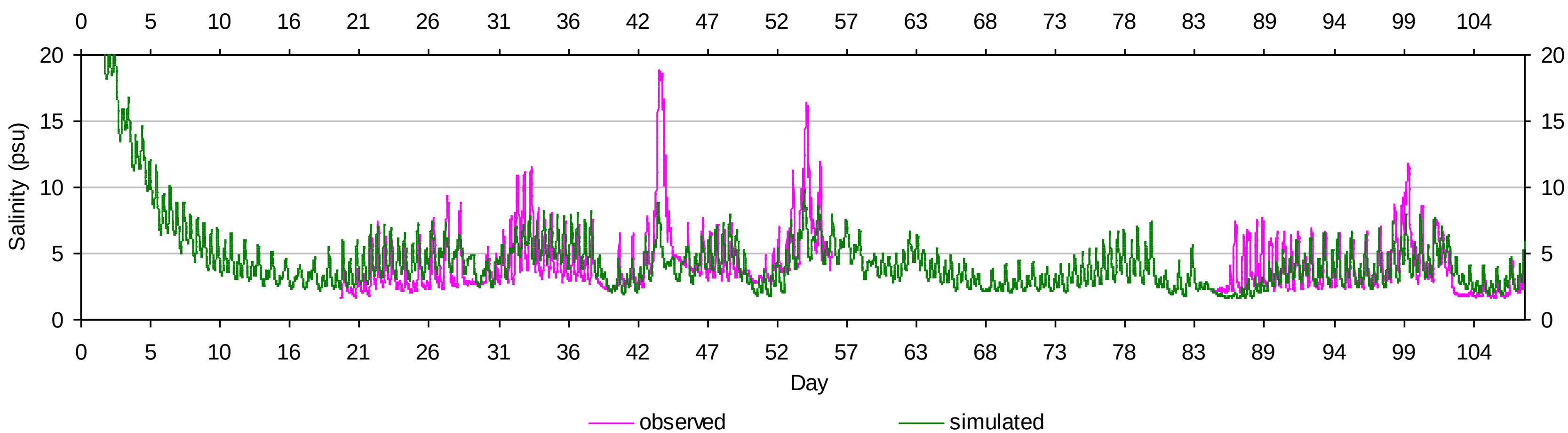

Figure 3-6. Observed and simulated bottom salinities at Homosassa River gauge (9/15/2006 – 12/31/2006)

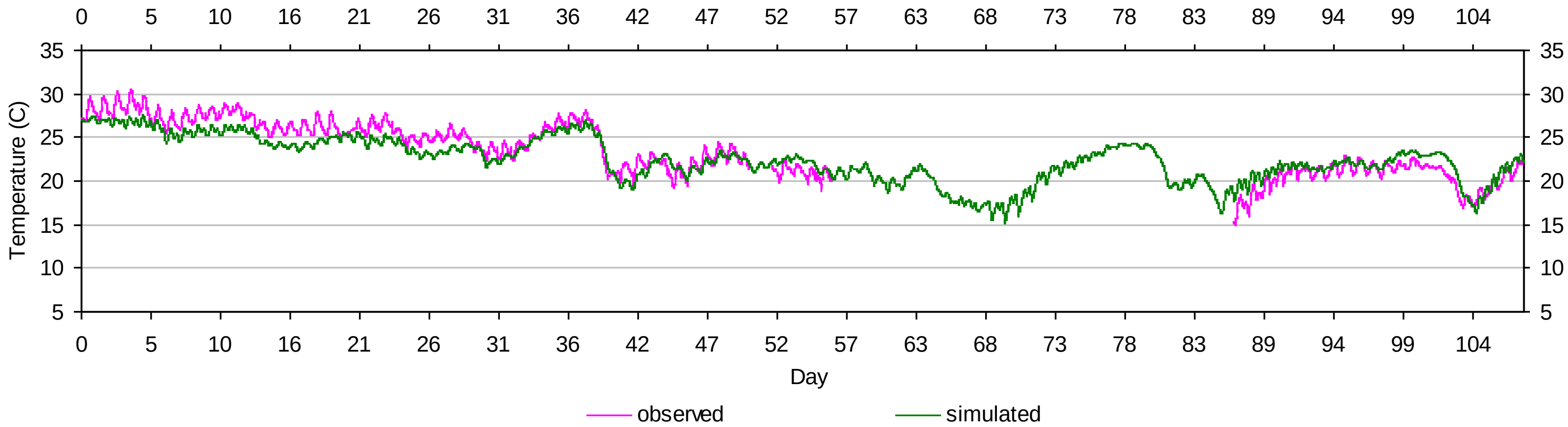

Figure 3-7. Observed and simulated surface temperatures at Homosassa River gauge (9/15/2006 – 12/31/2006)

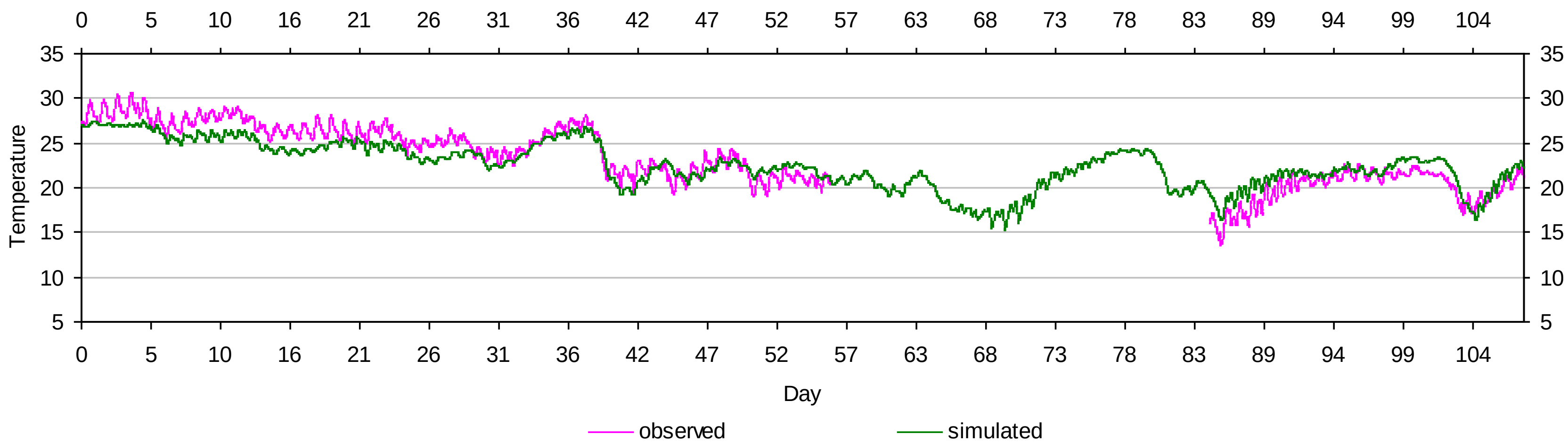

Figure 3-8. Observed and simulated bottom temperatures at Homosassa River gauge (9/15/2006 – 12/31/2006)

Table 3-6. Water surface elevation (meter) validation statistics*

Station ID	Shell Island Gauge		Homosassa River Gauge		Halls River Gauge	
	Observed	Simulated	Observed	Simulated	Observed	Simulated
Layer/Type	Surface		Surface		Surface	
# of pairs	16042		17376		17195	
Average	-0.06	-0.06	0.00	-0.04	-0.05	-0.03
Maximum	1.09	1.10	0.75	1.20	0.67	1.24
Minimum	-0.73	-0.74	-0.51	-0.73	-0.61	-0.66
5^{th}percentile	-0.42	-0.42	-0.26	-0.41	-0.33	-0.40
50^{th}percentile	-0.08	-0.08	0.00	-0.06	-0.05	-0.05
95^{th}percentile	0.37	0.37	0.28	0.40	0.24	0.41
STDEV**	0.25	.025	0.17	0.26	0.18	0.25
R**	1.00		0.74		0.77	
RMSE**	0.02		0.18		0.17	

* 15-minute interval for both observed and simulated data was used. Periods of missing record are excluded from the statistic calculations. Statistics are based on data during the period 1/1/2007 through 6/30/2007 (day 109 through day 289); the warm-up period (9/15/06 through 12/31/06) is excluded.

** R is the Pearson Coefficient, STDEV is the standard deviation, and RMSE is the root mean square error.

Table 3-7. Salinity (psu) validation statistics*

Station ID	Shell Island Gauge						Homosassa River Gauge				Halls River Gauge	
	Observed	Simulated	Observed	Simulated	Observed	Simulated	Observed	Simulated	Observed	Simulated	Observed	Simulated
Layer/Type	Surface		Middle		Bottom		Surface		Bottom		Bottom	
# of pairs	17,376		17,376		17,376		16,132		16,127		17,376	
Average	19.39	19.07	19.57	19.34	19.51	19.66	4.39	4.65	5.27	4.86	2.88	3.00
Maximum	28.47	27.19	29.48	27.19	30.28	27.20	17.90	12.72	17.90	12.72	14.40	5.68
Minimum	5.73	6.66	5.73	6.66	5.67	6.66	1.65	1.75	1.75	1.75	1.43	1.65
5^{th}percentile	12.29	12.97	12.43	13.19	12.23	13.39	2.05	2.36	2.11	2.37	1.74	2.21
50^{th}percentile	19.82	19.19	19.95	19.45	19.82	19.81	3.56	4.29	4.46	4.38	2.53	2.98
95^{th}percentile	25.19	25.19	25.62	24.82	25.90	25.16	9.39	8.30	11.38	8.82	5.31	3.79
STDEV**	3.91	3.60	4.02	3.58	4.14	3.63	2.46	1.89	3.00	2.08	1.22	0.51
R**	0.94		0.94		0.92		0.77		0.82		0.58	
RMSE**	1.38		1.42		1.59		1.60		1.81		1.02	

* 15-minute interval for both observed and simulated data was used. Periods of missing record are excluded from the statistic calculations. Statistics are based on data during the period 1/1/2007 through 6/30/2007 (day 109 through day 289); the warm-up period (9/15/06 through 12/31/06) is excluded.

** R is the Pearson Coefficient, STDEV is the standard deviation, and RMSE is the root mean square error.

Table 3-8. Water temperature (ºC) validation statistics*

Station ID	Shell Island Gauge						Homosassa River Gauge				Halls River Gauge	
	Observed	Simulated	Observed	Simulated	Observed	Simulated	Observed	Simulated	Observed	Simulated	Observed	Simulated
Layer/Type	Surface		Middle		Bottom		Surface		Bottom		Bottom	
# of pairs	17,376		17,376		17,376		16,132		16,127		17,376	
Average	22.16	22.02	22.20	22.09	22.18	22.12	23.50	22.50	23.54	22.52	23.13	22.56
Maximum	31.90	30.81	31.90	30.82	31.90	30.87	31.90	28.11	31.70	28.10	31.00	26.72
Minimum	11.60	11.33	11.60	11.57	11.60	11.57	14.50	13.05	14.50	13.04	12.40	15.30
5^{th}percentile	14.20	14.15	14.30	14.21	14.30	14.21	17.40	16.95	17.30	16.91	16.70	18.31
50^{th}percentile	22.40	22.37	22.40	22.48	22.40	22.51	23.60	22.92	23.60	22.92	23.30	22.93
95^{th}percentile	30.00	29.55	30.10	29.71	30.10	29.83	29.60	26.91	29.80	27.03	29.0	25.81
STDEV**	4.85	4.71	4.85	4.73	4.85	4.78	3.77	3.03	3.87	3.06	3.77	2.29
R**	0.99		0.99		0.99		0.94		0.94		0.92	
RMSE**	0.60		0.53		0.52		1.72		1.75		1.99	

* 15-minute interval for both observed and simulated data was used. Periods of missing record are excluded from the statistic calculations. Statistics are based on data during the period 1/1/2007 through 6/30/2007 (day 109 through day 289); the warm-up period (9/15/06 through 12/31/06) is excluded.

** R is the Pearson Coefficient, STDEV is the standard deviation, and RMSE is the root mean square error.

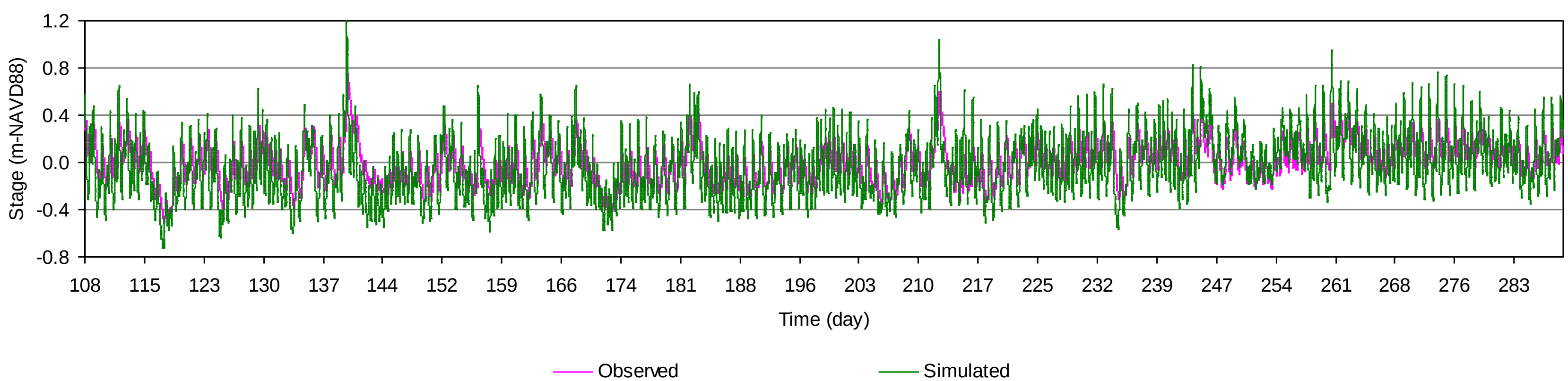

Figure 3-9. Observed and simulated tidal stages at Homosassa River gauge (1/1/2007 – 6/30/2007)

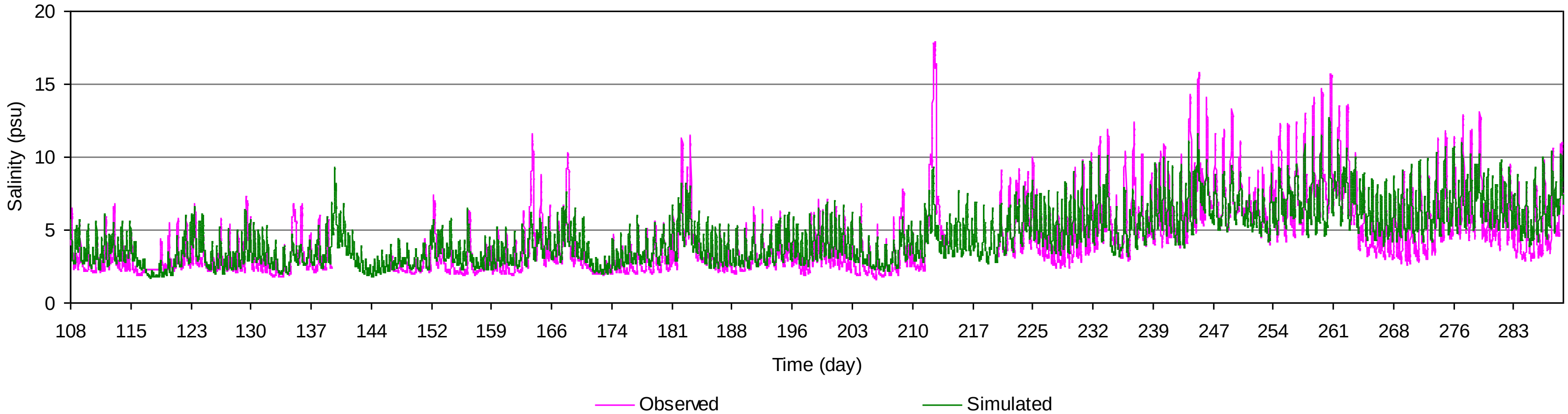

Figure 3-10. Observed and simulated surface salinities at Homosassa River gauge (1/1/2007 – 6/30/2007)

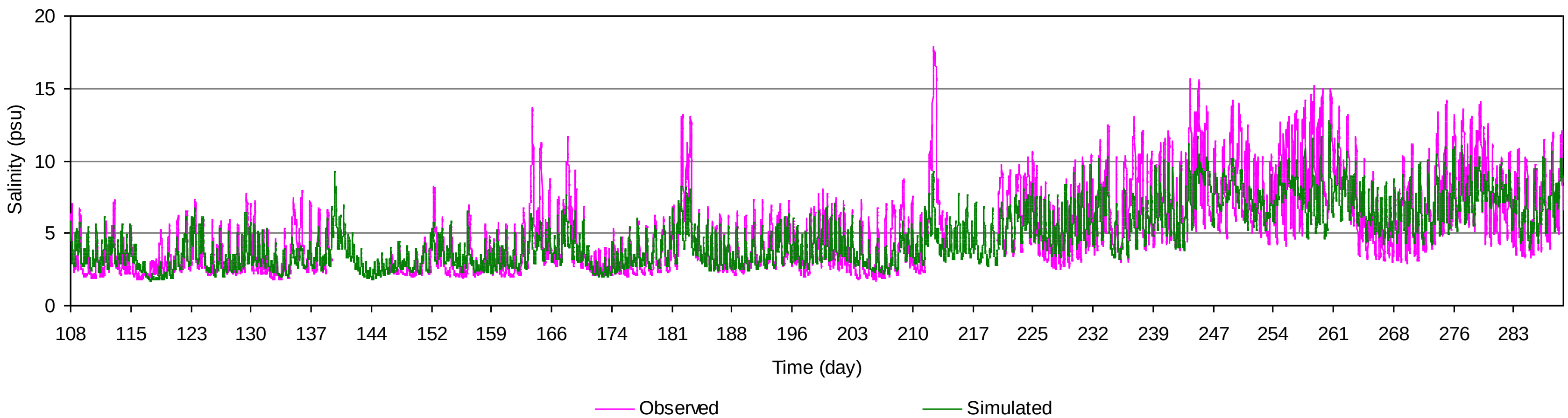

Figure 3-11. Observed and simulated bottom salinities at Homosassa River gauge (1/1/2007 – 6/30/2007)

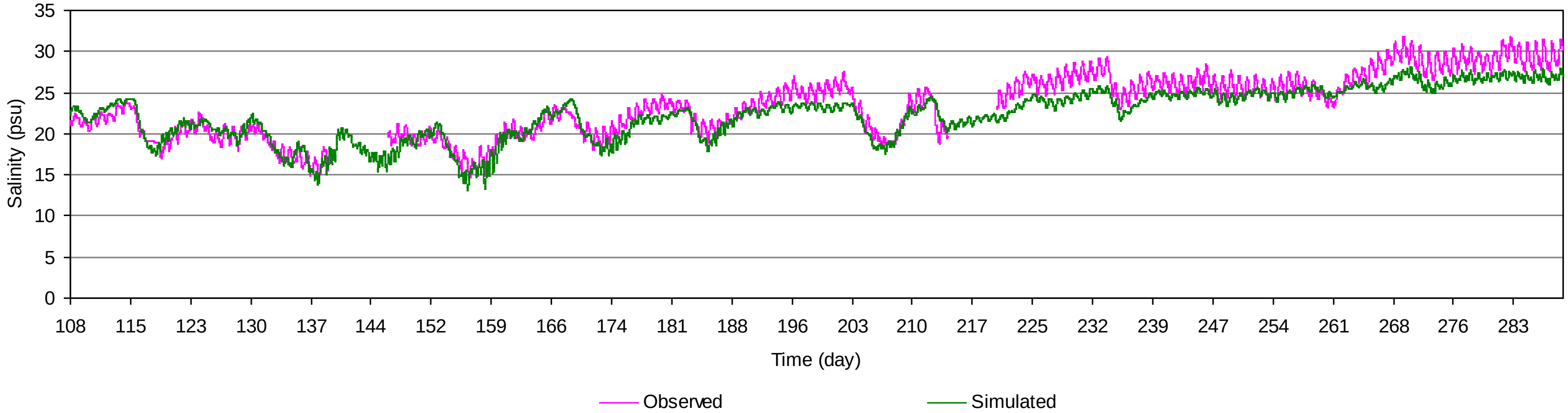

Figure 3-12. Observed and simulated surface temperature at Homosassa River gauge (1/1/2007 – 6/30/2007)

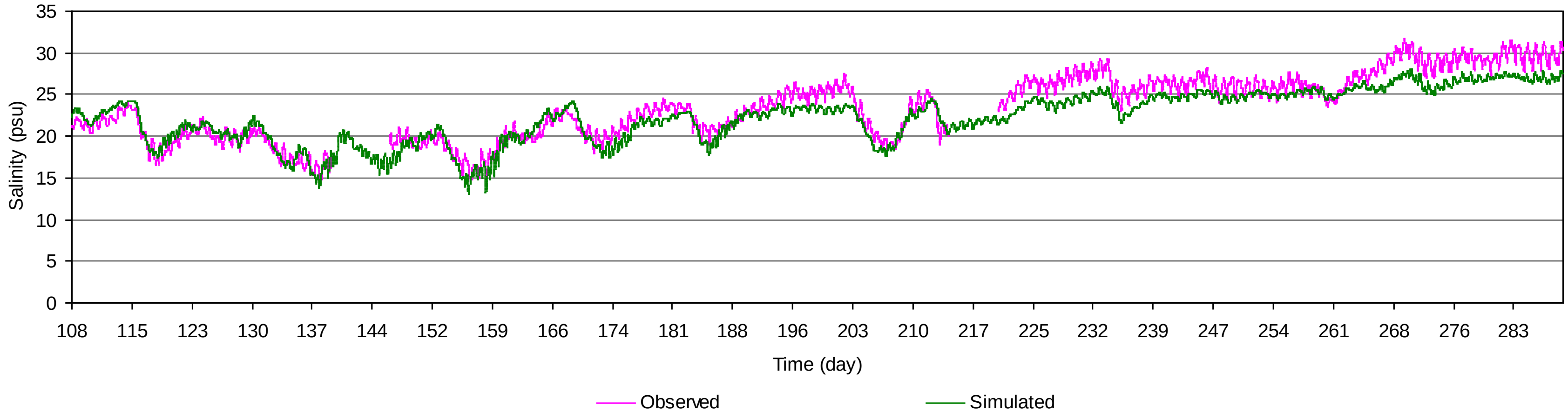

Figure 3-13. Observed and simulated bottom temperature at Homosassa River gauge (1/1/2007 – 6/30/2007)

To test the sensitivity of the calibrated model to key parameter changes, a series of model runs were conducted to evaluate the model response to the following scenarios: 1) half the time step, 2) increase the roughness height by 15%, 3) increase the horizontal mixing parameters by 15%, 4) decrease the horizontal mixing parameter by 15%, and 5) increase downstream boundary condition salinity by 1 psu. The mean and RMSE for salinity and temperature were calculated for each of these five cases and compared against baseline to evaluate sensitivity (Tables 3-9 and 3-10).

Parameter adjustments on the order of 15% generally have little impact on the model results (Tables 3-9 and 3-10). The model is most sensitive to an increase in the horizontal mixing coefficients for which a 15% increase resulted in an increase in salinity of about 0.4 psu at the Homosassa gauge and a change in the RMSE of about 5%.

Table 3-9. Sensitivity analysis: Comparison of Mean and RMS errors for salinity for Homosassa River gauge

Case	Mean (psu)		RMSE (psu)	
	Surface (16,132 pairs)	Bottom (16,127 pairs)	Surface (16,132 pairs)	Bottom (16,127 pairs)
Baseline	4.65	4.86	1.60	1.81
(1) ½ time step	4.72	4.97	1.61	1.79
(2) increase roughness	4.63	4.84	1.59	1.82
(3) increase mixing	5.03	5.28	1.72	1.74
(4) decrease mixing	4.26	4.45	1.59	1.98
(5) Increase Salinity	4.84	5.09	1.66	1.75

* 15-minute interval for both observed and simulated data was used. Periods of missing record are excluded from the statistic calculations. Statistics are based on data during the period 1/1/2007 through 6/30/2007 (day 109 through day 289); the warm-up period (9/15/06 through 12/31/06) is excluded.
** RMSE is the root mean square error.
Case (1) = half the time step
Case (2) = increase the roughness height by +15%
Case (3) = increase the horizontal mixing coefficients by +15%
Case (4) = increase the horizontal mixing coefficients by -15%
Case (5) = increase downstream salinity boundary condition by 1 psu

Table 3-10. Sensitivity analysis: Comparison of Mean and RMS errors for water temperature for Homosassa River gauge

Case	Mean (ºC)		RMSE (ºC)	
	Surface (16,132 pairs)	Bottom (16,127 pairs)	Surface (16,132 pairs)	Bottom (16,127 pairs)
Baseline	22.50	22.52	1.72	1.75
(1) ½ time step	22.50	22.53	1.71	1.75
(2) increase roughness	22.50	22.52	1.72	1.75
(3) increase mixing	22.49	22.52	1.71	1.74
(4) decrease mixing	22.51	22.53	1.73	1.77
(5) Increase Salinity	22.50	22.53	1.71	1.75

* 15-minute interval for both observed and simulated data was used. Periods of missing record are excluded from the statistic calculations. Statistics are based on data during the period 1/1/2007 through 6/30/2007 (day 109 through day 289); the warm-up period (9/15/06 through 12/31/06) is excluded.
** RMSE is the root mean square error.
Case (1) = half the time step
Case (2) = increase the roughness height by +15%
Case (3) = increase the horizontal mixing coefficients by +15%
Case (4) = increase the horizontal mixing coefficients by -15%
Case (5) = increase downstream salinity boundary condition by 1 psu

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4.0 MINIMUM FLOWS AND LEVELS ANALYSIS

4.1 Introduction

One objective of this investigation is to determine the changes in habitat area and/or volume based on flow reductions from the springs at the headwaters of the Homosassa River estuary. The calibrated and validated EFDC Model for the Homosassa River was used to determine the reduction in spring discharge that can occur without exceeding thermal and salinity criteria. This was completed by comparing MFL withdrawal scenarios to baseline values of bottom area and volume associated with thermal and salinity regimes.

4.2 Thermal Analysis

4.2.1 Critical Time Period

Manatees thrive in warm water environments with adequate bottom area and vegetation to graze. During cold weather, manatees seek refuge in upstream areas of low salinity and warmer water temperature. A manatee "season" runs from October 1 to March 31 because that represents the window when manatees may seek refuge in warmer spring waters when Gulf temperatures drop below 20ºC. Exposure to water colder than 20ºC for more than 3 days or 15ºC for more than four hours can be fatal to manatees (Rouhani et al. 2006). In addition, based on discussion with District staff, areas where the water depth is less than 3.8 ft are not deemed accessible to manatee and would not be considered part of the thermal refuge. For this evaluation, manatee habitat is defined as the volume of water at a critical time period that does not exceed the acute and chronic temperature requirements of the manatee and meets the depth criterion at mean low tide. The acute temperature requirement is a water temperature that does not fall below 15°C for more than four consecutive hours over a critical three day period as discussed below. The chronic temperature requirement is that the average daily water temperature does not fall below 20°C for any day over the three day critical period. Mean low tide is the average of recorded low tide at the Homosassa River gauge over the critical three day window.

To identify a critically cold event lasting three days during the 2007 – 2008 manatee season, a technique employed by the SWFWMD on the Chassahowitzka River (Dynamic Solutions 2008) and Weeki Wachee (Janicki & ATM 2007) was used. A three day event window was calculated using a joint probability of air temperature (from Brooksville FAWN-IFAS Station), spring discharge (Homosassa Springs), and tide (Homosassa River). Mean daily air temperature, spring discharge, and high tide for each day in the six-month manatee season were ranked from lowest to highest and assigned a Cunnane probability of non-exceedance with the joint probability of non-exceedance being the multiplication of the three. Since the timeframe of interest is three days, a three day moving average of joint probability was used to identify which three days has a combination of the lowest air temperature, lowest spring discharge, and lowest high tide. However, there are time periods when a three day moving average of joint probability was not available because of missing tidal values. Therefore, a second joint probability was calculated based only on discharge and air temperature. There are two possible windows identified; the first is 12/16/07 – 12/18/07 based on the joint probability of all three variables and the second is 1/2/08 – 1/4/08 based on only air temperature and discharge (Figure 4-1).

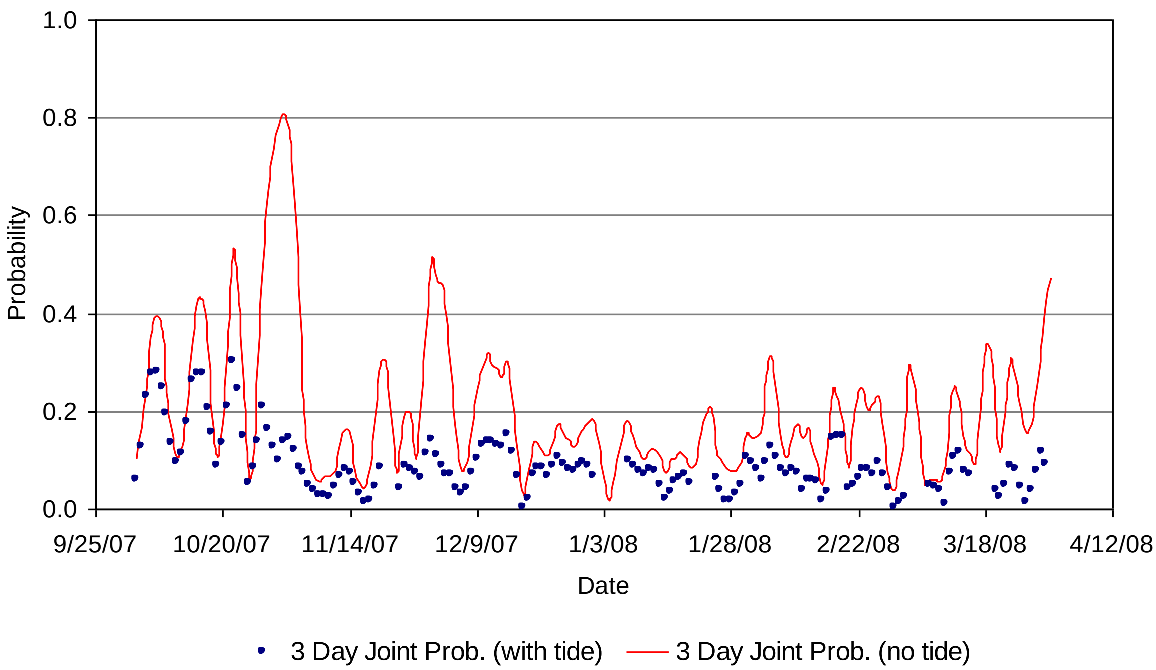


Figure 4-1. Joint probability analysis of critical cold events during the 2007-2008 manatee seasons with and without tide

To determine which three day window to utilize, a second plot was created of actual three day moving averages of air temperature and tide along with actual mean high tide values to characterize days when missing daily mean high tide values prohibited calculation of a three day moving average (Figure 4-2). The January window (1/2/08 – 1/4/08) is the more critical window because of lower three day moving averages of air temperature and the lowest daily mean high tide for this period of analysis. The January three-day window was used to evaluate the baseline condition and the influence of water withdrawals on the volume of manatee habitat associated with chronic and acute temperature requirements.

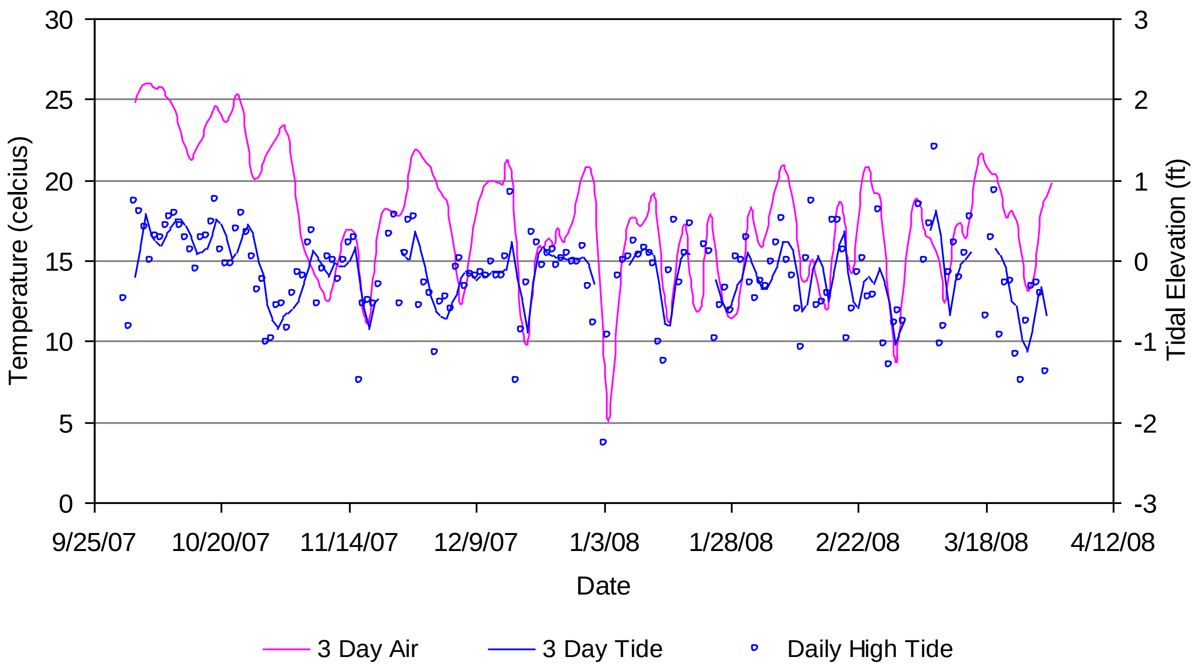


Figure 4-2. Three day moving average of daily mean air temperature and tide for Homosassa River gauge

4.2.2 Baseline Refuge Determination

To determine the baseline refuge, the model was run for the critical time period to determine depth-averaged temperatures associated with the acute and chronic conditions. Using the GIS based bathymetry analysis reported in section 2, contour plots also were developed depicting areas where the 3.8 ft depth criterion was met under baseline conditions. The resulting graphic displays the region of the river where both the temperature (along the river centerline) and depth criteria are met (Figures 4-3 and 4-4). The area/volume relationships presented in Section 2 and Appendix C were used to determine the baseline manatee habitat volume.

4.2.3 MFL Determination Based on Thermal Habitat

To determine the impact of flow reductions on the thermal refuge, the hydrodynamic model was run using 5, 10, 15, 20, 25 and 30% reductions in freshwater flow based on total spring flow. The acute and chronic thermal refuge volumes were calculated in the same manner as for the baseline condition (Figures 4-3 and 4-4). For the chronic condition and flow reductions of 25 and 30%, the area of the river meeting the depth requirement (i.e., dark green) extends a small amount laterally into areas not meeting the temperature requirement. This small error occurs because the temperature criterion is based on the centerline temperature associated with model grid cells, and the depth criterion is based on the GIS contouring of the bathymetry data.

The acute habitat baseline volume (112,288 m^3) is much larger than the chronic volume (64,566 m^3) and the absolute and percent reductions in habitat volume also are greater for the acute analysis for the same flow reductions (Table 4-1). Assuming that the manatee stay in a habitat that meets the chronic condition, then flow reductions on the order of 25 to 30% could occur before habitat was decreased by more than 15% of the baseline volume (Figure 4-5). However, a flow reduction between 5 and 10% would appreciably reduce the size of the acute condition habitat (Figure 4-6).

Table 4-1. Summary of thermal MFL analysis under different withdrawal scenarios based on Homosassa River domain

Condition	Withdrawal Scenarios	River Kilometer	Volume (m^3)	Volume Change (m^3)	Volume Change (%)
Chronic	Baseline	11.46	64,566	—	—
	5%	11.53	64,153	412	1
	10%	11.58	63,859	707	1
	15%	11.67	63,144	1,422	2
	20%	11.73	62,632	1,934	3
	25%	11.84	58,191	6,375	10
	30%	12.10	30,901	33,665	52
Acute	Baseline	9.56	112,288	—	—
	5%	9.69	103,212	9,075	8
	10%	10.00	87,749	24,539	22
	15%	10.34	73,881	38,407	34

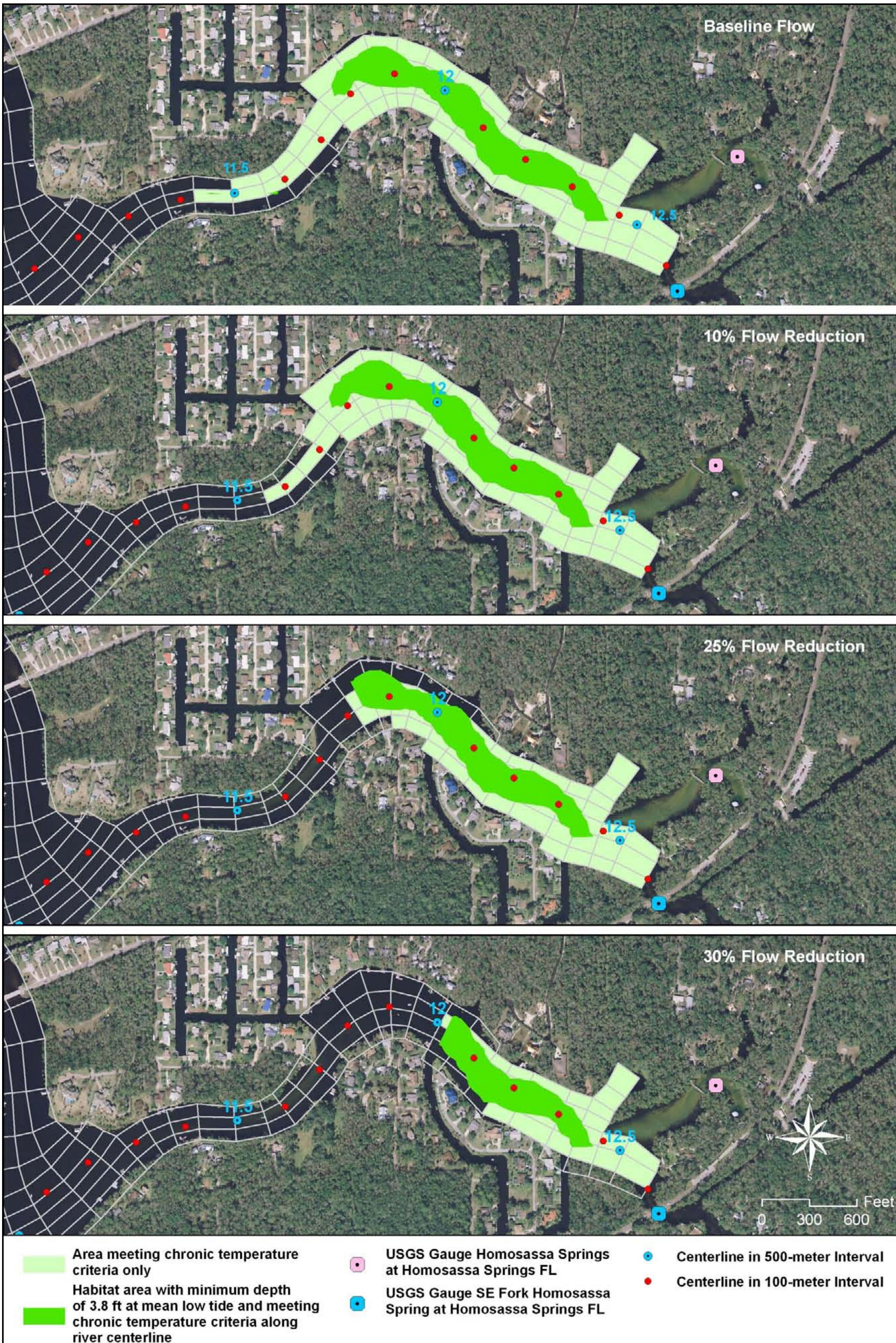


Figure 4-3. Chronic condition manatee habitats under various flow reductions

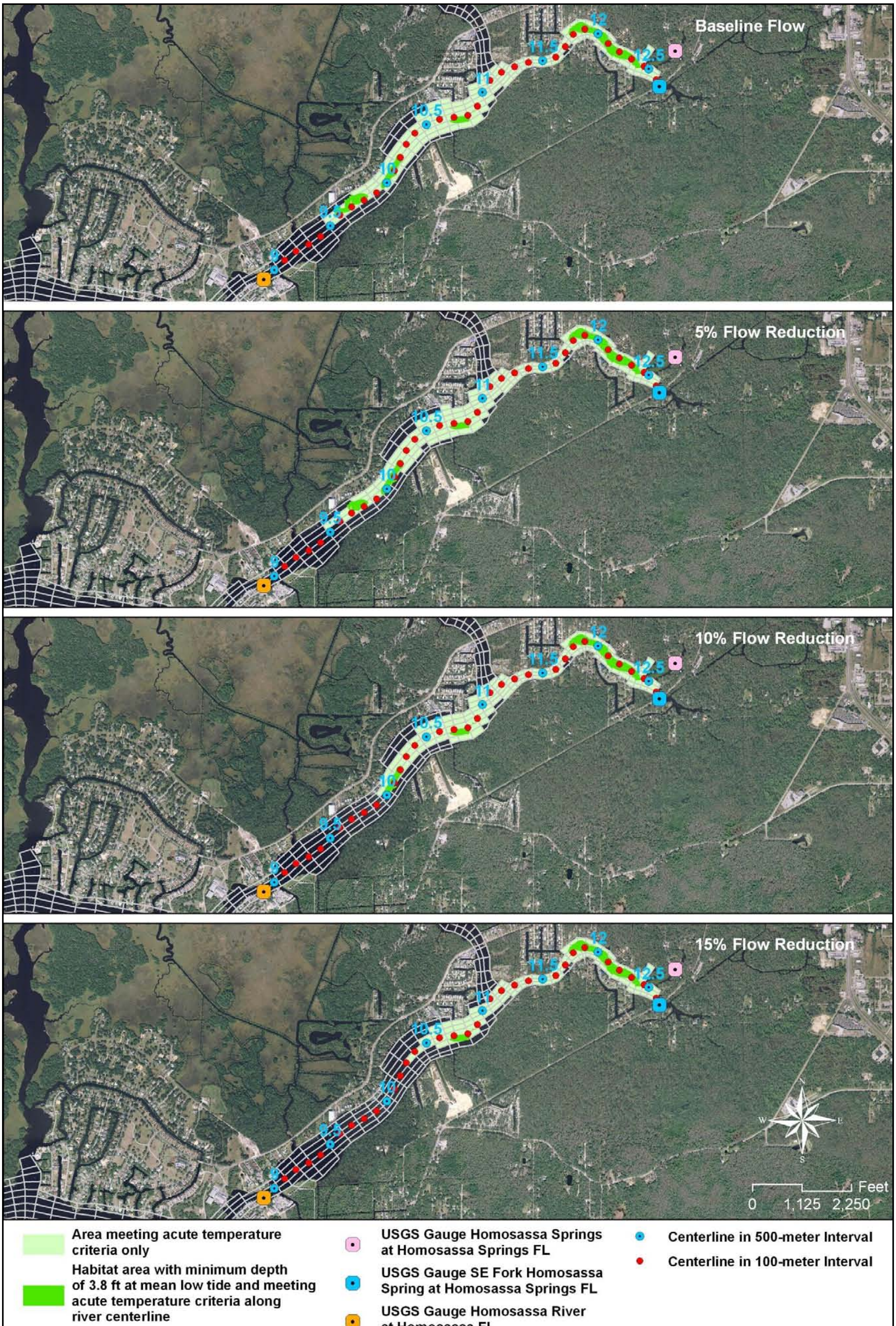


Figure 4-4. Acute condition manatee habitats under various flow reductions.

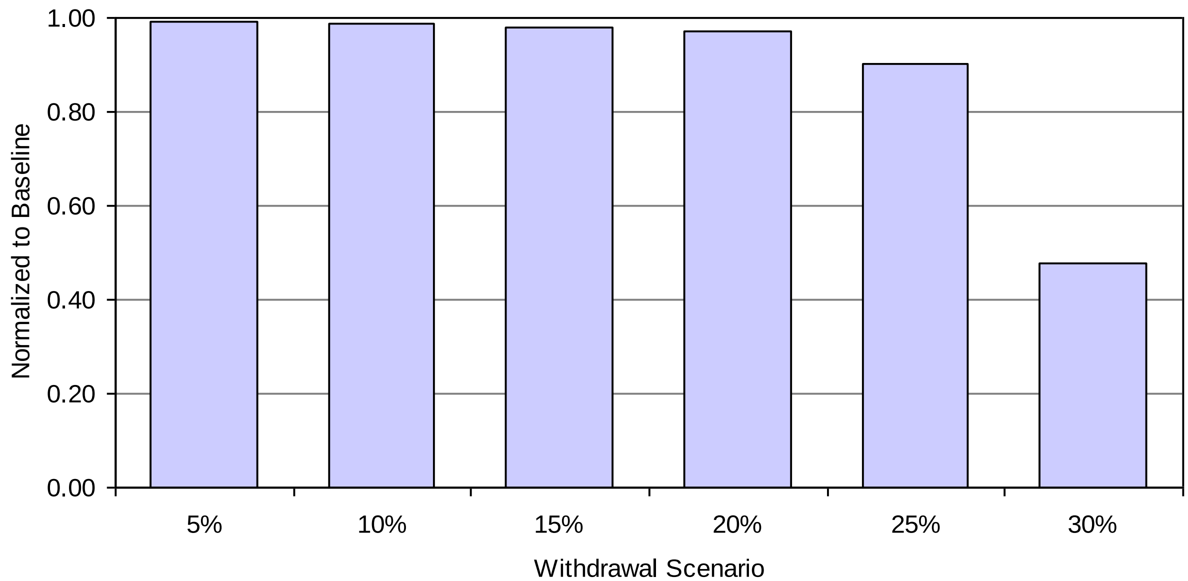


Figure 4-5. Effect of withdrawals on baseline volume for chronic manatee habitat condition

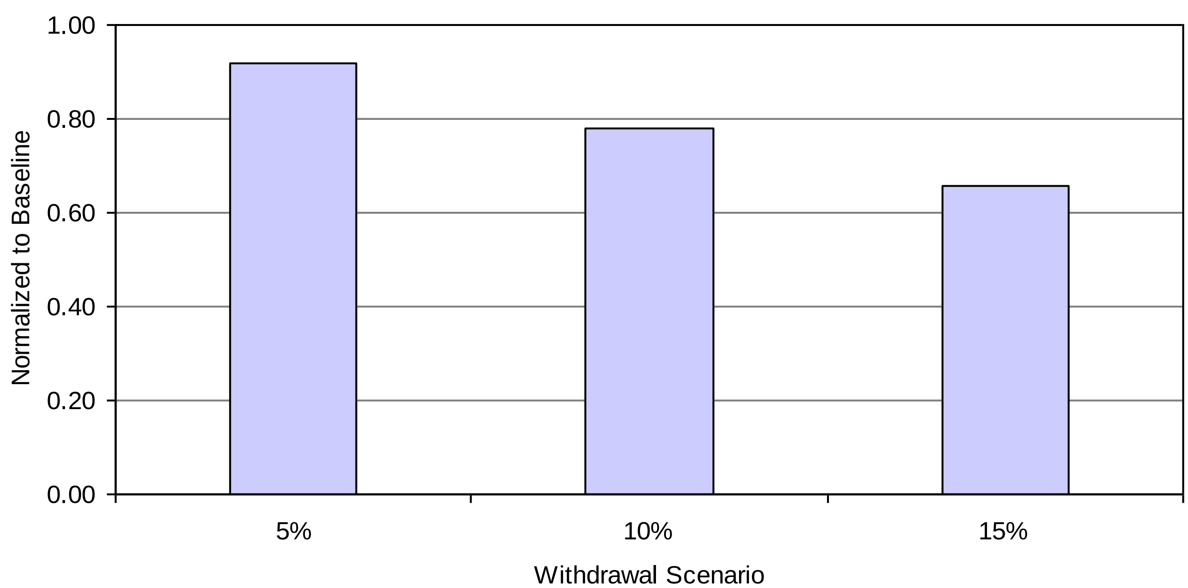


Figure 4-6. Effect of withdrawals on baseline volume for acute manatee habitat condition

4.3 Salinity Evaluation

Salinity regimes are important for aquatic and benthic species that inhabit estuarine systems. For this analysis, salinity regimes are defined as that bottom area or volume of river upstream of where a prescribed minimum salinity occurs. The hydrodynamic model was run for the 2007 calendar year using baseline, and 5, 10, 15, 20, 25, and 30% reductions in total freshwater spring flow, and salinity values were output every 3 hours. Bottom salinity and depth-averaged salinity were used to determine river bottom area and river volume associated with specified isohalines of 2, 3, 5, and 12 psu.

The median modeled centerline bottom salinities compare favorably with the observed longitudinal salinity distributions (Figure 4-7). The median salinity values are reasonable to represent the expected salinity under median flow conditions given the strong linear relationship between flow and salinity.

To determine habitat area and volume, the location (centerline RKM) was determined for salinity concentrations of 2, 3, 5, and 12 psu for each 3-hour output record. Median RKM values were then calculated for each isohaline and these RKM values were used to define habitat metrics associated with salinity concentrations less than 2, 3, 5, and 12 psu. For example, the median baseline location of the depth-averaged 3 psu isohaline is at RKM 10.90 (Table 4-2). The associated river volume is the volume upstream of RKM 10.90 or 236,409 m^3 (Table 4-4). The locations (RKM) of the isohalines for depth-averaged and bottom salinities were found by linear interpolation of the model output for each 3-hour interval (Tables 4-2 and 4-3). Baseline and flow reduction volumes and bottom areas associated with each isohaline (Tables 4-4 and 4-5, respectively) were then calculated using the volume/area relationships reported in Section 2.3 (Tables 4-4 and 4-5, respectively).

The 2 psu depth-averaged isohaline is very near the spring area and even a small change (5%) in flow results in a large relative change in volume associated with this isohaline (Tables 4-4 and Figure 4-8). The 2 psu isohaline moves upstream only about 0.11 km (110 meters) with a 5% flow reduction from baseline (Table 4-2), but the relative change in volume is about 45%. Use of the median location for the 2 psu isohaline is problematic because the average measured salinity (converted through measured conductivity) associated with Homosassa and Southeast Fork Springs is very near 2 psu and often exceeds 2 psu. In addition, the modeled input locations for the spring discharges are near or at the most upstream model cell at about RKM 12.48. The modeled bottom salinity in the most upstream cell exceeded 2 psu about 47% of the time for baseline conditions. A meaningful evaluation of the 2 psu isohaline location sensitivity to the full range of flow reduction scenarios is precluded by the proximity of the isohaline to the model boundary.

The 3 psu median depth-averaged isohaline is also located near the spring area, so a small reduction in flow results in moderately large changes in volume and river bottom area associated with this isohaline. Volume (Table 4-4 and Figure 4-8) associated with the isohaline is reduced 7% and river bottom area (Table 4-5 and Figure 4-9) is reduced by 8% with a 5% flow reduction.

The 5 and 12 psu median depth-averaged isohalines locations and associated upstream volumes and areas are less sensitive to low flow reductions. Areas and volumes upstream from these isohalines change by 4% or less with a 5% flow reduction (Tables 4-4 and 4-5, Figures 4-8 and 4-9). A 15% flow reduction results in a 15% change in volume associated with the 5 psu isohaline and a 10% change in volume associated with the 12 psu isohaline (Table 4-4). Bottom area changes associated with the 5 and 12 psu isohalines are similar to the volume changes (Table 4-5, Figure 4-9).

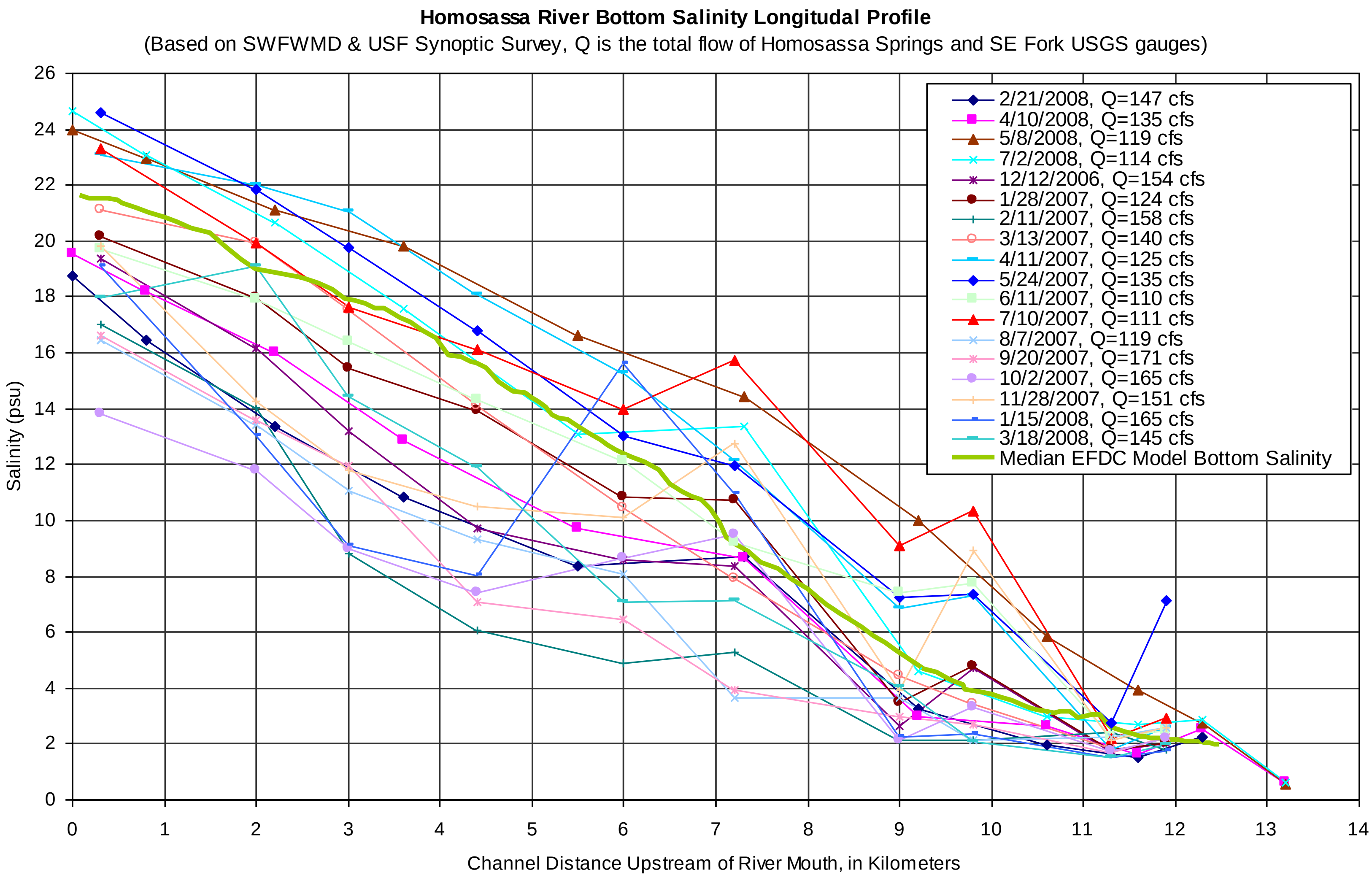


Figure 4-7. Longitudinal bottom salinity distribution for the Homosassa River associated with median centerline bottom salinity in 2007 based on EFDC model results and synoptic surveys completed by SWFWMD and the University of South Florida between December 2006 and July 2008

Table 4-2. RKM locations of selected isohalines for depth-averaged salinity under different withdrawal scenarios

Isohaline (psu)	RKMs under Different Withdrawal Scenarios						
	Baseline	5%	10%	15%	20%	25%	30%
2	12.18	12.29	12.37	>12.40	>12.40	>12.40	>12.40
3	10.90	10.98	11.07	11.22	11.28	11.44	11.61
5	9.03	9.18	9.33	9.50	9.69	9.94	10.16
12	5.81	5.93	6.15	6.32	6.43	6.53	6.74

Table 4-3. RKM locations of selected isohalines for bottom salinity under different withdrawal scenarios

Isohaline (psu)	RKMs under Different Withdrawal Scenarios						
	Baseline	5%	10%	15%	20%	25%	30%
2	12.33	>12.40	>12.40	>12.40	>12.40	>12.40	>12.40
3	10.92	11.00	11.08	11.23	11.32	11.47	11.65
5	9.10	9.23	9.39	9.57	9.71	10.02	10.26
12	6.19	6.36	6.43	6.51	6.72	6.89	6.98

Table 4-4. Volumes and relative changes for depth-averaged salinity isohalines under specified flow reductions

Isohaline (psu)	Baseline	5%		10%		15%		20%		25%		30%	
	Volume (m^3)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)
2	49,013	27,034	45	13,298	73	<7,006	>86	<7,006	>86	<7,006	>86	<7,006	>86
3	236,409	220,729	7	202,052	15	170,745	28	164,479	30	149,022	37	138,453	41
5	687,505	661,379	4	625,837	9	585,520	15	540,490	21	485,803	29	436,621	36
12	1,565,149	1,515,635	3	1,446,498	8	1,402,774	10	1,374,312	12	1,344,007	14	1,261,012	19

Table 4-5. Areas and relative changes for bottom salinity isohalines under specified flow reductions

Isohaline (psu)	Baseline	5%		10%		15%		20%		25%		30%	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
2	14,470	<6,498	>55	<6,498	>55	<6,498	>55	<6,498	>55	<6,498	>55	<6,498	>55
3	162,199	149,769	8	134,345	17	107,030	34	94,817	42	82,209	49	79,029	51
5	508,851	488,602	4	450,710	11	415,959	18	393,589	23	347,073	32	304,949	40
12	1,047,360	1,017,990	3	1,004,548	4	989,253	6	935,873	11	890,436	15	866,732	17

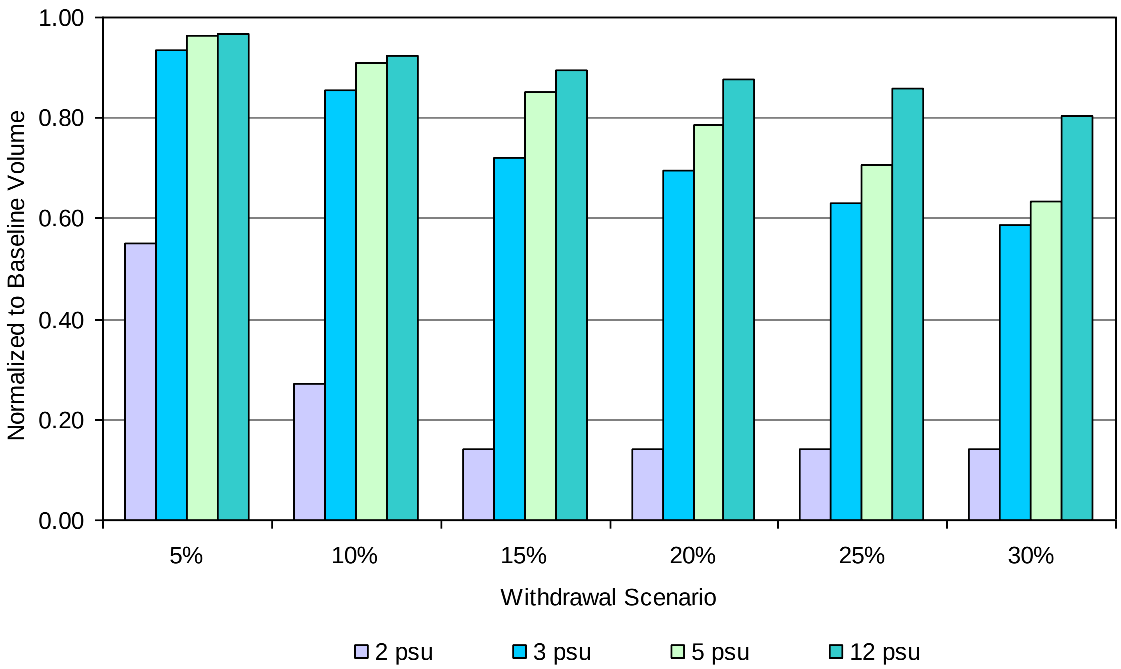


Figure 4-8. Effect of withdrawals on baseline volume for specified isohalines – EFDC model (for 2 psu isohaline under scenarios of 5 to 30% reduction, volumes are estimated using Table C-3 in Appendix C)

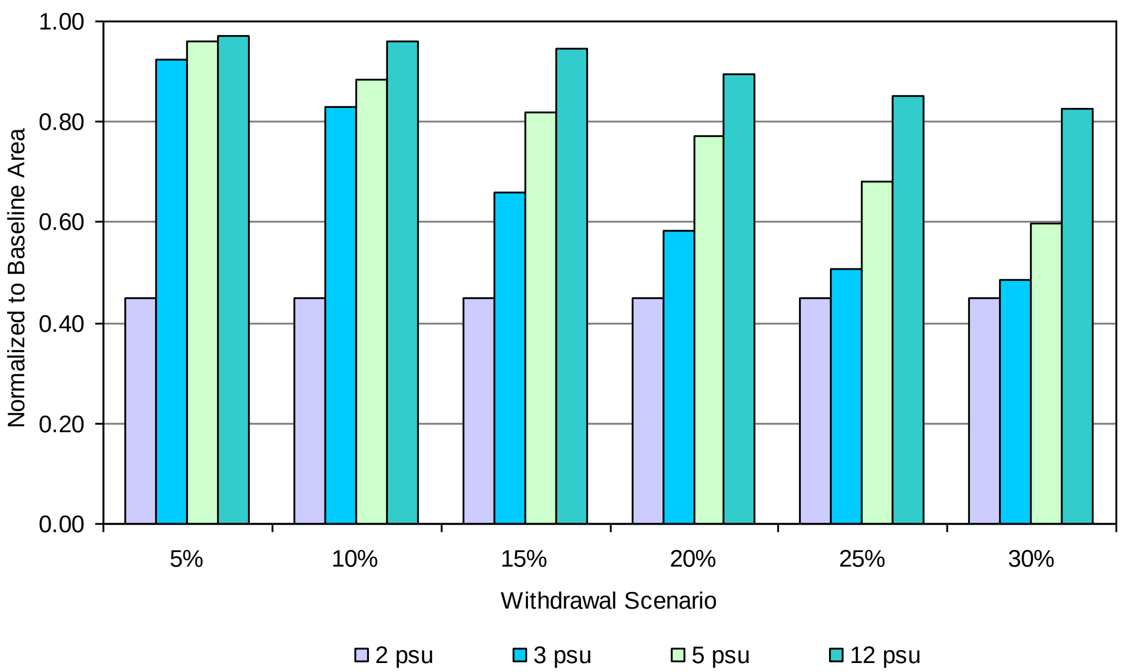


Figure 4-9. Effect of withdrawals on baseline area for specified isohalines – EFDC model (for 2 psu isohaline under scenarios of 5% to 30% reduction, areas are estimated using Table C-3 in Appendix C)

The isohaline empirical models also were used to estimate the change in isohaline positions as a result of decreased flow using the 2007 input data (i.e., the same year covered by the hydrodynamic model). For the analysis using the empirical models, daily total spring flow and mean tide values at the USGS gauge at Homosassa were used in the models to estimate the surface, bottom, and depth-average positions of the 3, 5, and 12 psu isohalines each day in 2007. The depth-averaged position was calculated as the average of the surface and bottom locations. The 2 psu isohaline was not evaluated because no empirical model could be developed for that isohaline. Baseline bottom areas and volumes associated with each isohaline were then calculated using the area/volume relationships reported in Section 2.3 and Appendix C. The procedure was repeated for flow reductions of 5, 10, 15, 20, 25, and 30%.

A 15% flow reduction results in a 10% change in volume associated with the 5 psu isohaline and 12% change in volume associated with the 12 psu isohaline (Figure 4-10). Bottom area changes associated with the 5 and 12 psu isohalines are 7 and 10 % for the 5 and 12 psu isohalines, respectively (Figure 4-11).

A more detailed comparison of the hydrodynamic and empirical model results is presented in Appendix J.

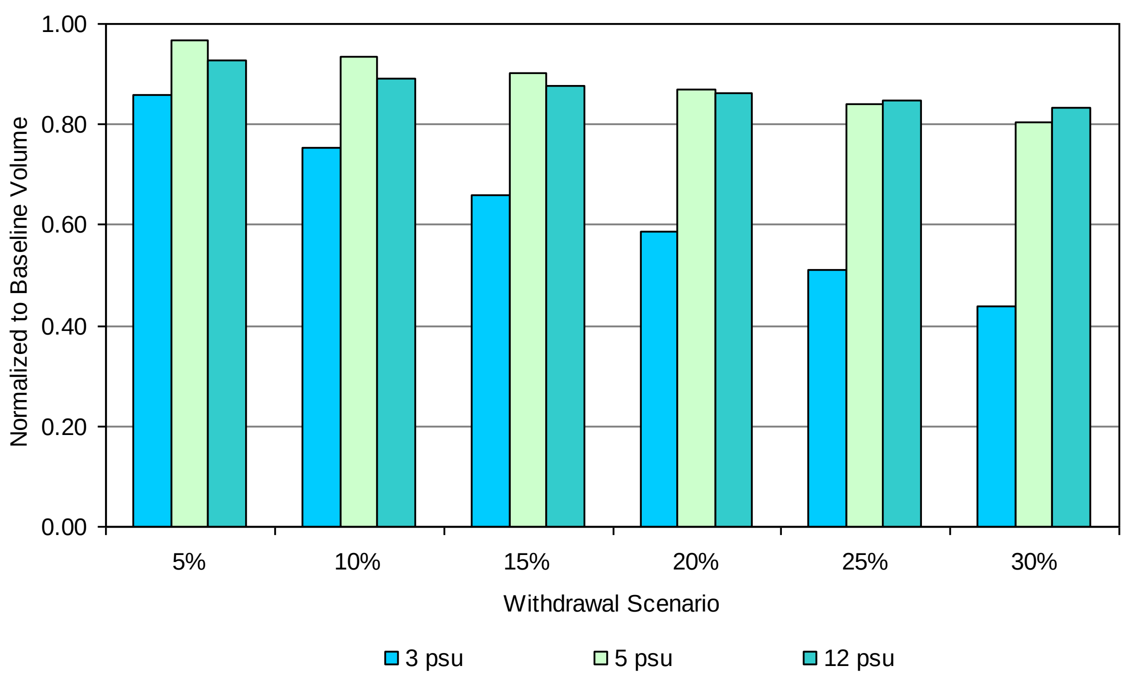


Figure 4-10. Effect of withdrawals on baseline volume for specified isohalines – empirical models

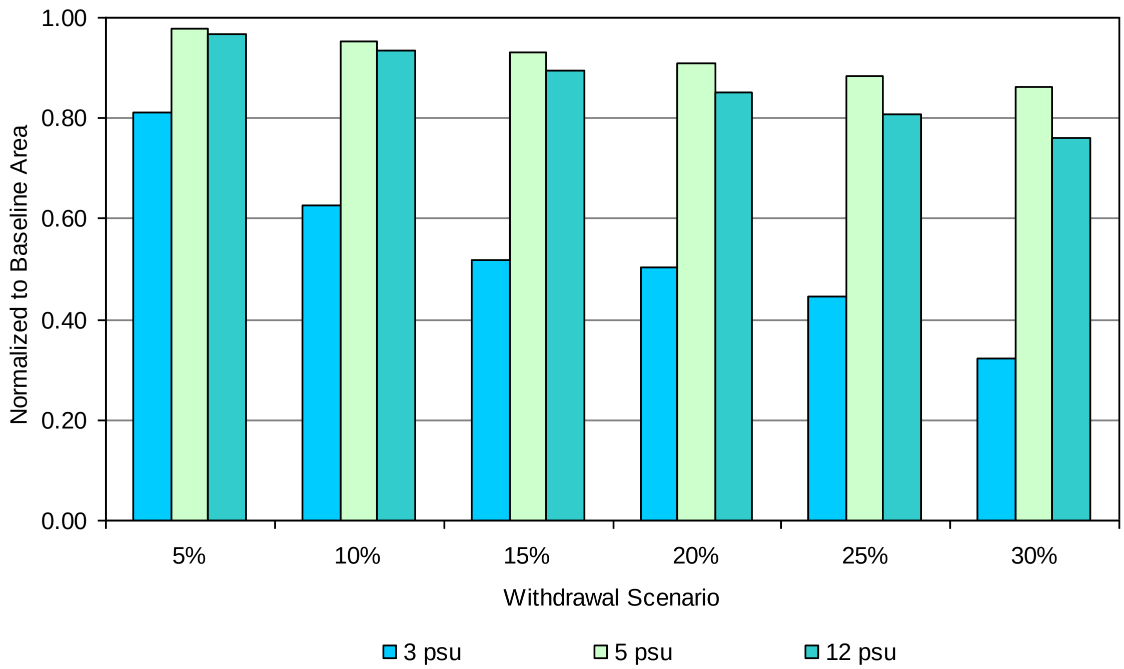


Figure 4-11. Effect of withdrawals on baseline area for specified isohalines - empirical models

References

Dynamic Solutions, LLC. November 3, 2008. Impacts of Withdrawals on the Chassahowitzka River System for Southwest Florida Water Management District under PO 07PO0001577.

Rouhani, S., P. Sucsy, G. Hall, W. Osburn, and M. Wild. 2006. Analysis of Blue Spring Discharge Data to Determine a Minimum Flow Regime. Prepared in cooperation with the Blue Spring Minimum Flow Interagency Working Group. Prepared for the St. Johns River Water Management District, Palatka, FL. Prepared by New Fields, Inc., Atlanta, Georgia. September 2006.

Janicki Environmental, Inc. and Applied Technology & Management (Janicki & ATM). 2007. Impacts of Withdrawals on the Thermal Regime of The Weeki Wachee River. Funded by Southwest Florida Water Management District, Purchase Order No. 06POSOW0555.

5.0 SUMMARY AND CONCLUSIONS

The goal of this investigation was to determine the change in habitat area and volume as a result of reduced spring flow. This was accomplished primarily by using a calibrated and validated EFDC hydrodynamic model to evaluate thermal and salinity habitat under existing baseline and reduced inflow conditions.

Thermal analysis was conducted for a three day chronic condition and a four hour acute condition associated with manatee use of the system as a thermal refuge. It was determined that although the acute condition habitat baseline volumes were much larger than chronic condition volumes, a flow reduction of 5 to 10% would appreciably reduce the acute condition volume. A flow reduction on the order of 20 to 25% was required before the chronic condition volume decreased by more than 15%.

Salinity analysis was conducted for one year based on a median isohaline location for four salinity concentrations. Depth-averaged and bottom salinities were used to determine the impact of spring flow reduction on volume and bottom area, respectively. The 2 psu isohaline often is very near the river area represented by the most upstream model cell. This occurs because the salinity at the spring often is greater than 2 psu, which precludes a meaningful evaluation associated with this isohaline. For the 3 psu isohaline, a 10% flow reduction results in a relative change of 15% in habitat volume whereas flow reductions of 15 % are required before the change habitat associated with the 5 and 12 psu isohalines is greater than 10%. For bottom area, the flow reduction that can occur before a 15% change in bottom habitat occurs is between 10% and 25% depending on the isohaline being considered.

Regression models also were developed for isohaline locations (i.e., 3, 5, and 12 psu) and salinity as a function of flow. The results of the statistical isohaline models and numerical hydrodynamic model generally are similar. For example, for the 3 psu isohaline, a 5% flow reduction results in a relative area and volume change of greater than 15%. Similarly, a 15% flow reduction is needed to elicit a 10% change in habitat area and volume associated with the 5 and 12 psu isohaline. At flow reductions greater than 10%, the hydrodynamic model predicts greater habitat loss associated with the 5 psu isohaline and similar habitat loss associated with the 12 psu isohaline when compared to the empirical model results.

There are three key efforts that could be implemented to improve the accuracy and validity of the EFDC model of the Homosassa River. First would be to explicitly grid all of the interconnecting channels to reduce the magnitude of the funnel that was required for adequate model calibration. This should improve tidal resolution as well as better capture the mixing occurring in the system. The second improvement would involve developing an accurate water balance for the system. The accuracy of the gauged flow is marginal and the relatively large amount of ungauged discharge reported in the literature should be verified. Additional measurements and/or modeling would increase confidence in the hydrologic boundary conditions. Finally, the nearshore water divide between the Homosassa River, Crystal River, and Chassahowitzka River is not well defined. A better hydrodynamic demarcation of those systems would assist in setting the model domain boundary and improving the water balance.

Appendix A

Available Data Summary

Table A-1. Initial and boundary condition input associated data summary

Data Type	Source	Location	Period of Record	Frequency	Site Name (ID)	Comments
Temperature (cel) at 60 cm, 2m,and 10 m; solar radiation (wm2) at 2m, dew point temperature (cel) at 2m, rainfall (inch), wind speed/direction (mph) at 10 m, relative humidity, ET	FAWN-IFAS	Brookeville	3/27/2000 - 6/11/2008	15-minute (hourly, daily are also available)	–	Occasional 30 minute to 2+ hour gaps in the time record without blank rows. Only identifiable by carefully scrutinizing the time record. Missing records can be supplemented with Floral City & Inglis.
Fractional Cloud Cover	NOAA NCDC	Tampa International Airport	9/1/2006 - 3/31/2008	3 hour increments	–	Fractional cloud cover downloaded from TIA which is nearest station.
Stage	USGS	Homosassa River - Shell Island	10/01/1984 - 04/07/2008	daily	02310712 Homosassa River at Shell Island	Downloaded daily - 15 minute provided by District
Top, middle, and bottom conductance water temperature	USGS	Homosassa River - Shell Island	09/15/2006 - 04/07/2008	daily	02310712 Homosassa River at Shell Island	Downloaded daily - 15 minute provided by District
Stage Discharge, bottom conductance bottom temperature	USGS	Homosassa Springs	11/02/1988 - 04/07/2008 (stage) 10/18/1995 - 04/06/2008 (discharge) 06/28/2004 - 04/07/2008 (cond.) 06/28/2004 - 04/07/2008 (temp)	daily	02310678 Homosassa Springs at Homosassa Springs	Downloaded daily - 15 minute provided by District
Stage Discharge, near bottom Conductance near bottom temperature	USGS	SE Fork Homosassa Springs	10/01/2002 - 02/10/2008 (stage) 10/01/2002 - 04/06/2008 (discharge) 05/03/2006 - 04/07/2008 (cond.) 05/03/2006 - 04/07/2008 (temp)	daily	02310688 SE Fork Homosassa Spring at Homosassa Springs	Downloaded daily - 15 minute provided by District
Centerline GIS shapefile	SWFWMD	Entire River	–	–	–	Assigned RKM using ArcGIS and confirmed with District. RKM is necessary for MFL evaluation.
Bathymetry (shoreline centerline cross-sections)	SWFWMD - USF	Entire River	–	–	–	surveyed centerline and shoreline positions and cross-section in NAD 83 and UTM17 in meters, GIS maps for contour and shoreline in UTM17 coordinate system

Table A-2. Model development associated data summary

Data Type	Source	Location	Period of Record	Frequency	Site Name (ID)	Comments
Discharge, stage, top and bottom temperature top and bottom conductance	USGS	Homosassa River	06/08/1984 - 11/05/1985 & 05/17/2004 - 06/03/2008 (discharge)* 10/01/1970 - 04/24/2008 (stage) 05/05/2006 - 06/15/2008 (top temp & cond.) 05/18/2004 - 04/07/2008 (bottom temp & cond.)	daily	02310700 Homosassa River at Homosassa	Downloaded daily - 15 minute provided by District
Stage	USGS	Hall River	10/27/2000 - 02/20/2008	daily	02310690 Halls River near Homosassa	Downloaded daily - 15 minute provided by District
USGS AVM site	USGS	Homosassa River			02310700Homosassa River at Homosassa	
Stage	USGS	Homosassa River - Shell Island	10/01/1984 - 04/07/2008	daily	02310712 Homosassa River at Shell Island	Downloaded daily - 15 minute provided by District
Top, middle, and bottom conductance water temperature	USGS	Homosassa River - Shell Island	09/15/2006 - 04/07/2008	daily	02310712 Homosassa River at Shell Island	Downloaded daily - 15 minute provided by District
Stage Discharge, bottom conductance bottom temperature	USGS	Homosassa Springs	11/02/1988 - 04/07/2008 (stage) 10/18/1995 - 11/07/1995 & 01/09/1996 - present (discharge)* 06/28/2004 - 04/07/2008 (cond.) 06/28/2004 - 04/07/2008 (temp)	daily	02310678 Homosassa Springs at Homosassa Springs	Downloaded daily - 15 minute provided by District
Stage Discharge, near bottom Conductance near bottom temperature	USGS	SE Fork Homosassa Springs	10/01/2002 - 02/10/2008 (stage) 10/01/2000 - present (discharge)* 05/03/2006 - 04/07/2008 (cond.) 05/03/2006 - 04/07/2008 (temp)	daily	02310688 SE Fork Homosassa Spring at Homosassa Springs	Downloaded daily - 15 minute provided by District

* Discharge data are intermit during the early period of record and more continuous in recent years

Table A-3. Other supporting data summary

Data Type	Source	Location	Period of Record	Frequency	Site Name (ID)	Comments
Boundary Condition (Air and water temperatures, barometric pressure, precipitation, wind speed/direction/gusts, relative humidity, conductivity, water level)	USF	Marker #26 at the entrance to Homosassa river, Citrus County, Florida	04/01/1999 - present (not all parameters are continuous)	6-minute	USF-COMPS (Time reported is UTC (Coordinated Universal Time: subtract 5 hours for EST, subtract 4 hours for EDT.)	Data from 04/1999-06/2004 were downloaded. From 07/2004 to present are not available online and have been requested through USF.
Temperature (F); solar radiation (kwm2), wind speed/direction (mph); relative humidity (%); precipitation (in)	NOAA NCDC	Floral City	4/1/03 - 5/31/08 (missing 1/28/07 - 1/29/07)	hourly	–	Precipitation data exists hourly for 2003 - 2005 and in 15 minute increments for summer months of 2006 & 2007. Won't be able to use precipitation data.
Temperature (F); solar radiation (kwm2), wind speed/direction (mph); relative humidity (%); precipitation (in)	NOAA NCDC	Inglis	4/1/03 - 5/31/08 (missing 2/5/08 - 2/19/08 & 6/11/04 - 6/16/04)	hourly	–	Precipitation data exists hourly for 2003 - 2005 and in 15 minute increments for summer months of 2006 & 2007. Won't be able to use precipitation data.
Temperature (cel) at 60 cm, 2m,and 10 m; solar radiation (wm2) at 2m, dew point temperature (cel) at 2m, rainfall (inch), wind speed/direction (mph) at 10 m, relative humidity, ET	FAWN-IFAS	Dover	5/5/98 - 6/11/2008	15-minute (hourly, daily are also available)	–	Occasional 30 minute to 2+ hour gaps in the time record without blank rows. Only identifiable by carefully scrutinizing the time record.
Profile data	SWFWMD	Homosassa River	1984-1985	–	–	Information from the note provided by Sid on 04/08/2008
Profile data	SWFWMD	Homosassa River	March to Fall 2008	–	–	Information from the note provided by Sid on 04/08/2008
Field measurement (channel width, cross-section area, velocity, discharge, gage height)	USGS	Homosassa River	1984 - 2008	–	02310678 Homosassa Springs at Homosassa Springs	–
Field measurement (channel width, cross-section area, velocity, discharge, gage height)	USGS	Homosassa River	1984 - 2006	–	02310688 SE Fork Homosassa Spring at Homosassa Springs	–
Field measurement (channel width, cross-section area, velocity, discharge, gage height)	USGS	Homosassa River	1984 - 2007	–	02310700 Homosassa River at Homosassa	–
Centerline GIS shapefile	SWFWMD	Entire River	–	–	–	Assigned RKM using ArcGIS and confirmed with District. RKM is necessary for MFL evaluation.

Table A-4. Summary of daily USGS gauge data*

Site	Discharge**	Stage**	Salinity/Cond	Temp	Comments
02310712 Shell Island	—	9/15/2006 - 04/07/2009	09/15/2006 - 04/07/2009	09/15/2006 - 04/07/2009	Top, middle, and bottom conductance Top, middle, and bottom temperature mean /low/high gage height. Gage height is not available if 15-minute are not available for all day.
02310700 Homosassa River	05/17/2004 - 06/03/2008	5/14/2004 - 04/24/2008	05/18/2004 - 06/15/2008 (bot) 05/05/2006 - 06/15/2008 (top)	05/18/2004 - 06/15/2008 (bot) 05/05/2006 - 06/15/2008 (top)	Discharge (filtered and non-filtered), stage (mean /high/low gauge height have more data points, other stage data either repeat or may use a different datum, suggest not to use. top and bottom (max and min) temperature top and bottom (max and min) conductance the average of max and min is not same as the average of 15-minute data for a given day
02310678 Homosassa Springs	10/18/1995 - 06/15/2008	01/09/1996 - 06/15/2008	06/28/2004 - 06/15/2008	06/28/2004 - 06/15/2008	Stage Discharge, bottom (max and min) conductance bottom (max and min) temperature the average of bottom max and min is not same as the average of 15-minute bottom data for a given day for both temperature and conductivity
02310688 SE Fork Homosassa Spring	10/01/2002 - 05/26/2008	10/01/2002 - 04/30/2008	05/03/2006 - 05/26/2008	05/03/2006 - 05/26/2008	Stage Discharge, bottom (max and min) conductance bottom (max and min) temperature
02310690 Hall River	—	10/27/2000 - 05/06/2008	—	—	Stage
2883201082315601 Weeki Wachee Well	□	09/30/1974 - 09/30/2009	□	□	Well stage

* All gauge height datum are converted to NAVD88 except that recorded at Weeki Wachee Well, which is referenced to NGVD29

** The listed period of records (POR) for stage and discharge indicate where continuous daily data are available. Minor data points may be available before the listed PORs

Table A-5. Summary of 15-minute USGS gauge data*

Site	Discharge	Stage	Salinity/Cond	Temp	Comments
02310712 Shell Island	—	09/14/2006 - 09/30/2008	09/14/2006 - 09/30/2008	09/14/2006 - 09/30/2008	Top, middle, and bottom conductance, temperature
02310700 Homosassa River	05/19/2004 - 09/30/2008	05/13/2004 - 09/30/2008	05/17/2004 - 09/30/2008 (bot) 05/05/2006 - 09/30/2008 (top)	05/17/2004 - 09/30/2008 (bot) 05/05/2006 - 09/30/2008 (top)	Discharge (filtered and non-filtered), stage, top and bottom temperature top and bottom conductance
02310678 Homosassa Springs	10/01/2001 - 09/30/2008	10/01/1995 - 09/30/2009	06/28/2004 - 09/30/2009	06/28/2004 - 09/30/2009	Stage Discharge, bottom conductance bottom temperature
02310688 SE Fork Homosassa Spring	09/29/2003 - 09/30/2008	10/01/2000 - 09/30/2008	05/03/2006 - 09/30/2008	05/03/2006 - 09/30/2008	Stage Discharge, bottom conductance bottom temperature
02310690 Hall River	—	06/20/2006 - 09/30/2008	06/20/2006 - 09/30/2008	06/20/2006 - 09/30/2008	Stage bottom conductance bottom temp

* All gauge height datum are converted to NAVD88

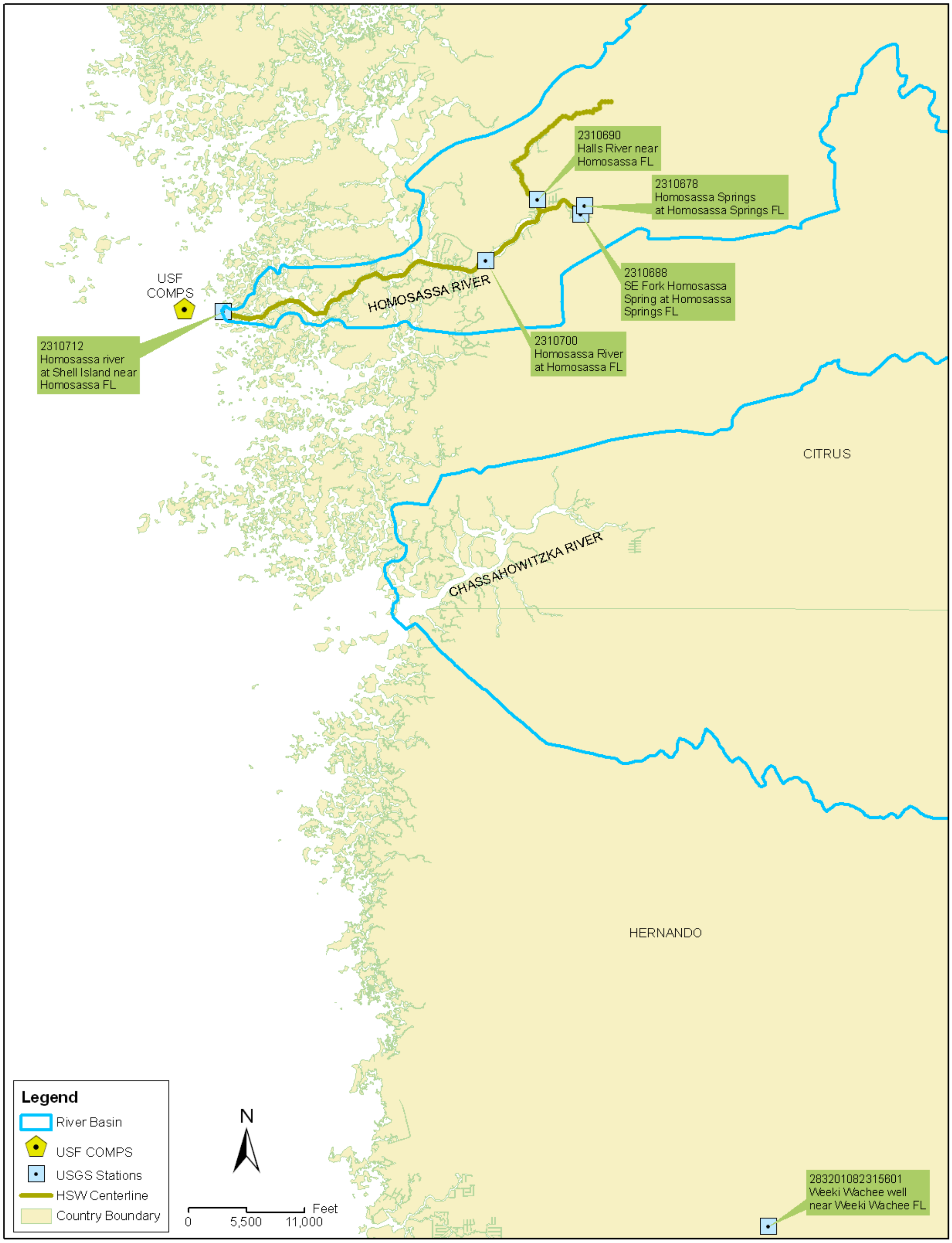


Figure A-1. Homosassa River and USGS gauging stations

Appendix B

Investigation Summary of USGS Gage Datum and Spring Flow Calculation

The USGS maintains five gauging stations within the study area at which stage is measured. In addition, discharge is reported for three of the gauging stations based on the following stream-gauging methods which were discussed with Dave Fulcher (USGS-Tampa) on May 1, 2009.

Homosassa Springs at Homosassa (02310678):

The current rating curve for the spring discharge reported at this station is represented by the equation:

$$Q = 90.8162 + 3.823(GW) - 20.3771(GH) \quad \text{(B-1)}$$

where

Q = spring discharge measurement (cfs),
GW = maximum daily groundwater level measured at the Floridan aquifer monitor well Weeki Wachee Well at Weeki Wachee (283201082315601) on the day of the discharge measurement used for the rating (ft NGVD29), and
GH = 15-minute gauge height of the river stage recorded at the time of the discharge measurement used for the rating, in feet relative to a gauge datum that is 2.99 feet below NAVD88.

Discharge measurements are made quarterly to characterize the rating. Measurements used to be made using conventional, Price-AA current meters deployed simultaneously by three people wading to minimize the measurement time. An acoustic doppler current profiler (ADCP) is now used. According to Mr. Fulcher, the standard error of the rating is approximately 15 percent, and no shifts have been applied during the rating analysis.

Although the rating curve in equation B-1 was developed using the maximum daily groundwater level measured at the Weeki Wachee well, the 15-minute discharge is calculated using the concurrent 1-hour groundwater level recorded at the Weeki Wachee monitor well and the 15-minute stage recorded at the spring. The average daily flow reported for the station is the average of 96 unit values of discharge calculated at 15-minute intervals during the day. During periods when unit discharge cannot be calculated using equation B-1, spring discharge is estimated from hydrographic comparison with nearby spring gauge(s).

SE Fork Homosassa Spring at Homosassa (02310688):

The current rating curve for the spring discharge reported at this station is represented by the equation:

$$Q = 18.63 + 3.31(GW) - 10.31(GH) - 418.14(dS/dt) \quad \text{(B-2)}$$

where

Q = spring discharge (cfs),
GW = maximum daily groundwater level measured at the Floridan aquifer monitor well 283201082315601 (Weeki Wachee at Weeki Wachee) on the day of the discharge

measurement used for the rating (ft NGVD29),
GH = 15-minute gauge height of the river recorded at the time of the discharge measurement used for the rating (ft NGVD29), and
dS/dt = change in river stage during a 15-minute period (ft).

The rating is maintained and average daily flow is calculated using the same methods as for the Homosassa Springs station, although the standard error of the SE Fork station's rating is somewhat higher.

Homosassa River at Homosassa (02310700):

Discharge at this station is currently determined using the index-velocity method and the following equations:

$$Q = V_m * A \quad \text{(B-3)}$$

$$V_m = 0.00902154 + 0.9019V_i + 0.12138V_i^2 + 0.045375(GH) \quad \text{(B-4)}$$

$$A = 0.9749(GH)^2 + 214.94(GH) + 1806.4 \quad \text{(B-5)}$$

where

Q = river discharge (cfs),
A = area of channel cross section at the gauge (ft^2),
V_m = average velocity in the channel cross section at the gauge (ft/s),
V_i = average velocity in channel measured during a 2-minute period by an "uplooking" acoustic velocity meter anchored on the channel bottom near the gauge (ft/s), and
GH = 15-minute gauge height of the river recorded at the time of the discharge measurement used for the rating, in ft NGVD29 (see follow section regarding gauge datum).

Discharge measurements are now made quarterly using an ADCP to characterize the rating. Measurements used to be made every 6 months using a conventional, Price-AA current meter deployed by boat. A relationship between gauge height and channel cross-sectional area was determined by field survey and data collected during discharge measurements.

The average daily flow reported for the station is the average of 96 unit values of discharge calculated at 15-minute intervals during the day based on the 15-minute stage and index velocity recordings. During periods when unit discharge cannot be calculated using equations B-3, B-4, and B-5, discharge is estimated from hydrographic comparison with nearby gauging stations.

The average daily flows determined in this manner are referred to as "unfiltered" flows which represent actual river discharge and the combined influences of freshwater inflow and tide.

The unfiltered unit (i.e. 15-minute) discharges are then post-processed and adjusted using a numerical filtering algorithm to reduce (ideally to eliminate) the influence of tide. A Butterworth filter was used prior to water year 2007, and a Godin filter has subsequently been used to determine records published as "filtered" daily flow.

Gauge Datum

Inconsistencies in gauge datum reported by the USGS were discovered for several stations during the process of evaluating historic stage data that would be used to calibrate the hydrodynamic model. Our findings are summarized below since it is not known whether the historic stage records maintained by the USGS will be adjusted and republished to common datum.

Station	Gauge Height Datum
Homosassa Springs	2.99 feet below NAVD88
SE Fork Homosassa Springs	NGVD29
Halls River near Homosassa	NAVD88
Homosassa River at Homosassa	1.492 feet below NGVD29
Homosassa River at Shell Island	Recently republished to NAVD88; historic stage records appeared to be 11.61 feet below NAVD88
Weeki Wachee Well	NGVD29

In general, stages in this area referenced to NAVD88 can be adjusted by adding 0.81 feet to convert to stages referenced to NGVD29. This adjustment factor was determined using the Corpscon (Version 6.0) software.

Appendix C

River Volume and Bottom Area Calculation

Homosassa River Volume and Area Calculation

Source & Tools

- Homosassa River centerline and associated river kilometer (RKM) (Figure C-1) based on the SWFWMD's and USF's centerlines. RKMs represent the distance along the centerline from river mouth to specified locations
- Shoreline Mapping and Bathymetric Survey (Figure C-2) provided by USF through SWFWMD
- ArcGIS 9.2 with the 3D Analyst extension was used to create TIN domain (Figure C-3) to provide data for further processing in SURFER 8.0

Datum

- North American Vertical Datum of 1988 (NAVD88)

Description

Elevation-based volume and area calculation

- Elevation-based volume and area were calculated separately for Homosassa River main channel and Halls River (Tables C-1 and C-2 and Figures C-4 and C-5)
- Volume and bottom area represent the volumetric water (in cubic meter) and river bottom area (in square meter) under a plane of the zero-meter elevation
- Both volume and bottom area were calculated in a 0.5-meter increment from the zero-elevation to a 6.5-meter elevation below zero-meter NAVD88 for Homosassa River main channel and to a 2.5-meter below the datum for Halls River

River reach-based volume and area calculation

- 12 sets of tables and graphs (Tables C-3 to C-14 and Figures C-6 to C-17) were prepared for volume and bottom area for a range of surface water elevations from 0.0 to -5.5 m-NAVD88 depending on river reach
- Volume and bottom area represent the volumetric water (in cubic meters) and river bottom area (in square meters) under the selected elevation plane, respectively, for each river reach
- 36 river reaches were defined. Each river reach represents a segment of river from a specified RKM to the most upstream point (headsprings) within the river channel from mouth RKM 0.0 to RKM 12.4,
- Each river reach shifts upstream by a 0.5-km increment from RKM 0.0 to RKM 9.0 and by a 0.2-km increment from RKM 9.0 to RKM 12.4. Therefore, volume and bottom area are accumulative

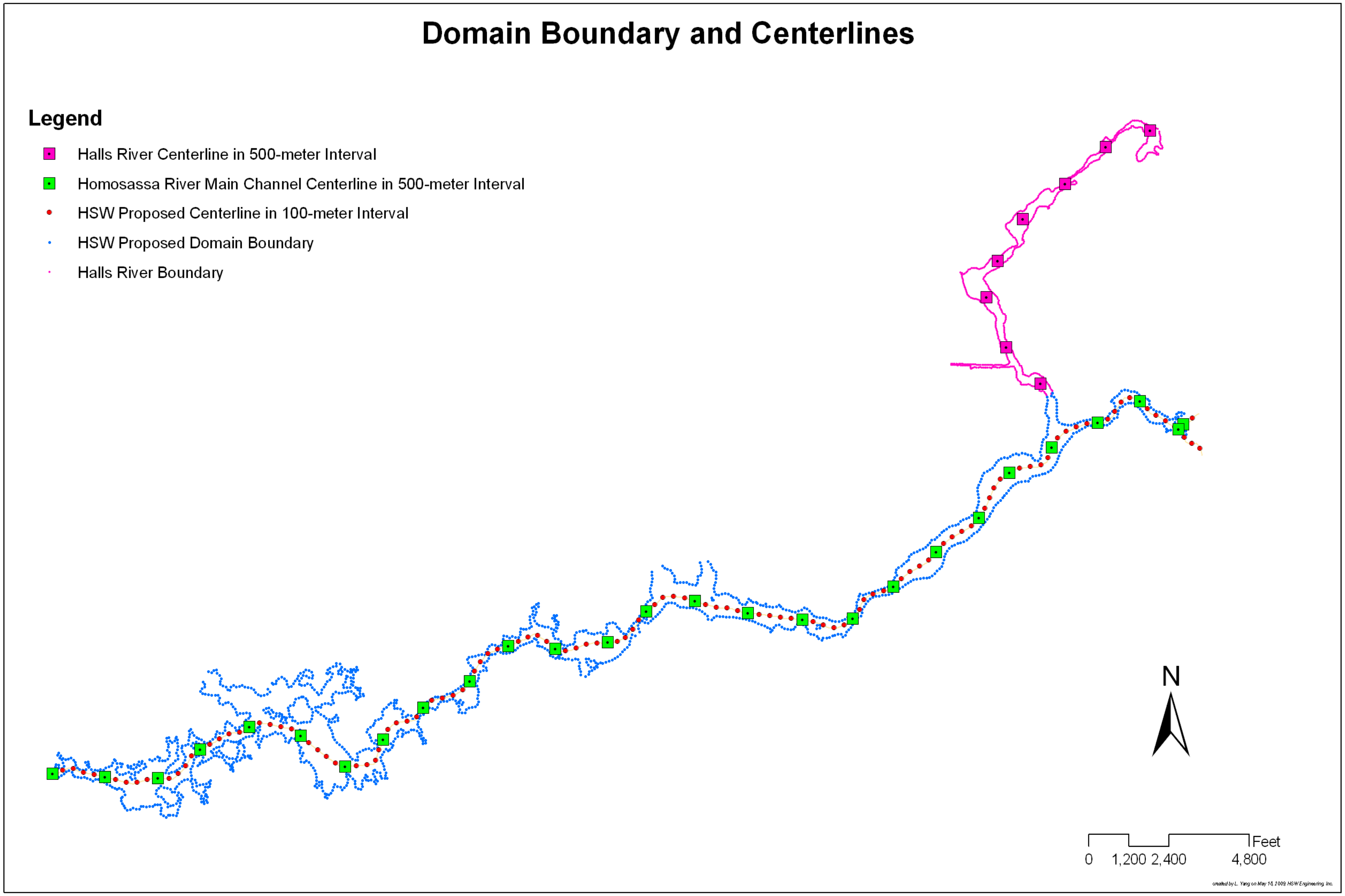


Figure C-1. Domain boundary and centerline with respect of volume and bottom area calculation

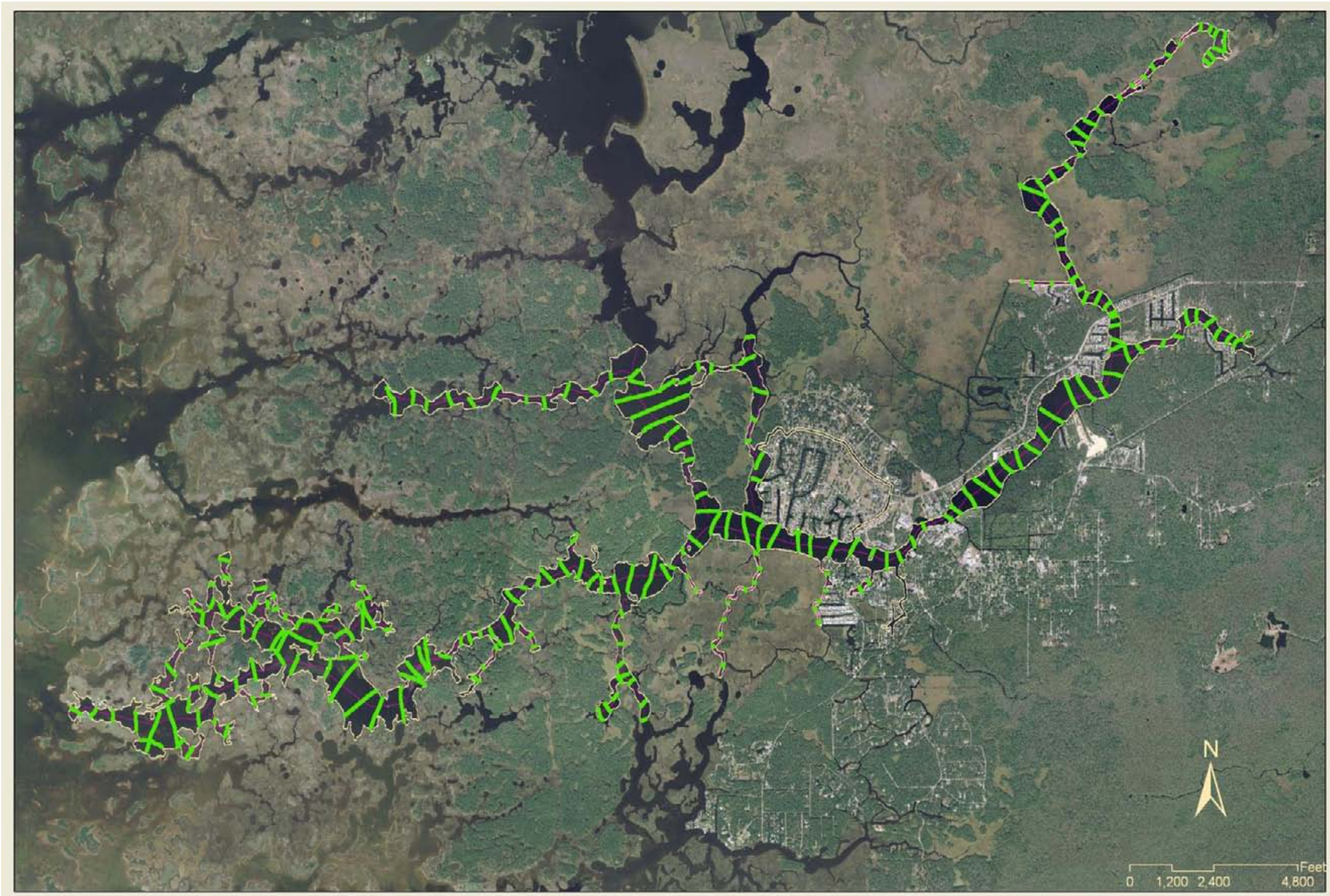


Figure C-2. Bathymetric survey map (Data from University of South Florida through SWFWMD)

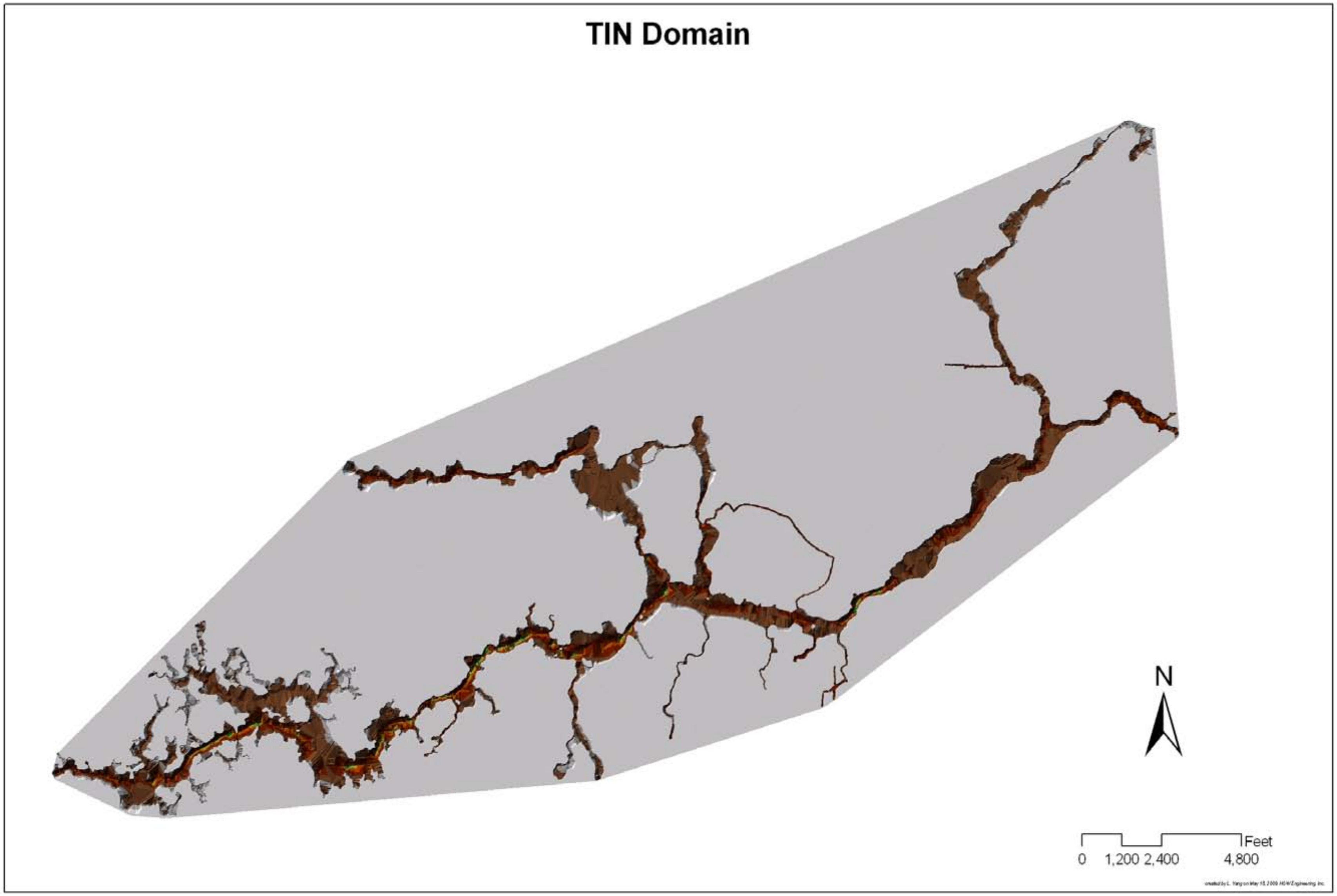


Figure C-3. TIN domain created using bathymetry data

Table C-1. Homosassa River main channel elevation-based volume and area calculation

Elevation (m)	Bottom Area (m^2)	Volume (m^3)
-6.5	-	-
-6.0	-	-
-5.5	175	29
-5.0	640	206
-4.5	3,939	1,151
-4.0	17,688	5,683
-3.5	56,792	22,954
-3.0	129,259	67,385
-2.5	255,190	159,608
-2.0	483,121	338,410
-1.5	901,516	671,289
-1.0	1,725,290	1,317,682
-0.5	2,447,172	2,371,647
0.0	2,761,195	3,680,316

- not available

Table C-2. Halls River elevation-based volume and area calculation

Elevation (m)	Bottom Area (m^2)	Volume (m^3)
-2.5	-	-
-2.0	856	76
-1.5	12,225	2,783
-1.0	48,507	15,838
-0.5	297,860	109,198
0.0	340,848	269,290

- not available

Figure C-4. Homosassa River Main Channel Elevation-based Volume & Area

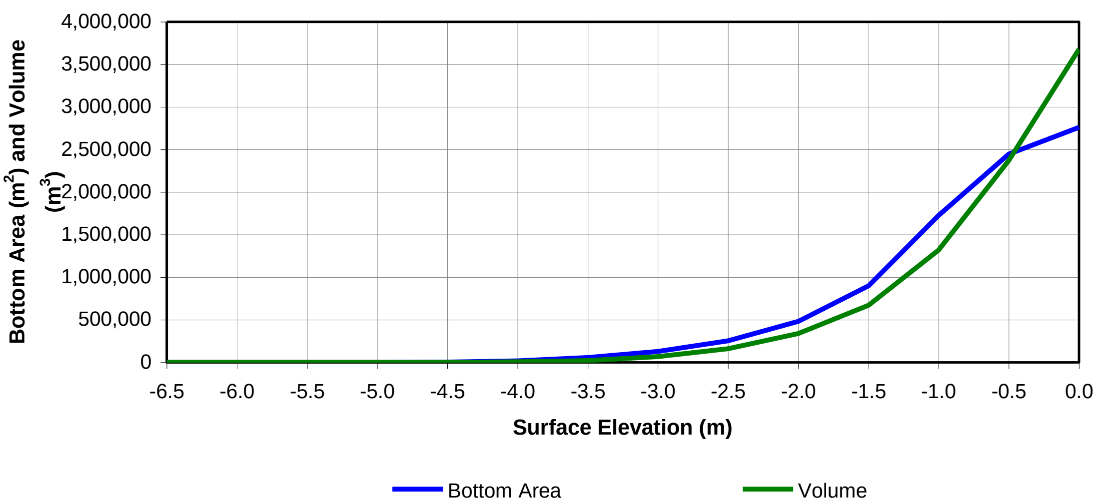


Figure C-5. Halls River Elevation-Based Volume & Area

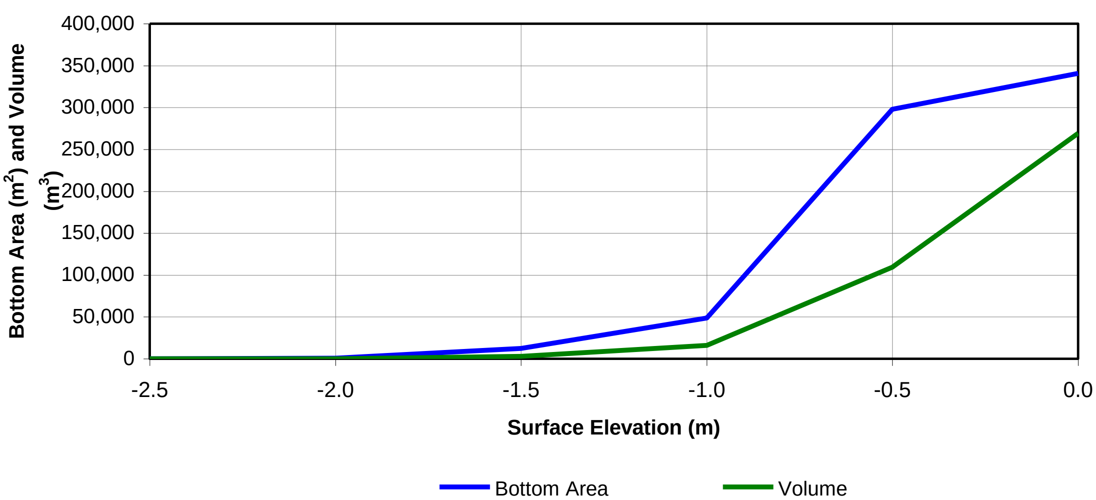


Table C-3. Homosassa River main channel reach-based volume and area calculation (Elevation = 0.0 m-NAVD88)

Reach	RKM	Bottom Area (m^2)	Volume (m^3)
1	0.0	2,761,195	3,680,316
2	0.5	2,715,615	3,622,086
3	1.0	2,529,471	3,412,375
4	1.5	2,303,206	3,213,369
5	2.0	2,102,468	2,977,875
6	2.5	1,926,328	2,725,328
7	3.0	1,623,134	2,423,062
8	3.5	1,520,102	2,242,988
9	4.0	1,419,779	2,084,826
10	4.5	1,339,784	1,958,880
11	5.0	1,288,469	1,844,367
12	5.5	1,201,277	1,688,611
13	6.0	1,080,690	1,486,623
14	6.5	992,599	1,356,053
15	7.0	862,457	1,159,127
16	7.5	732,569	987,733
17	8.0	642,781	874,120
18	8.5	555,765	767,646
19	9.0	522,663	693,058
20	9.2	495,496	657,598
21	9.4	449,131	608,471
22	9.6	410,810	564,592
23	9.8	378,569	513,046
24	10.0	349,566	472,910
25	10.2	318,931	427,992
26	10.4	268,599	368,174
27	10.6	217,663	307,000
28	10.8	179,052	255,524
29	11.0	150,309	217,295
30	11.2	112,092	173,028
31	11.4	82,513	151,609
32	11.6	81,681	138,909
33	11.8	71,012	124,584
34	12.0	47,516	84,693
35	12.2	28,108	43,988
36	12.4	6,498	7,006

Figure C-6
Homosassa River Main Channel Reach-based Volume & Area
(Elevation = 0.0 m-NAVD88)

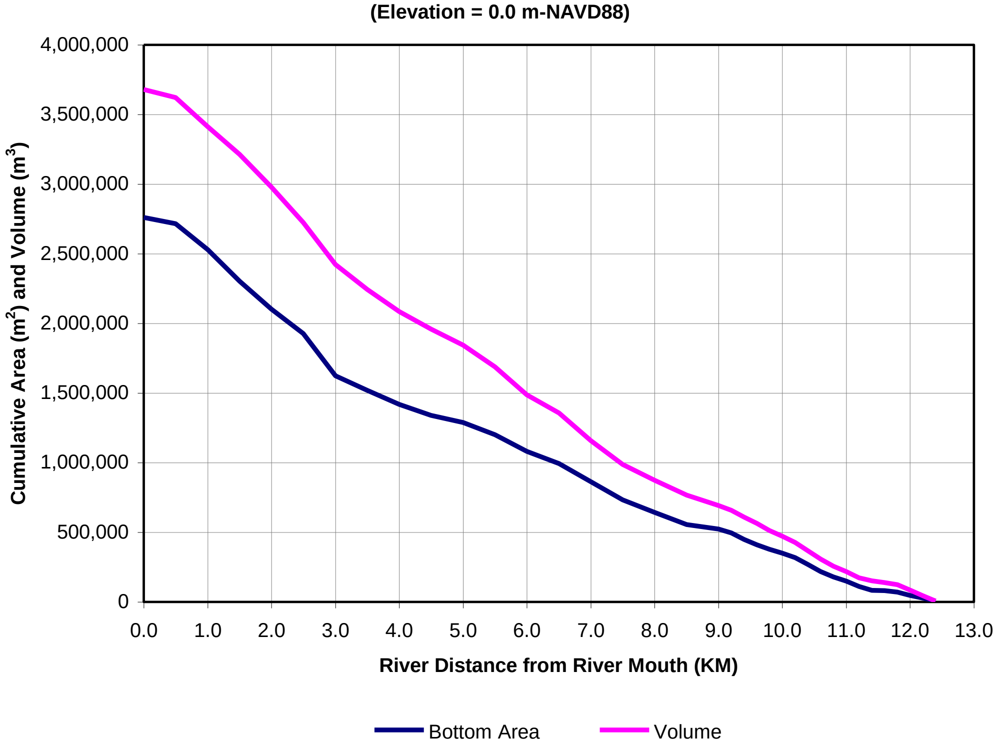


Table C-4. Homosassa River main channel reach-based volume and area calculation (Elevation = -0.5 m-NAVD88)

Reach	RKM	Bottom Area (m^2)	Volume (m^3)
1	0.0	2,447,172	2,371,647
2	0.5	2,410,515	2,334,184
3	1.0	2,249,629	2,211,895
4	1.5	2,081,860	2,115,560
5	2.0	1,912,183	1,973,960
6	2.5	1,744,986	1,808,170
7	3.0	1,483,917	1,648,698
8	3.5	1,386,564	1,519,003
9	4.0	1,299,714	1,407,359
10	4.5	1,229,406	1,318,656
11	5.0	1,184,919	1,227,865
12	5.5	1,108,007	1,112,398
13	6.0	995,525	968,750
14	6.5	924,810	877,607
15	7.0	804,659	742,844
16	7.5	682,782	634,519
17	8.0	598,768	564,317
18	8.5	523,492	498,265
19	9.0	493,161	439,281
20	9.2	467,572	416,969
21	9.4	422,995	390,554
22	9.6	386,776	365,348
23	9.8	356,197	329,478
24	10.0	328,840	303,447
25	10.2	300,019	273,376
26	10.4	251,945	238,159
27	10.6	202,933	201,965
28	10.8	165,862	169,437
29	11.0	137,202	145,565
30	11.2	101,134	119,702
31	11.4	84,833	107,433
32	11.6	75,514	99,724
33	11.8	65,178	90,682
34	12.0	43,786	61,977
35	12.2	24,760	30,853
36	12.4	5,321	4,048

Figure C-7
Homosassa River Main Channel Reach-based Volume & Area
(Elevation = -0.5 m-NAVD88)

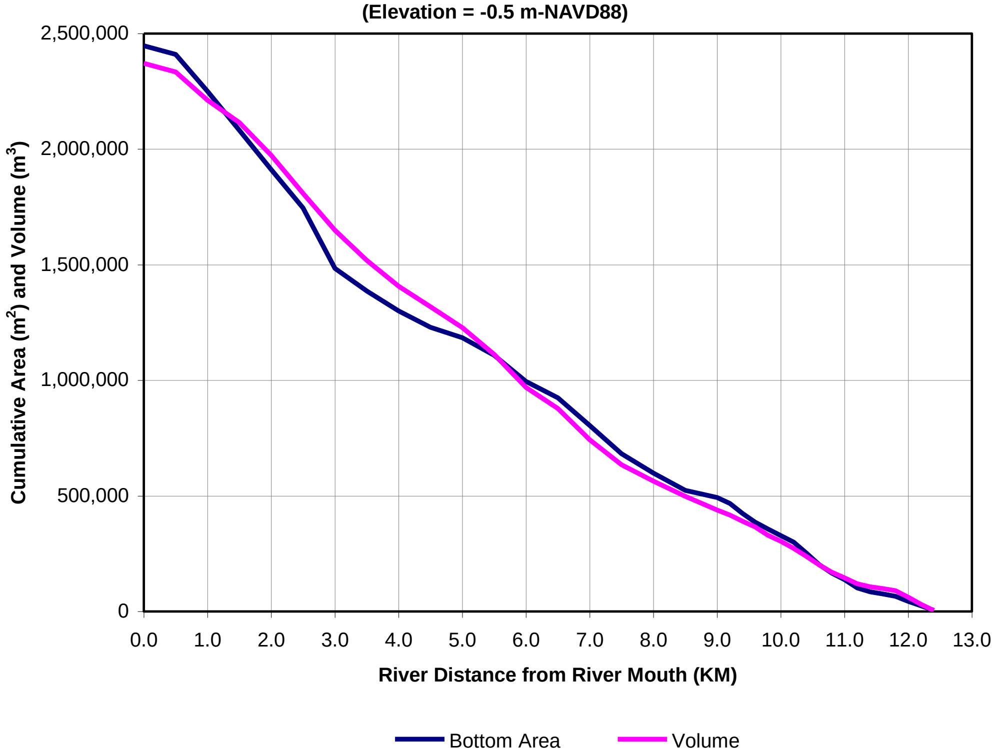


Table C-5. Homosassa River main channel reach-based volume and area calculation (Elevation = -1.0 m-NAVD88)

Reach	RKM	Bottom Area (m^2)	Volume (m^3)
1	0.0	1,725,290	1,317,682
2	0.5	1,696,715	1,296,400
3	1.0	1,597,244	1,239,865
4	1.5	1,539,248	1,192,462
5	2.0	1,441,744	1,114,347
6	2.5	1,323,309	1,023,289
7	3.0	1,199,316	962,429
8	3.5	1,125,509	876,027
9	4.0	1,058,633	803,418
10	4.5	1,005,761	746,315
11	5.0	965,610	676,487
12	5.5	900,502	596,186
13	6.0	801,092	505,807
14	6.5	749,293	445,439
15	7.0	646,969	367,059
16	7.5	548,349	315,193
17	8.0	480,542	283,942
18	8.5	426,832	251,589
19	9.0	399,233	206,895
20	9.2	381,245	196,301
21	9.4	355,245	190,177
22	9.6	330,835	181,645
23	9.8	303,837	160,419
24	10.0	280,299	147,425
25	10.2	255,711	130,950
26	10.4	216,606	118,486
27	10.6	172,975	105,984
28	10.8	142,794	90,995
29	11.0	117,594	81,035
30	11.2	88,386	72,089
31	11.4	75,168	67,362
32	11.6	67,673	63,870
33	11.8	58,372	59,810
34	12.0	39,093	41,264
35	12.2	20,830	19,447
36	12.4	4,048	1,722

Figure C-8
Homosassa River Main Channel Reach-based Volume & Area
(Elevation = -1.0 m-NAVD88)

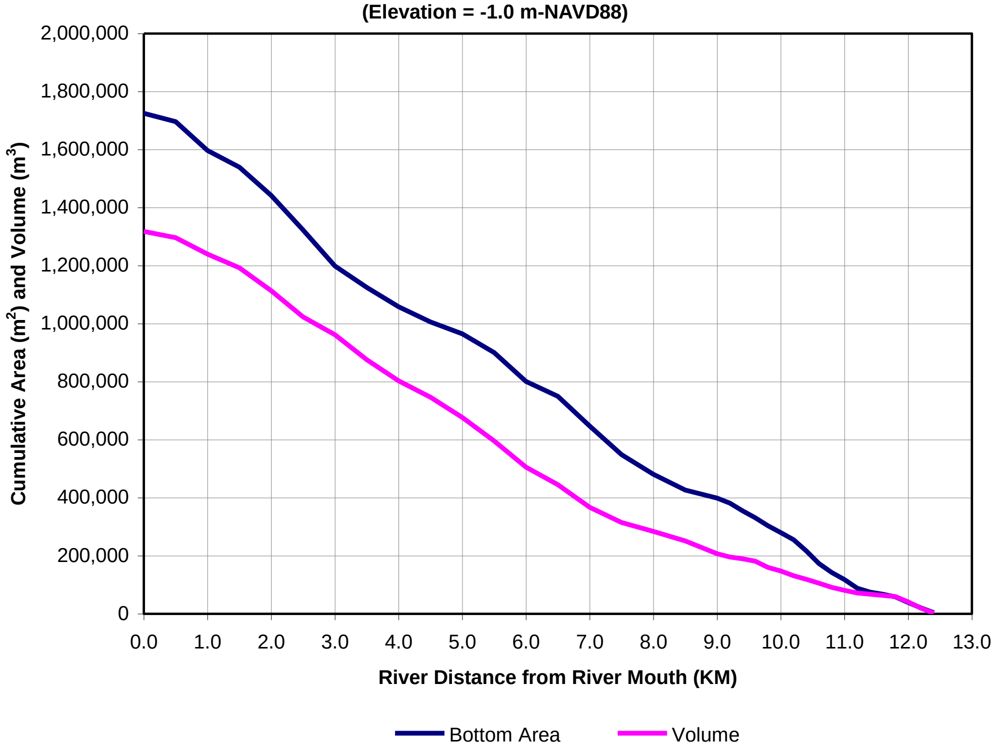


Table C-6. Homosassa River main channel reach-based volume and area calculation (Elevation = -1.5 m-NAVD88)

Reach	RKM	Bottom Area (m^2)	Volume (m^3)
1	0.0	901,516	671,289
2	0.5	882,774	661,857
3	1.0	843,292	639,301
4	1.5	808,597	614,391
5	2.0	761,880	572,260
6	2.5	705,538	523,290
7	3.0	659,081	499,361
8	3.5	606,218	444,741
9	4.0	561,706	399,274
10	4.5	523,451	364,344
11	5.0	488,593	313,380
12	5.5	439,720	261,532
13	6.0	371,474	214,601
14	6.5	332,575	176,463
15	7.0	277,150	137,282
16	7.5	231,052	122,080
17	8.0	207,393	113,575
18	8.5	181,465	100,063
19	9.0	157,336	68,393
20	9.2	149,513	63,303
21	9.4	145,731	62,763
22	9.6	141,669	61,219
23	9.8	121,308	51,742
24	10.0	107,874	48,388
25	10.2	92,187	42,024
26	10.4	85,538	40,993
27	10.6	82,929	40,800
28	10.8	69,852	36,917
29	11.0	61,679	35,678
30	11.2	56,696	35,247
31	11.4	53,412	34,946
32	11.6	50,236	34,199
33	11.8	46,912	33,255
34	12.0	31,296	23,516
35	12.2	14,947	10,433
36	12.4	1,324	218

Figure C-9
Homosassa River Main Channel Reach-based Volume & Area
(Elevation = -1.5 m-NAVD88)

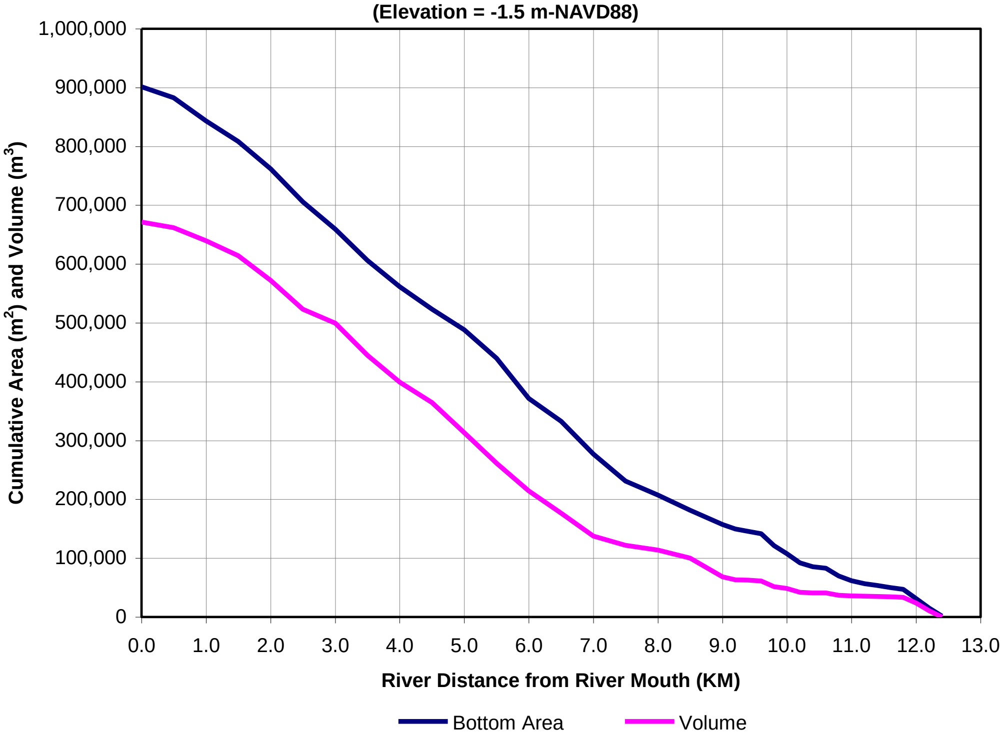


Table C-7. Homosassa River main channel reach-based volume and area calculation (Elevation = -2.0 m-NAVD88)

Reach	RKM	Bottom Area (m^2)	Volume (m^3)
1	0.0	483,121	338,410
2	0.5	474,647	335,706
3	1.0	456,769	326,190
4	1.5	436,919	314,792
5	2.0	409,027	289,308
6	2.5	374,783	262,573
7	3.0	355,041	254,592
8	3.5	316,318	222,627
9	4.0	283,270	196,454
10	4.5	255,918	177,826
11	5.0	225,992	142,922
12	5.5	193,397	110,893
13	6.0	158,884	89,187
14	6.5	130,508	67,878
15	7.0	102,572	49,091
16	7.5	95,418	46,755
17	8.0	88,386	45,024
18	8.5	78,225	40,501
19	9.0	57,844	19,664
20	9.2	52,921	17,730
21	9.4	52,828	17,725
22	9.6	51,520	17,369
23	9.8	42,516	15,229
24	10.0	40,670	14,982
25	10.2	34,579	14,050
26	10.4	34,579	14,044
27	10.6	34,579	14,044
28	10.8	31,739	13,735
29	11.0	31,689	13,729
30	11.2	31,689	13,729
31	11.4	31,701	13,722
32	11.6	31,615	13,723
33	11.8	30,990	13,640
34	12.0	21,032	10,382
35	12.2	9,256	4,423
36	12.4	1	0

Figure C-10
Homosassa River Main Channel Reach-based Volume & Area
(Elevation = -2.0 m-NAVD88)

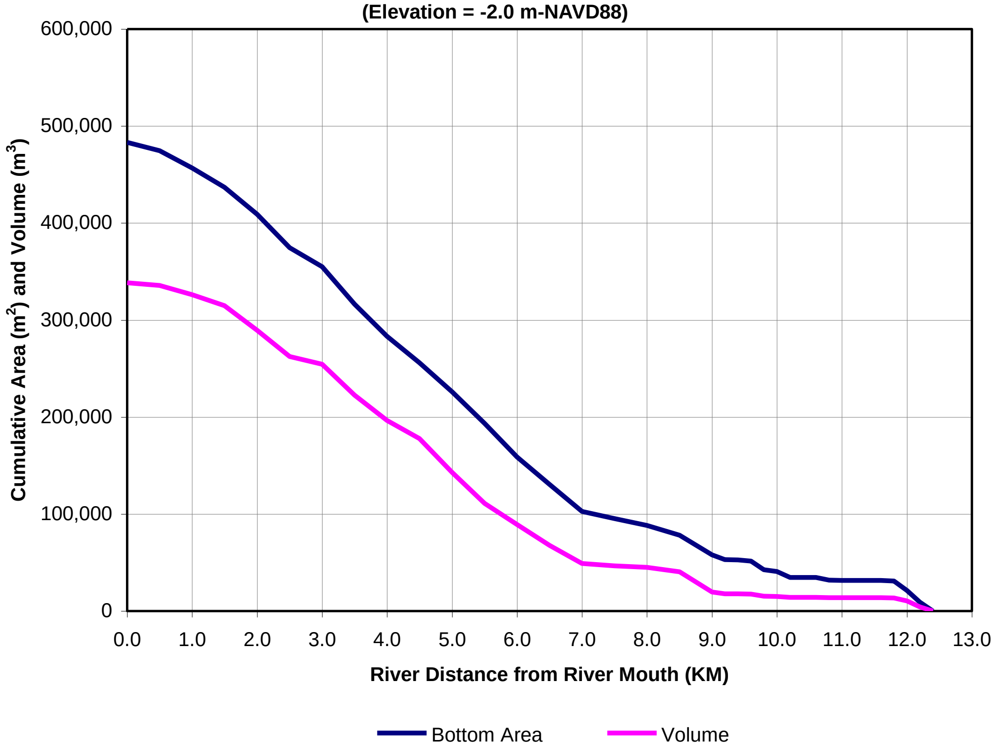


Table C-8. Homosassa River main channel reach-based volume and area calculation (Elevation = -2.5 m-NAVD88)

Reach	RKM	Bottom Area (m^2)	Volume (m^3)
1	0.0	255,190	159,608
2	0.5	253,126	159,277
3	1.0	245,304	155,998
4	1.5	236,118	151,735
5	2.0	216,564	138,011
6	2.5	196,211	124,691
7	3.0	189,510	122,643
8	3.5	164,784	106,463
9	4.0	142,592	94,156
10	4.5	128,185	86,010
11	5.0	103,401	64,741
12	5.5	80,896	46,358
13	6.0	63,907	37,040
14	6.5	47,188	26,996
15	7.0	34,335	17,798
16	7.5	32,766	17,221
17	8.0	32,024	17,137
18	8.5	28,642	15,828
19	9.0	12,845	4,037
20	9.2	11,266	3,717
21	9.4	11,266	3,717
22	9.6	11,133	3,711
23	9.8	10,108	3,679
24	10.0	10,708	3,686
25	10.2	10,706	3,686
26	10.4	10,706	3,686
27	10.6	10,706	3,686
28	10.8	10,711	3,688
29	11.0	10,706	3,686
30	11.2	10,706	3,686
31	11.4	10,706	3,678
32	11.6	10,706	3,686
33	11.8	10,706	3,686
34	12.0	8,624	3,203
35	12.2	3,723	1,217
36	12.4	-	-

- not available

Figure C-11
Homosassa River Main Channel Reach-based Volume & Area
(Elevation = -2.5 m-NAVD88)

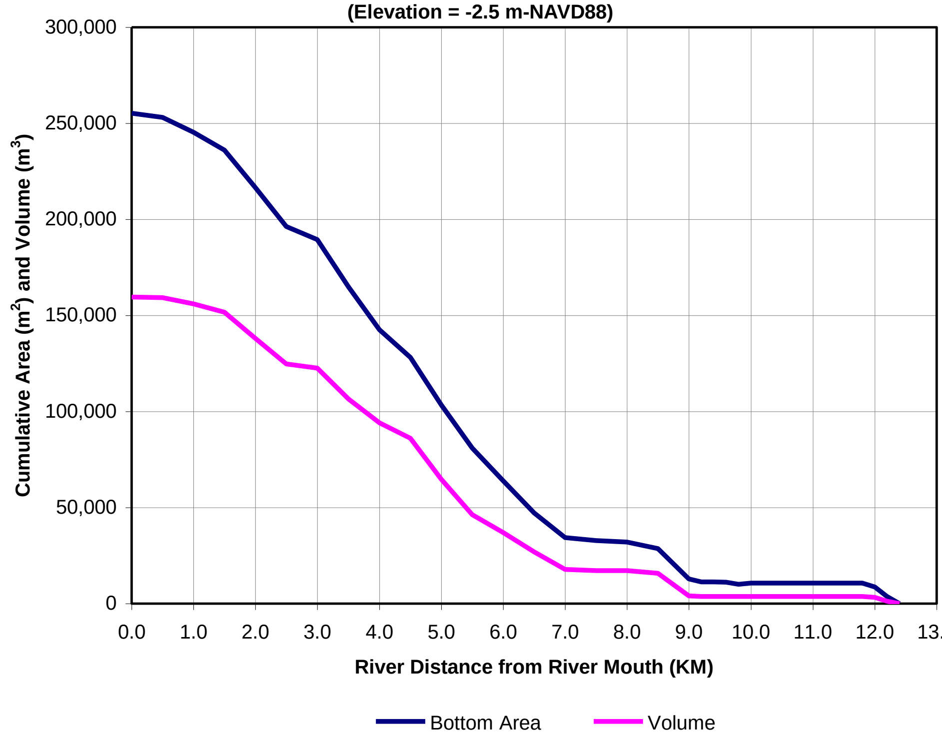


Table C-9. Homosassa River main channel reach-based volume and area calculation (Elevation = -3.0 m-NAVD88)

Reach	RKM	Bottom Area (m^2)	Volume (m^3)
1	0.0	129,259	67,385
2	0.5	129,266	67,395
3	1.0	126,425	66,579
4	1.5	122,767	65,262
5	2.0	111,460	59,224
6	2.5	100,623	53,630
7	3.0	99,166	53,405
8	3.5	85,407	46,668
9	4.0	75,046	42,331
10	4.5	67,591	39,270
11	5.0	49,842	28,706
12	5.5	35,797	19,096
13	6.0	27,914	15,670
14	6.5	20,193	11,333
15	7.0	14,342	6,533
16	7.5	13,886	6,438
17	8.0	13,993	6,441
18	8.5	12,719	6,129
19	9.0	2,988	614
20	9.2	2,887	605
21	9.4	2,887	605
22	9.6	2,887	605
23	9.8	2,878	599
24	10.0	2,887	605
25	10.2	2,887	605
26	10.4	2,887	605
27	10.6	2,887	605
28	10.8	2,887	605
29	11.0	2,887	605
30	11.2	2,887	605
31	11.4	2,887	605
32	11.6	2,887	605
33	11.8	2,887	605
34	12.0	2,684	589
35	12.2	947	140
36	12.4	-	-

- not available

Figure C-12
Homosassa River Main Channel Reach-based Volume & Area
(Elevation = -3.0 m-NAVD88)

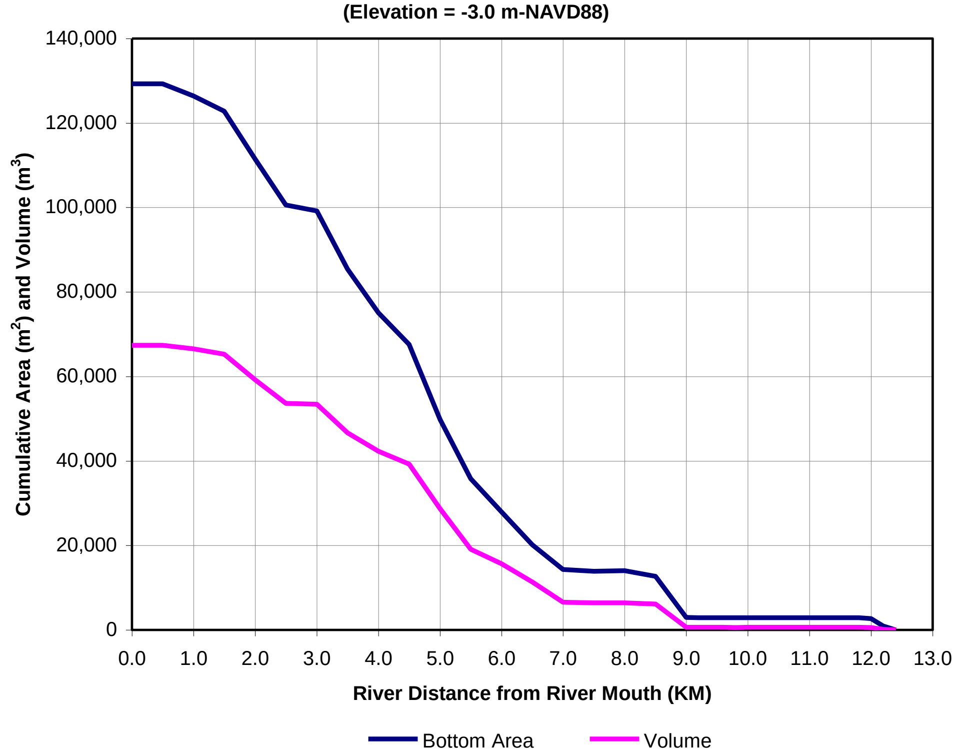


Table C-10. Homosassa River main channel reach-based volume and area calculation (Elevation = -3.5 m-NAVD88)

Reach	RKM	Bottom Area (m^2)	Volume (m^3)
1	0.0	56,792	22,954
2	0.5	56,802	22,961
3	1.0	56,198	22,840
4	1.5	55,072	22,673
5	2.0	49,704	20,591
6	2.5	45,011	18,639
7	3.0	45,011	18,639
8	3.5	39,304	16,561
9	4.0	35,965	15,369
10	4.5	33,599	14,762
11	5.0	24,032	10,980
12	5.5	15,482	7,010
13	6.0	12,457	6,138
14	6.5	8,833	4,497
15	7.0	5,457	1,919
16	7.5	5,432	1,917
17	8.0	5,434	1,917
18	8.5	5,278	1,900
19	9.0	260	34
20	9.2	260	34
21	9.4	260	34
22	9.6	260	34
23	9.8	255	33
24	10.0	260	34
25	10.2	260	34
26	10.4	260	34
27	10.6	260	34
28	10.8	260	34
29	11.0	260	34
30	11.2	260	34
31	11.4	260	34
32	11.6	260	34
33	11.8	260	34
34	12.0	260	34
35	12.2	-	-
36	12.4	-	-

- not available

Figure C-13
Homosassa River Main Channel Reach-based Volume & Area
(Elevation = -3.5 m-NAVD88)

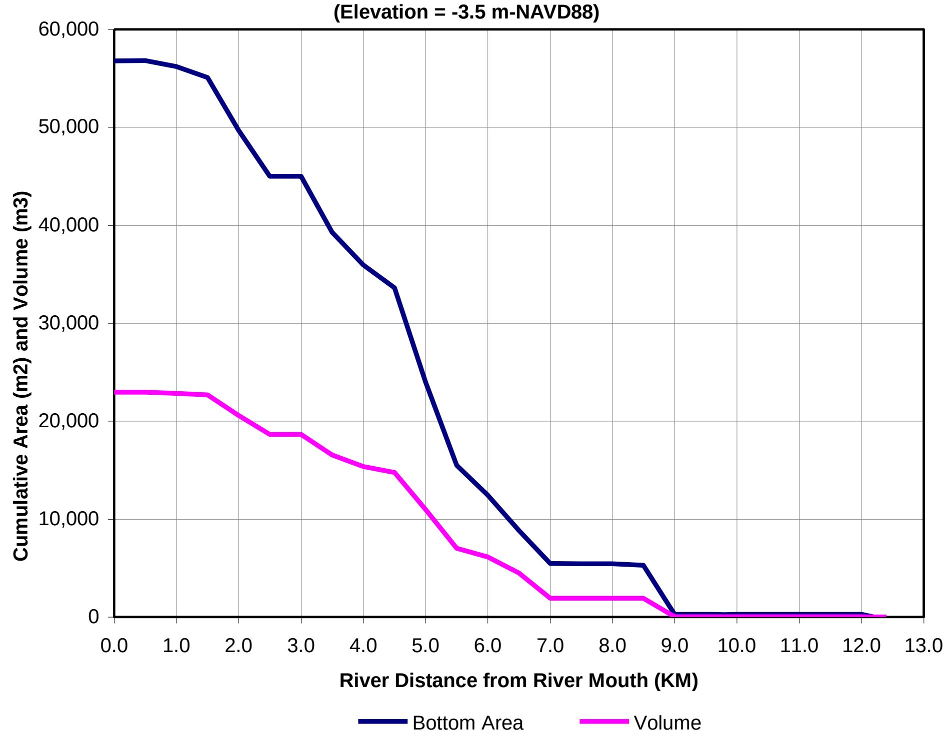


Table C-11. Homosassa River main channel reach-based volume and area calculation (Elevation = -4.0 m-NAVD88)

Reach	RKM	Bottom Area (m^2)	Volume (m^3)
1	0.0	17,688	5,683
2	0.5	17,699	5,685
3	1.0	17,694	5,684
4	1.5	17,670	5,684
5	2.0	15,916	5,308
6	2.5	14,236	4,913
7	3.0	14,236	4,913
8	3.5	12,679	4,527
9	4.0	11,835	4,234
10	4.5	11,440	4,166
11	5.0	8,666	3,225
12	5.5	5,334	2,152
13	6.0	4,813	2,125
14	6.5	3,499	1,611
15	7.0	1,535	331
16	7.5	1,535	331
17	8.0	1,535	331
18	8.5	1,535	331
19	9.0	-	-
20	9.2	-	-
21	9.4	-	-
22	9.6	-	-
23	9.8	-	-
24	10.0	-	-
25	10.2	-	-
26	10.4	-	-
27	10.6	-	-
28	10.8	-	-
29	11.0	-	-
30	11.2	-	-
31	11.4	-	-
32	11.6	-	-
33	11.8	-	-
34	12.0	-	-
35	12.2	-	-
36	12.4	-	-

- not available

Figure C-14
Homosassa River Main Channel Reach-based Volume & Area
(Elevation = -4.0 m-NAVD88)

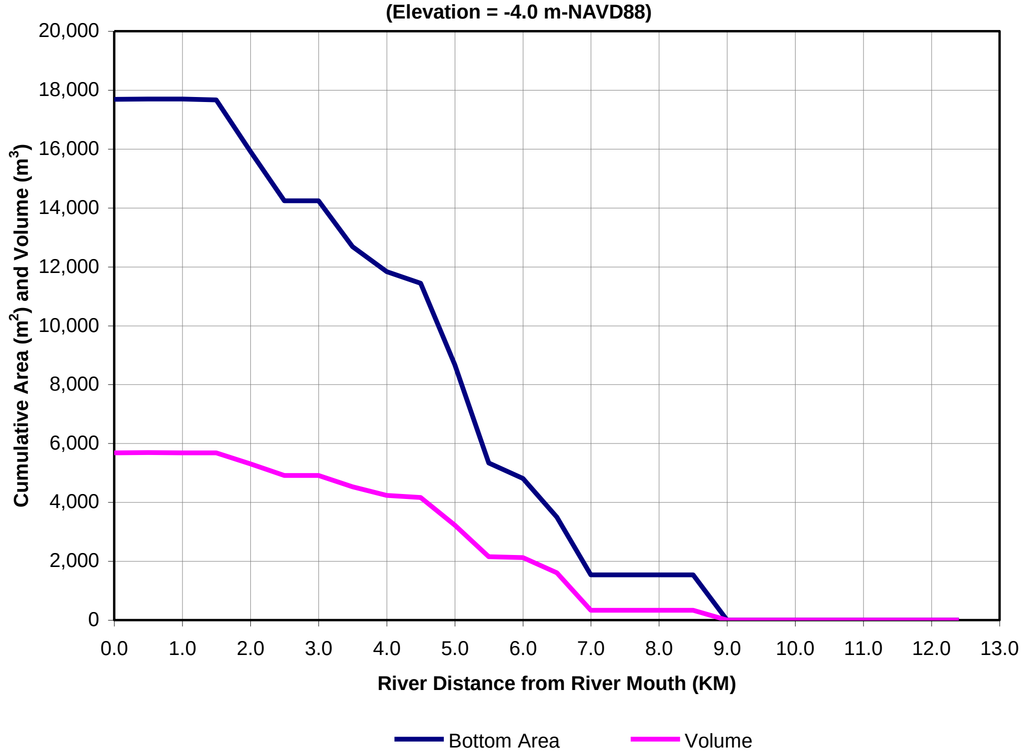


Table C-12. Homosassa River main channel reach-based volume and area calculation (Elevation = -4.5 m-NAVD88)

Reach	RKM	Bottom Area (m^2)	Volume (m^3)
1	0.0	3,939	1,151
2	0.5	3,939	1,151
3	1.0	3,939	1,151
4	1.5	3,939	1,151
5	2.0	3,939	1,151
6	2.5	3,728	1,112
7	3.0	3,728	1,112
8	3.5	3,553	1,086
9	4.0	3,293	1,044
10	4.5	3,267	1,040
11	5.0	2,500	878
12	5.5	1,627	689
13	6.0	1,627	689
14	6.5	1,228	575
15	7.0	164	25
16	7.5	164	25
17	8.0	164	25
18	8.5	164	25
19	9.0	-	-
20	9.2	-	-
21	9.4	-	-
22	9.6	-	-
23	9.8	-	-
24	10.0	-	-
25	10.2	-	-
26	10.4	-	-
27	10.6	-	-
28	10.8	-	-
29	11.0	-	-
30	11.2	-	-
31	11.4	-	-
32	11.6	-	-
33	11.8	-	-
34	12.0	-	-
35	12.2	-	-
36	12.4	-	-

- not available

Figure C-15
Homosassa River Main Channel Reach-based Volume & Area
(Elevation = -4.5 m-NAVD88)

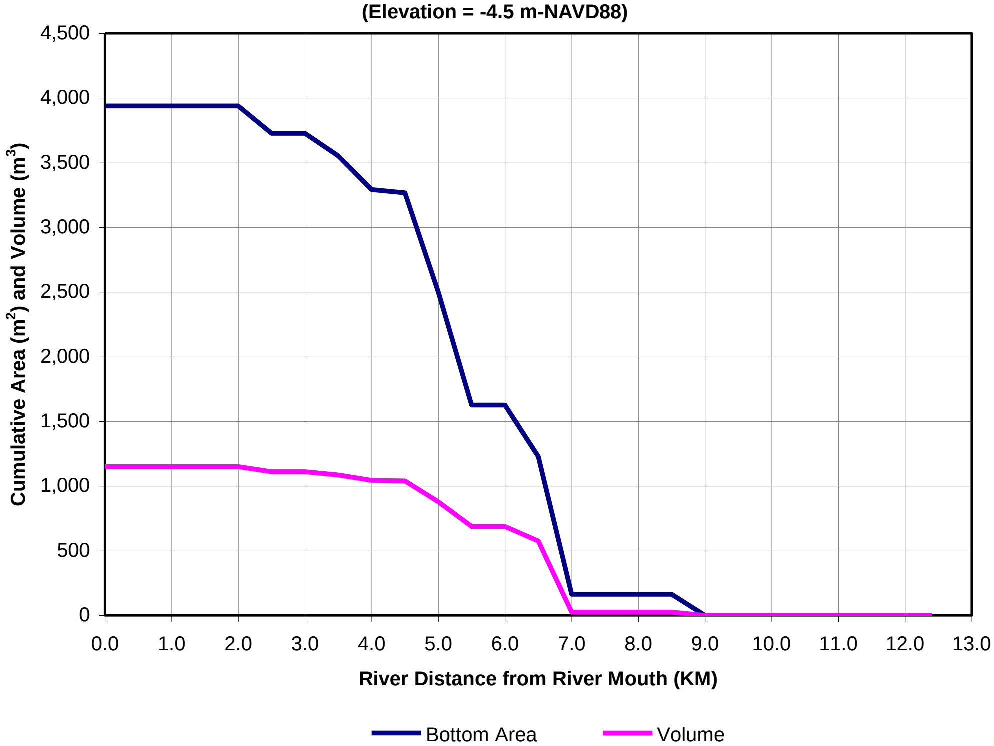
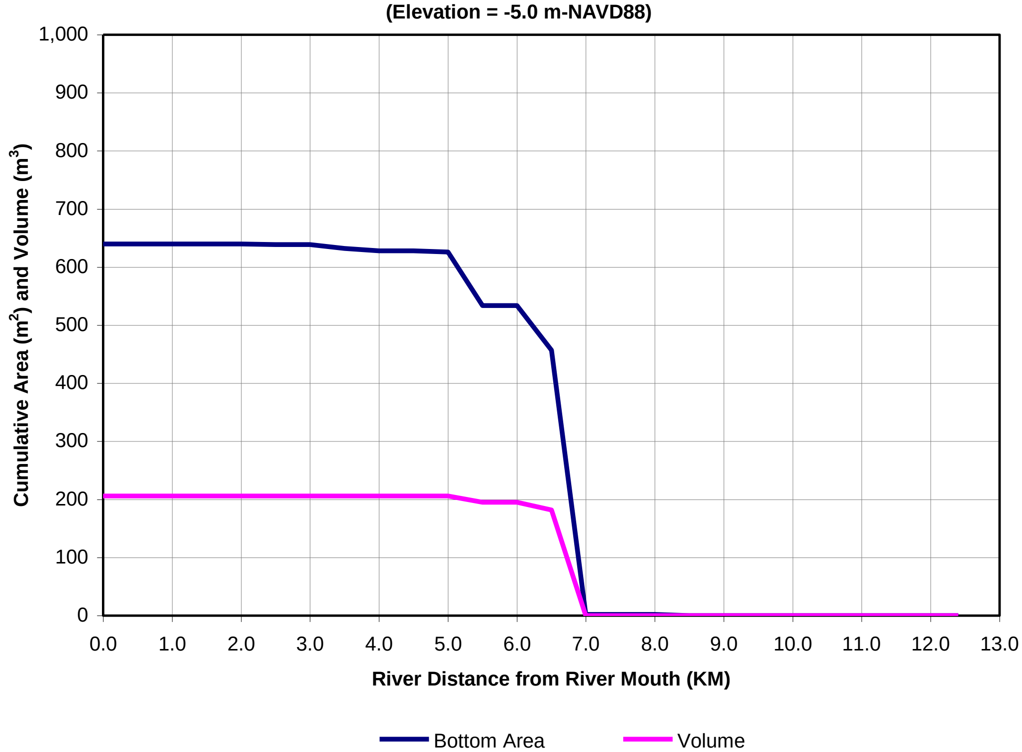


Table C-13. Homosassa River main channel reach-based volume and area calculation (Elevation = -5.0 m-NAVD88)

Reach	RKM	Bottom Area (m^2)	Volume (m^3)
1	0.0	640	206
2	0.5	640	206
3	1.0	640	206
4	1.5	640	206
5	2.0	640	206
6	2.5	639	206
7	3.0	639	206
8	3.5	632	206
9	4.0	628	206
10	4.5	628	206
11	5.0	626	206
12	5.5	534	195
13	6.0	534	195
14	6.5	457	182
15	7.0	2	0
16	7.5	2	0
17	8.0	2	0
18	8.5	-	-
19	9.0	-	-
20	9.2	-	-
21	9.4	-	-
22	9.6	-	-
23	9.8	-	-
24	10.0	-	-
25	10.2	-	-
26	10.4	-	-
27	10.6	-	-
28	10.8	-	-
29	11.0	-	-
30	11.2	-	-
31	11.4	-	-
32	11.6	-	-
33	11.8	-	-
34	12.0	-	-
35	12.2	-	-
36	12.4	-	-

- not available

Figure C-16
Homosassa River Main Channel Reach-based Volume & Area
(Elevation = -5.0 m-NAVD88)



Appendix D

30-day Moving Average Analysis

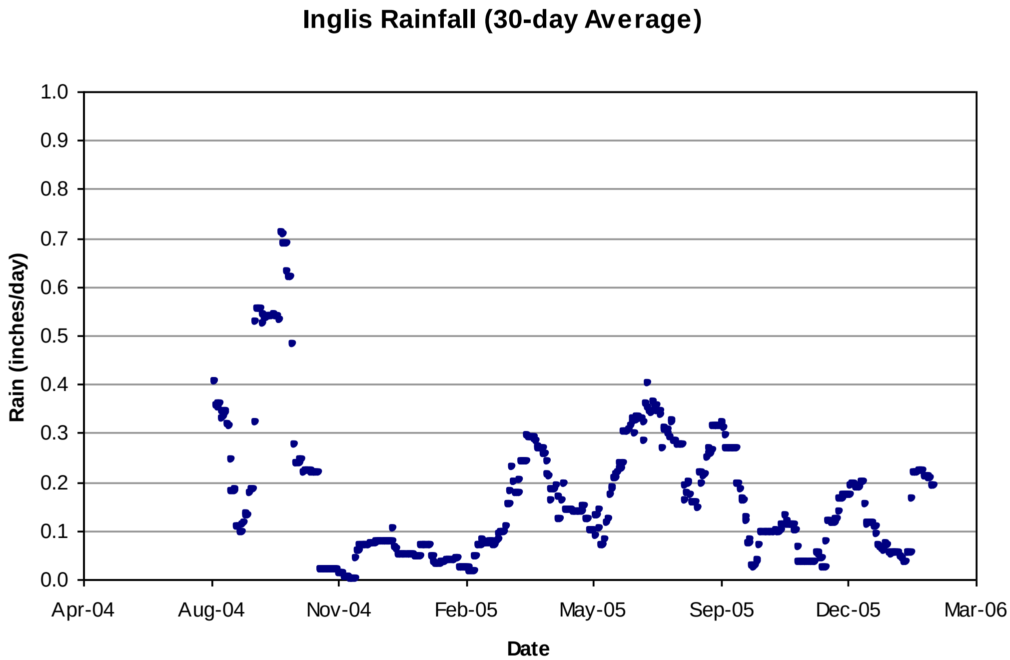


Figure D-1. 30-day moving average for daily rainfall at Inglis, FL

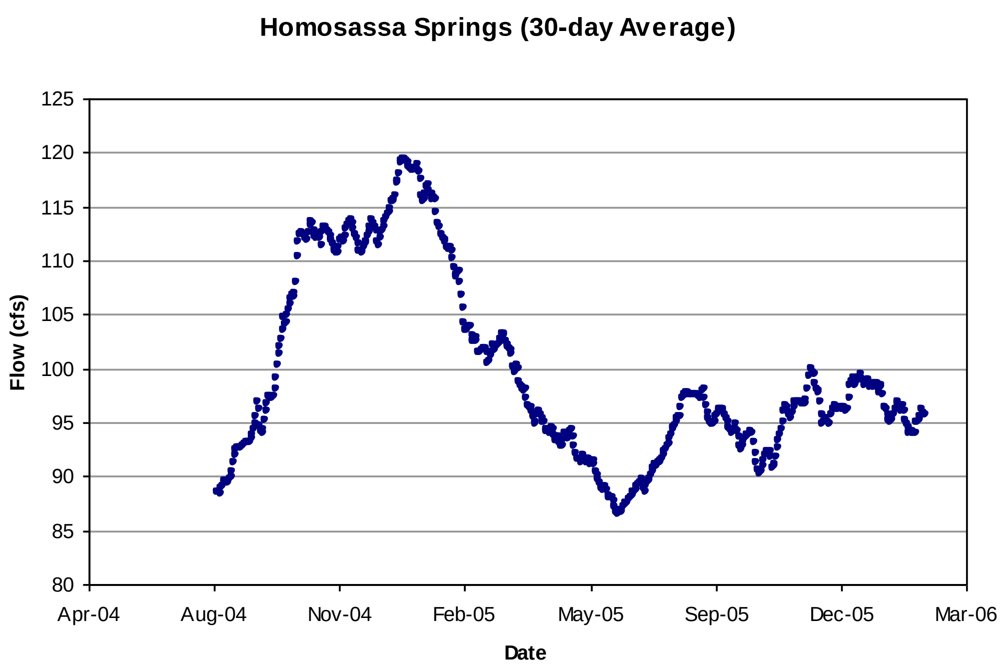


Figure D-2. 30-day moving average for daily flow for Homosassa Springs

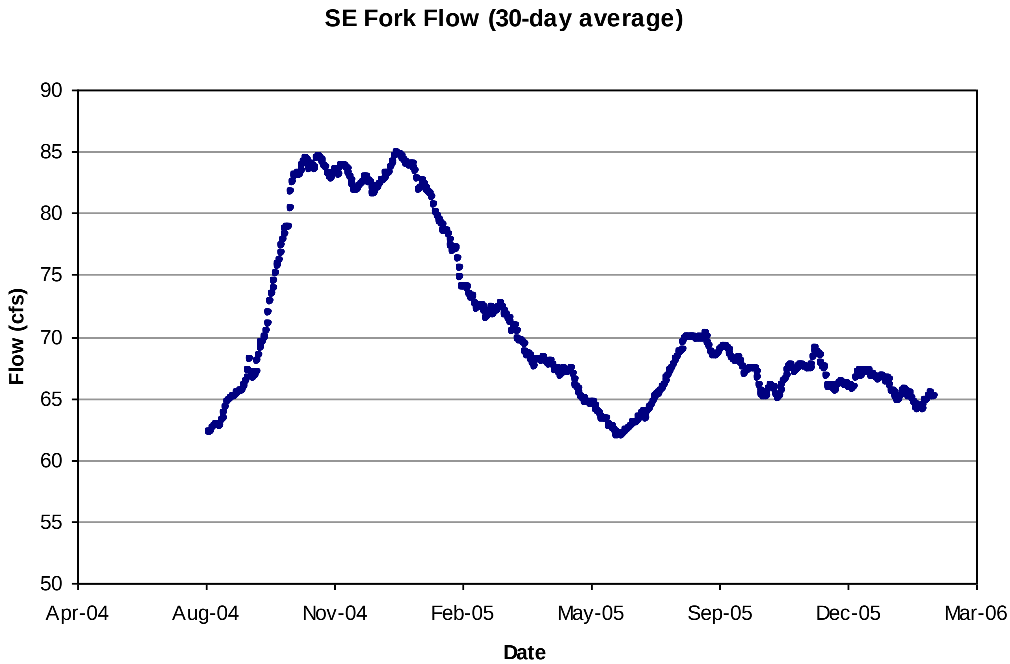


Figure D-3. 30-day moving average for daily flow for SE Fork Homosassa Spring

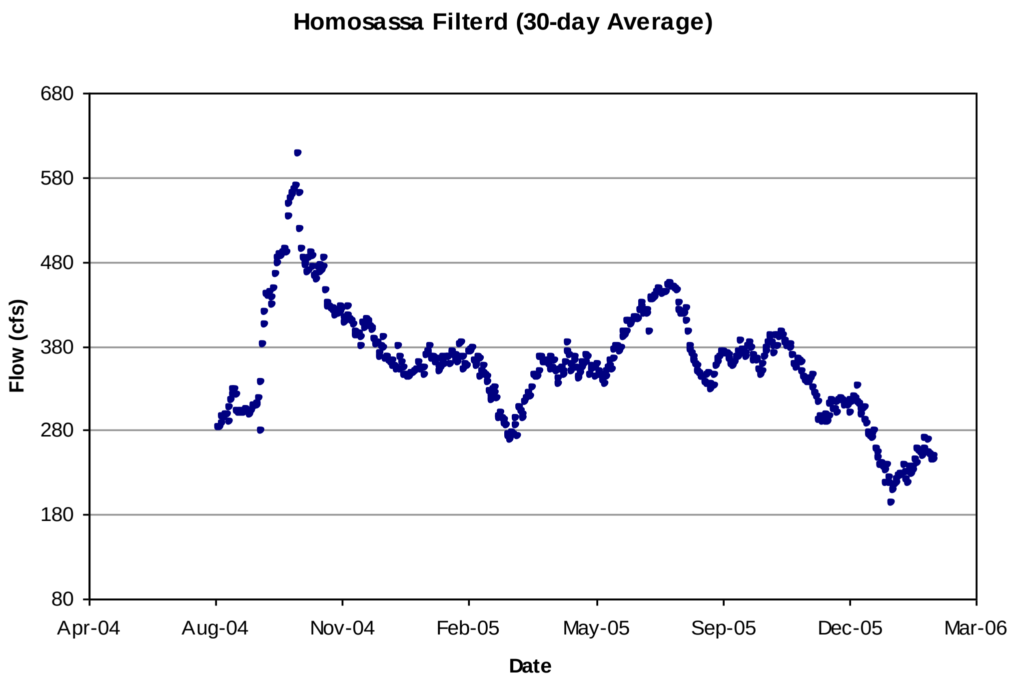


Figure D-4. 30-day moving average for daily flow for Homosassa River

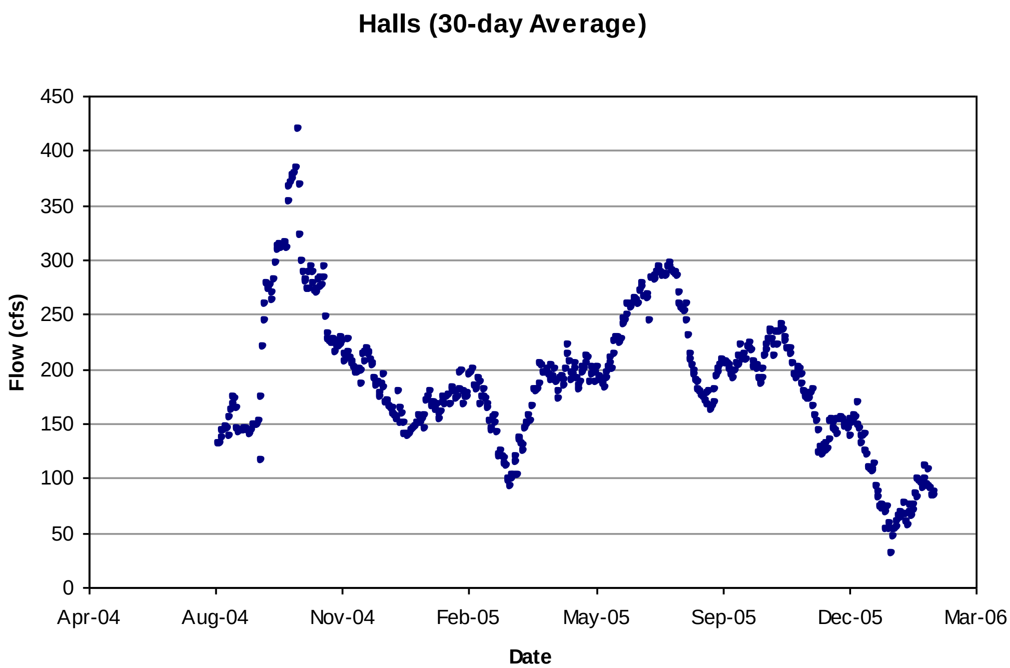


Figure D-5. 30-day moving average for daily flow for Halls River

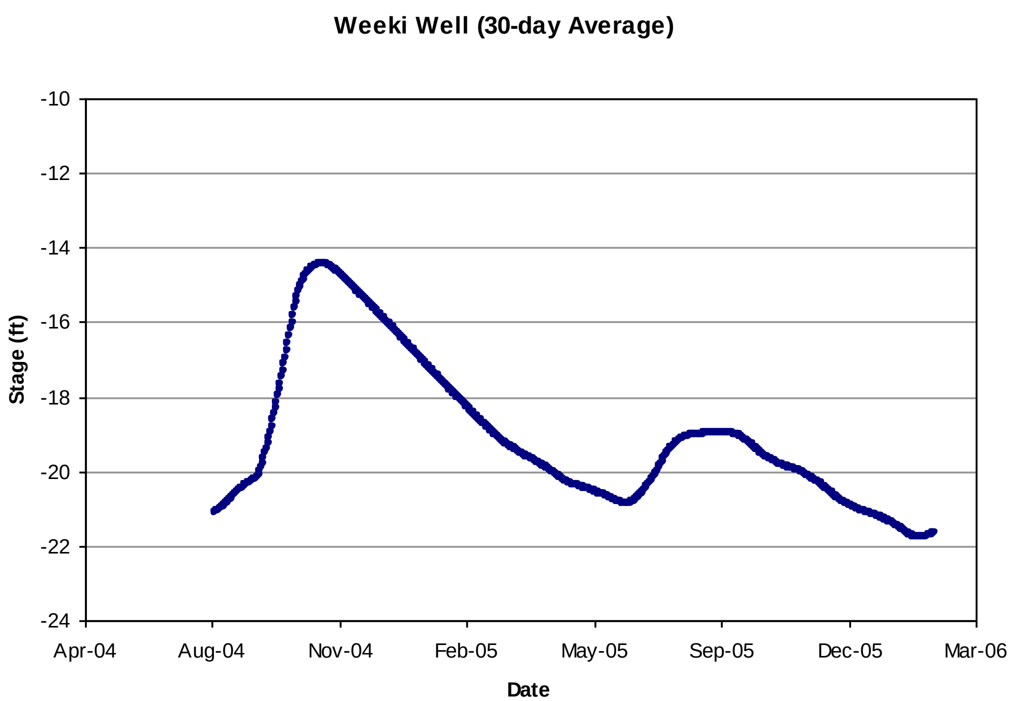


Figure D-6. 30-day moving average for stage at Weeki Wachee well near Weeki Wachee, FL (gauge ID = 02883201082315601)

Appendix E

15-minute Salinity versus Stage and Flow

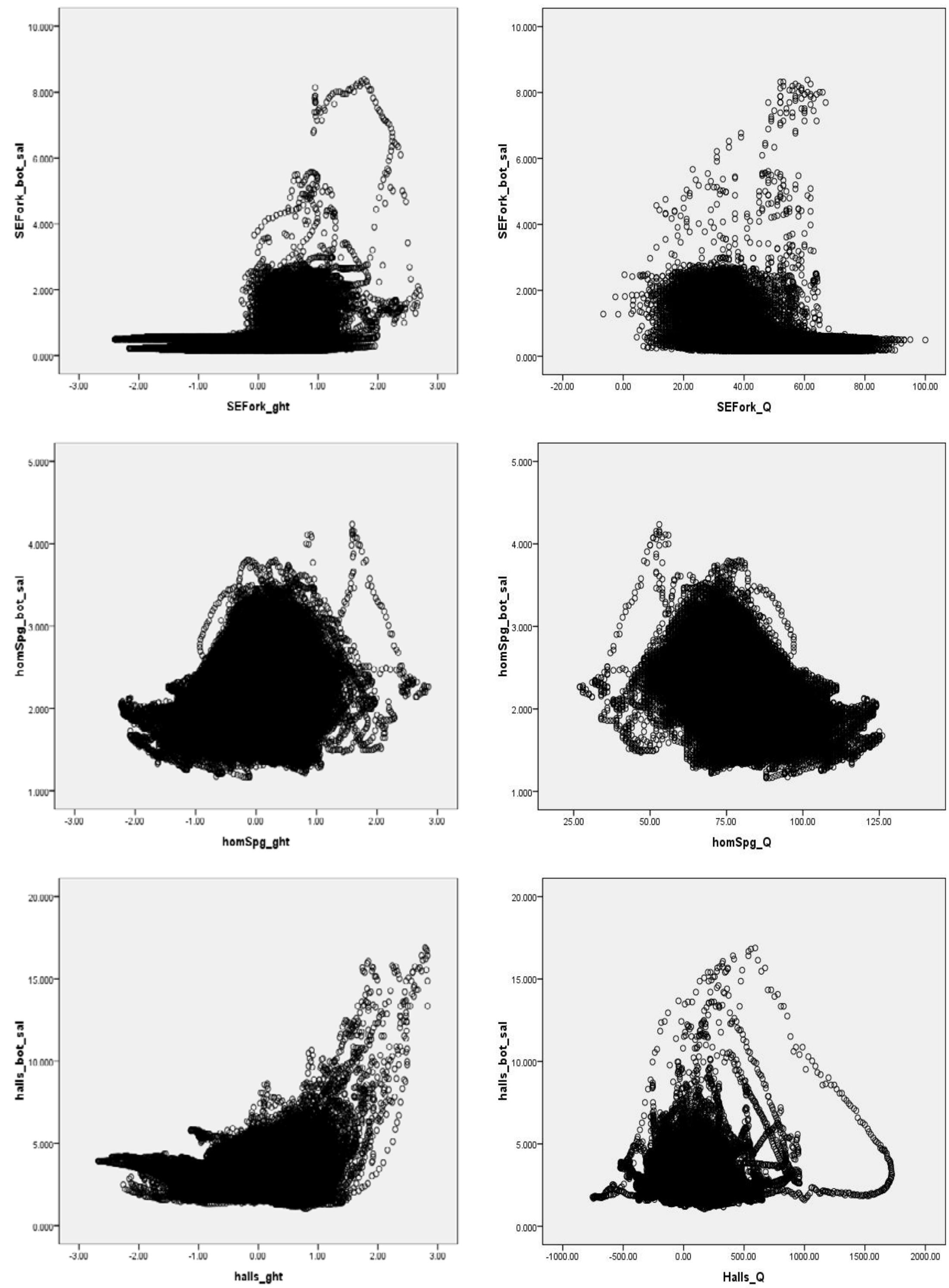


Figure E-1. 15-minute salinity versus stage (left) and flow (right) at SE Fork Spring (top), Homosassa Springs (center), and Halls River (bottom)

Appendix F

Salinity Profiles and Salinity versus Total Spring Flow

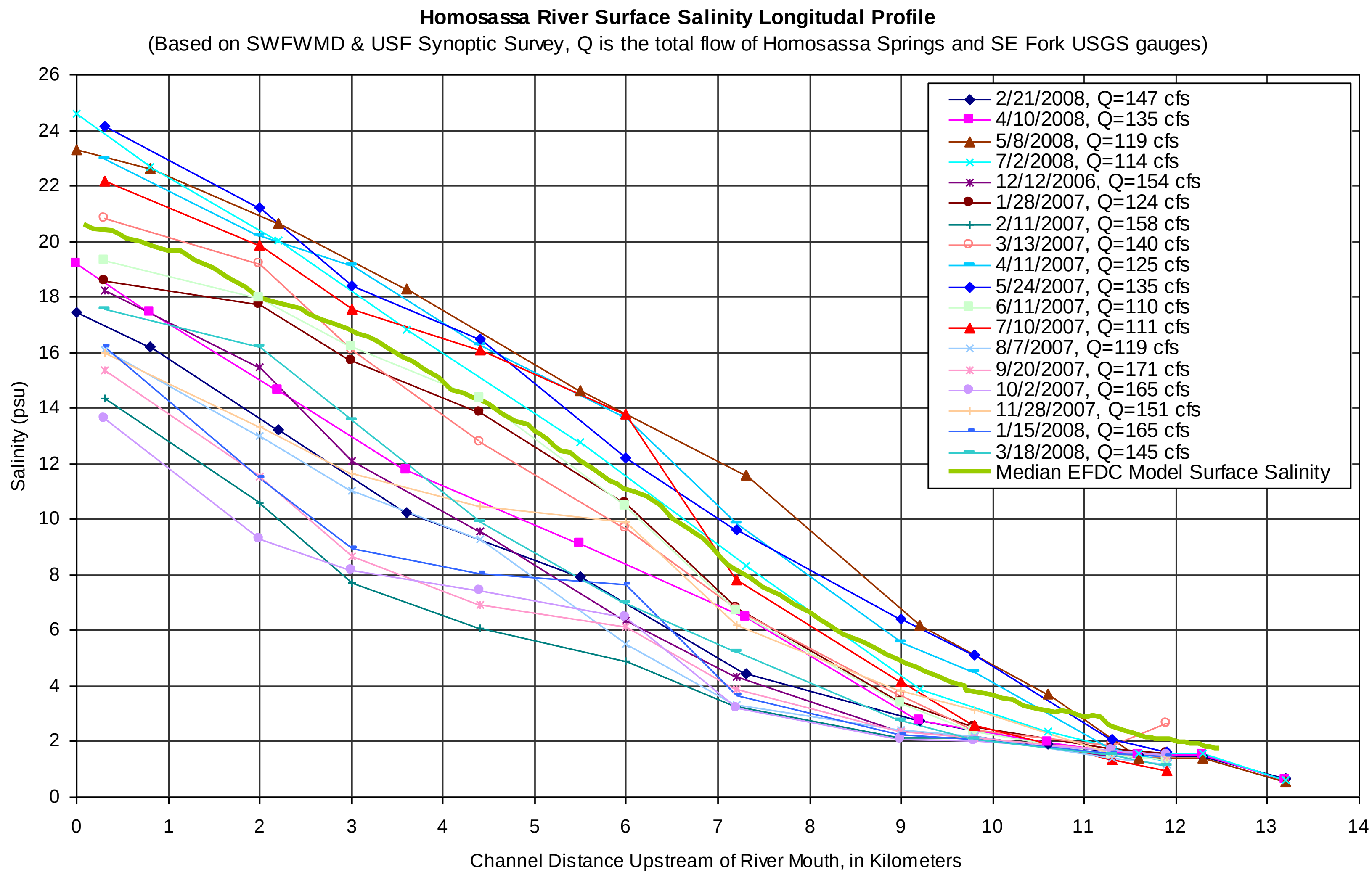


Figure F-1. Longitudinal surface salinity distributions for the Homosassa River associated with median river centerline surface salinity in 2007 based on EFDC model results and synoptic surveys completed by SWFWMD and the University of South Florida between December 2006 and July 2008

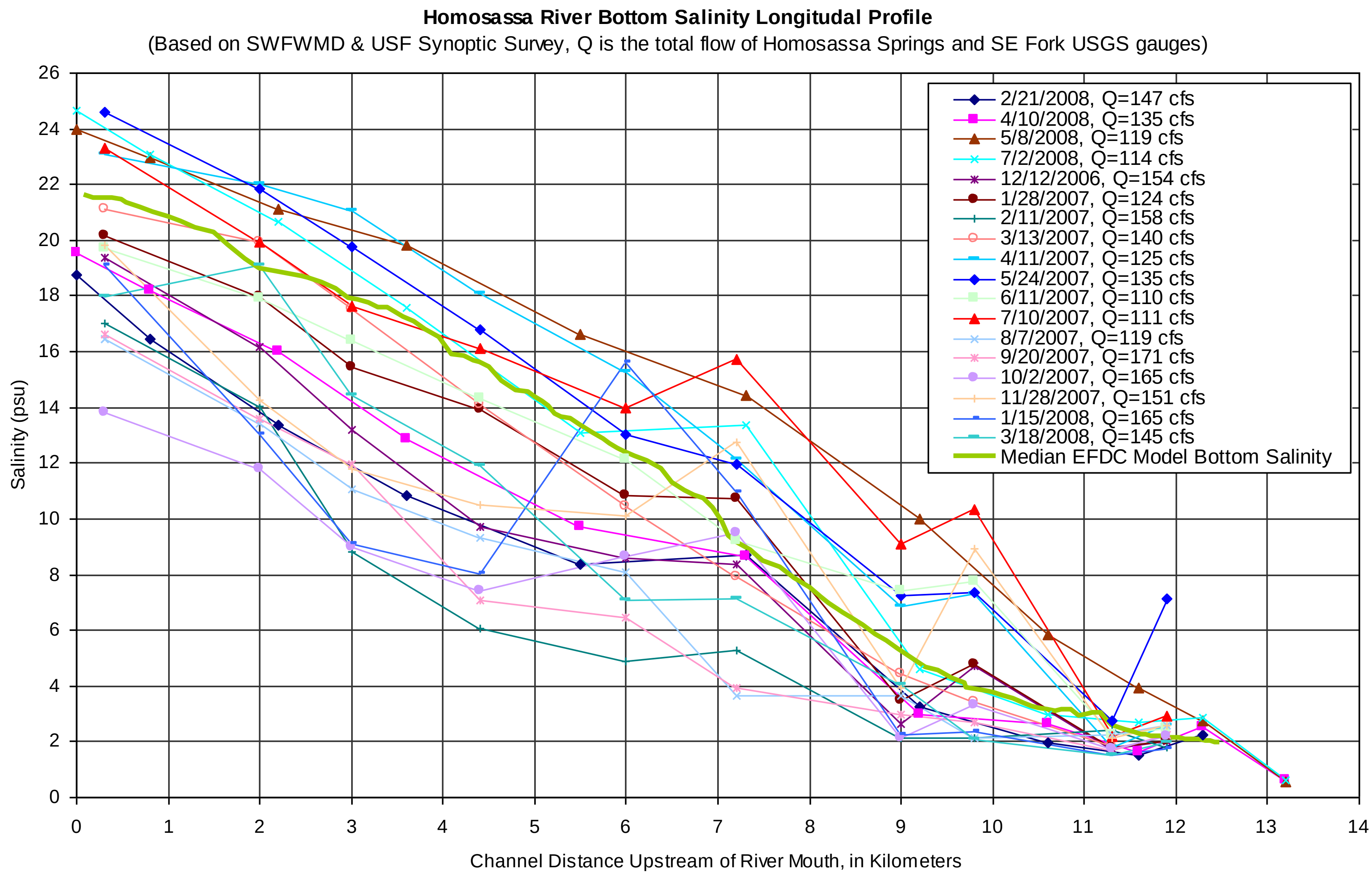
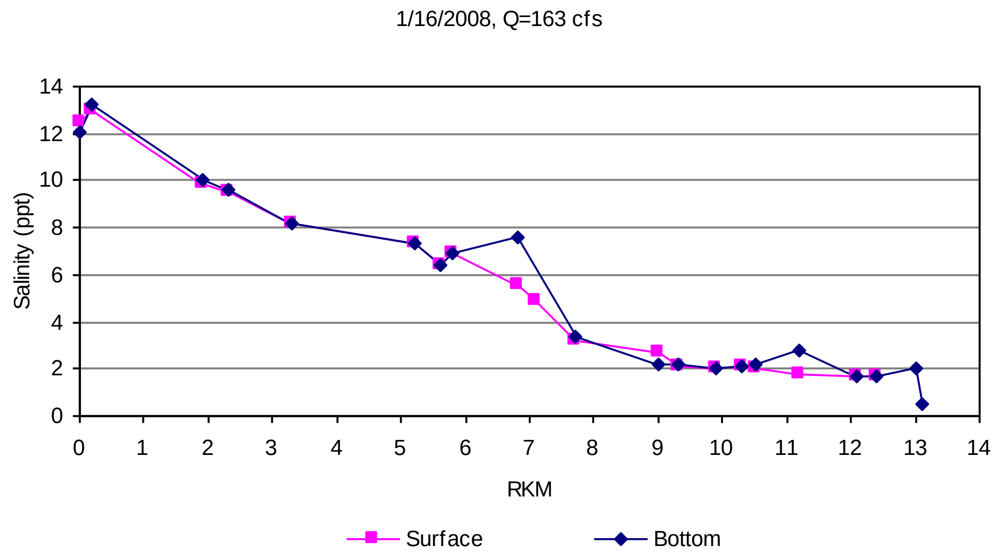
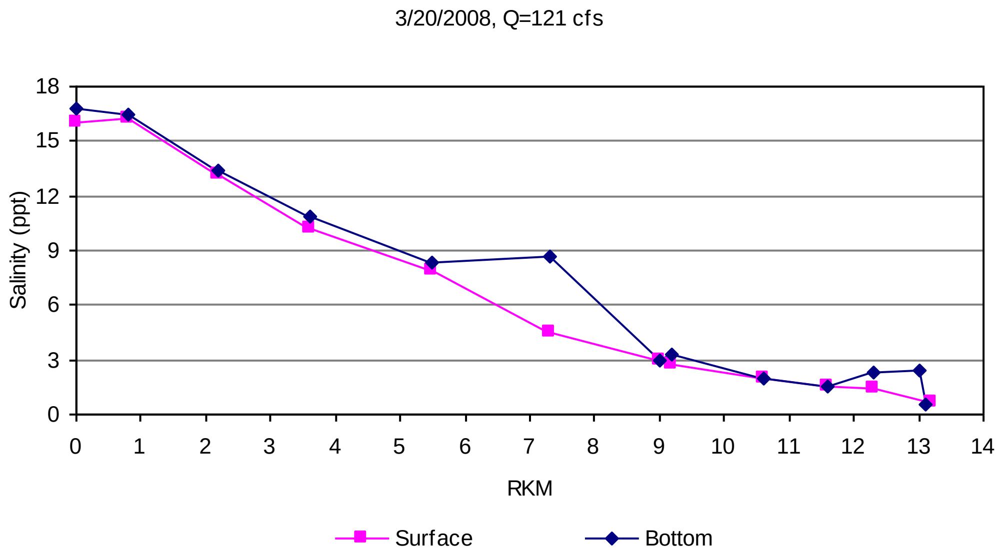


Figure F-2. Longitudinal bottom salinity distributions for the Homosassa River associated with median river centerline bottom salinity in 2007 based on EFDC model results and synoptic surveys completed by SWFWMD and the University of South Florida between December 2006 and July 2008


1/16/2008, Q=163 cfs
Salinity (ppt)
RKM
Surface
Bottom


3/20/2008, Q=121 cfs
Salinity (ppt)
RKM
Surface
Bottom

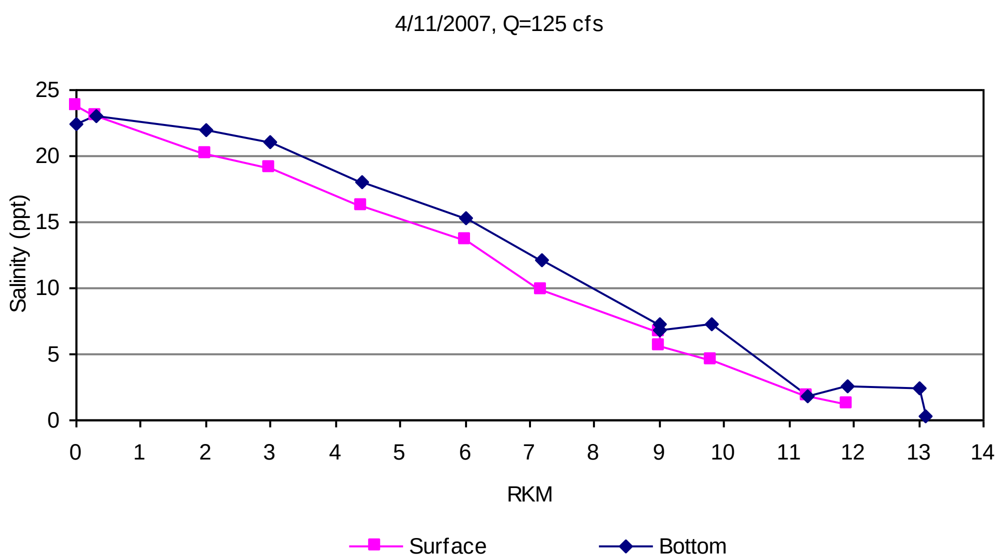
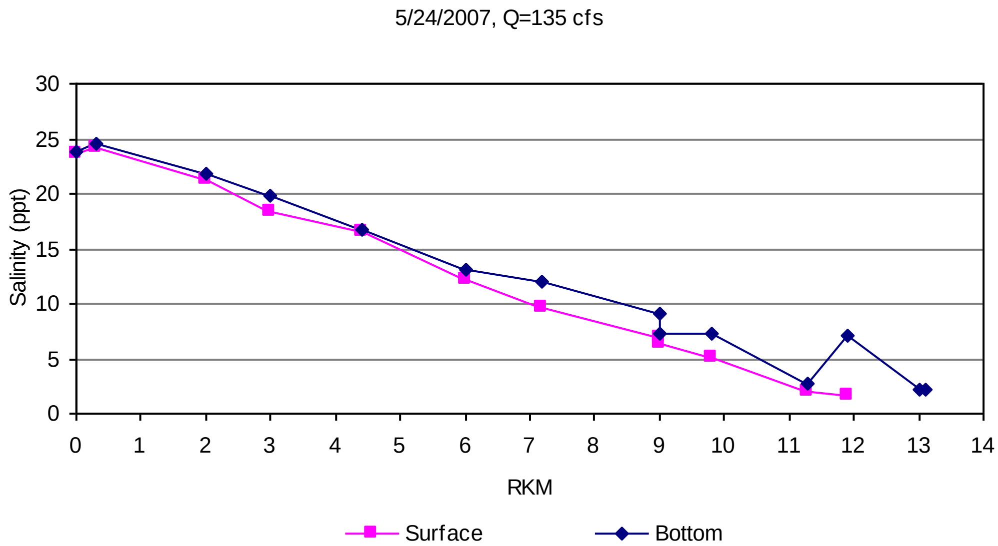
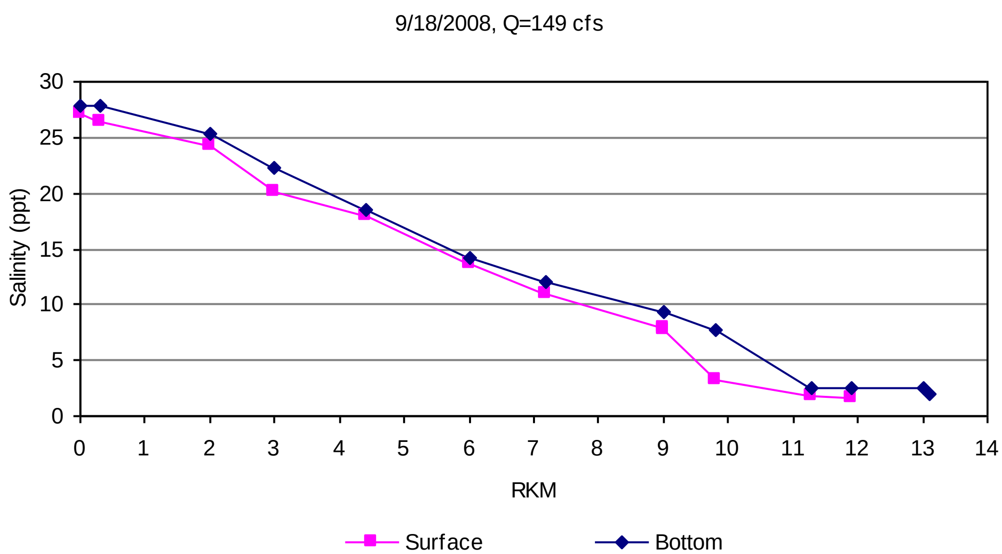

4/11/2007, Q=125 cfs
Salinity (ppt)
RKM
Surface
Bottom

Figure F-3. Surface and bottom salinity profile comparison on selected dates





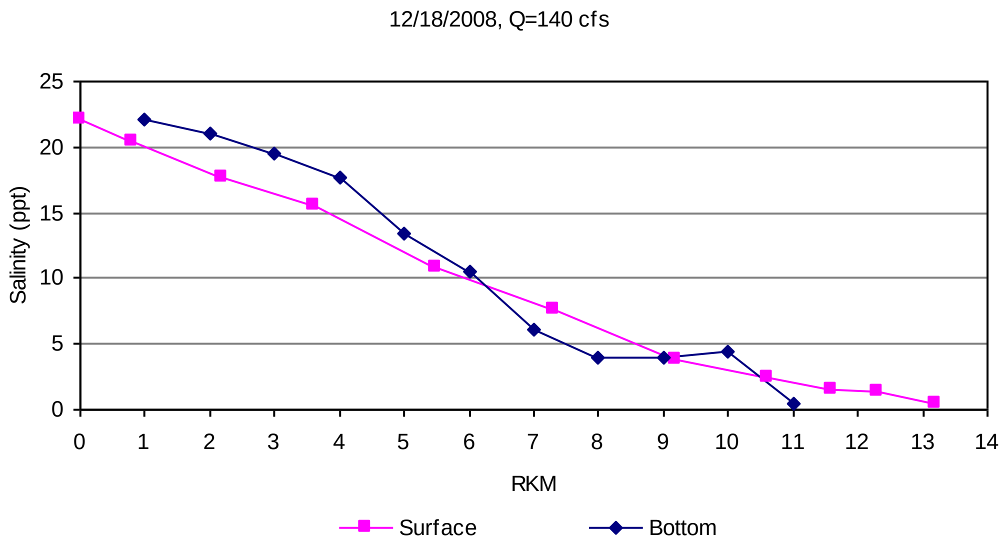


Figure F-3. Surface and bottom salinity profile comparison on selected dates (continued)

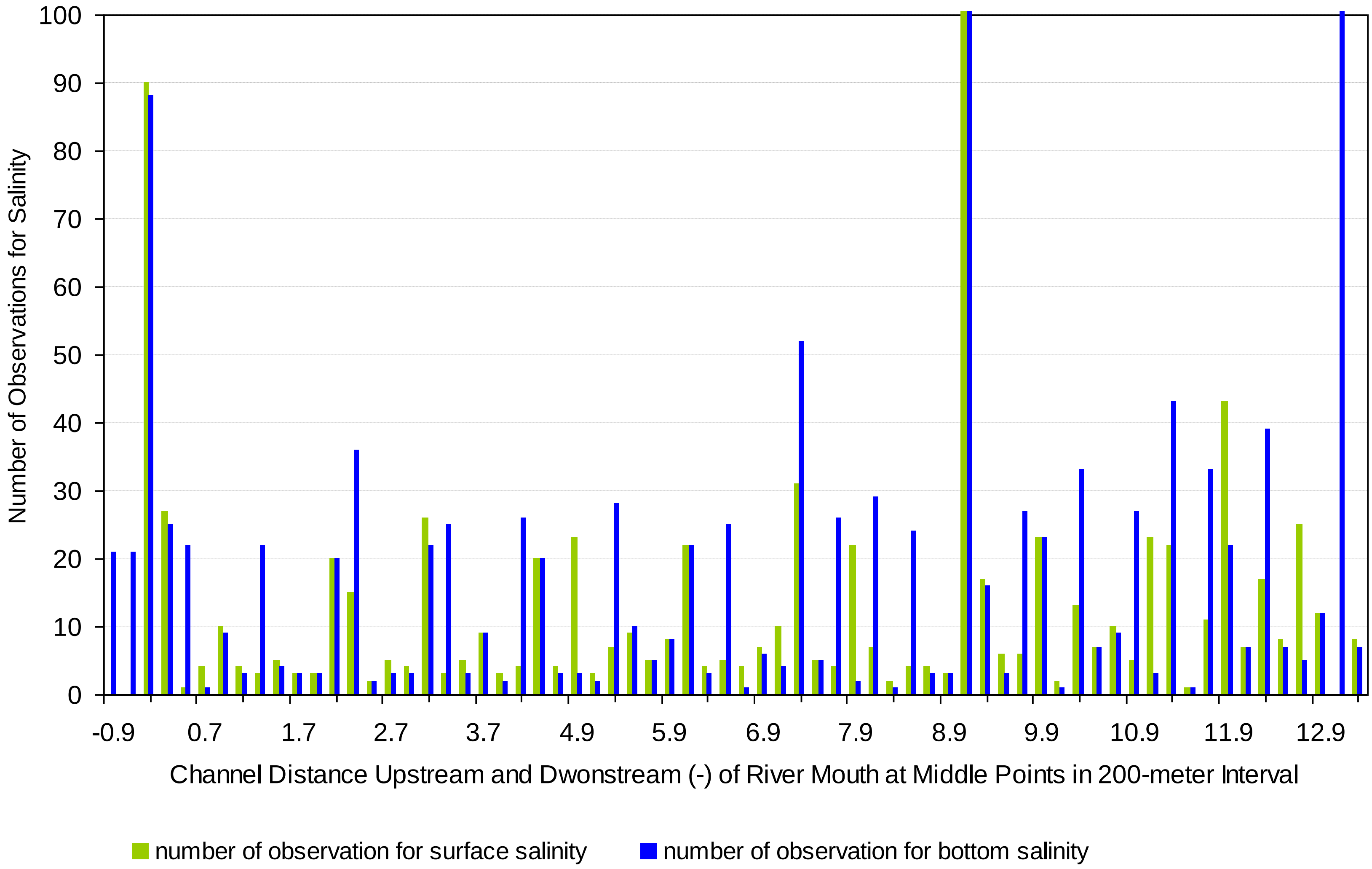


Figure F-4. Number of observations of surface and bottom salinities in 200-meter interval along river centerline

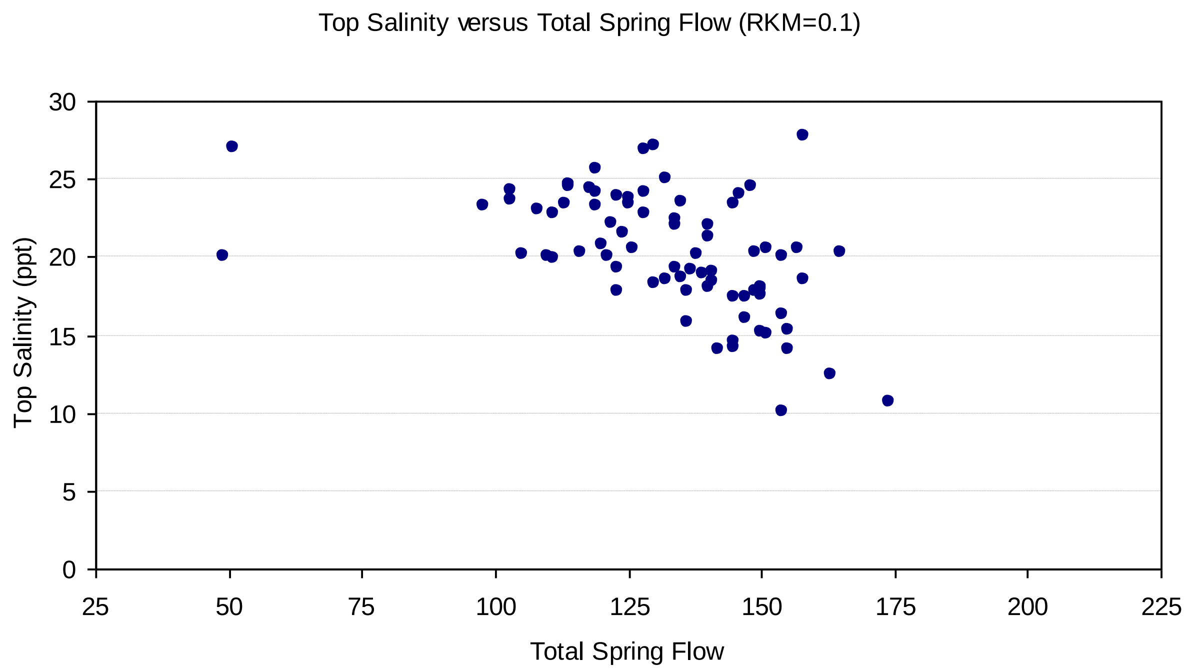


Figure F-5. Surface salinity versus total spring flow for the river segment RKMs 0.0 to 0.2

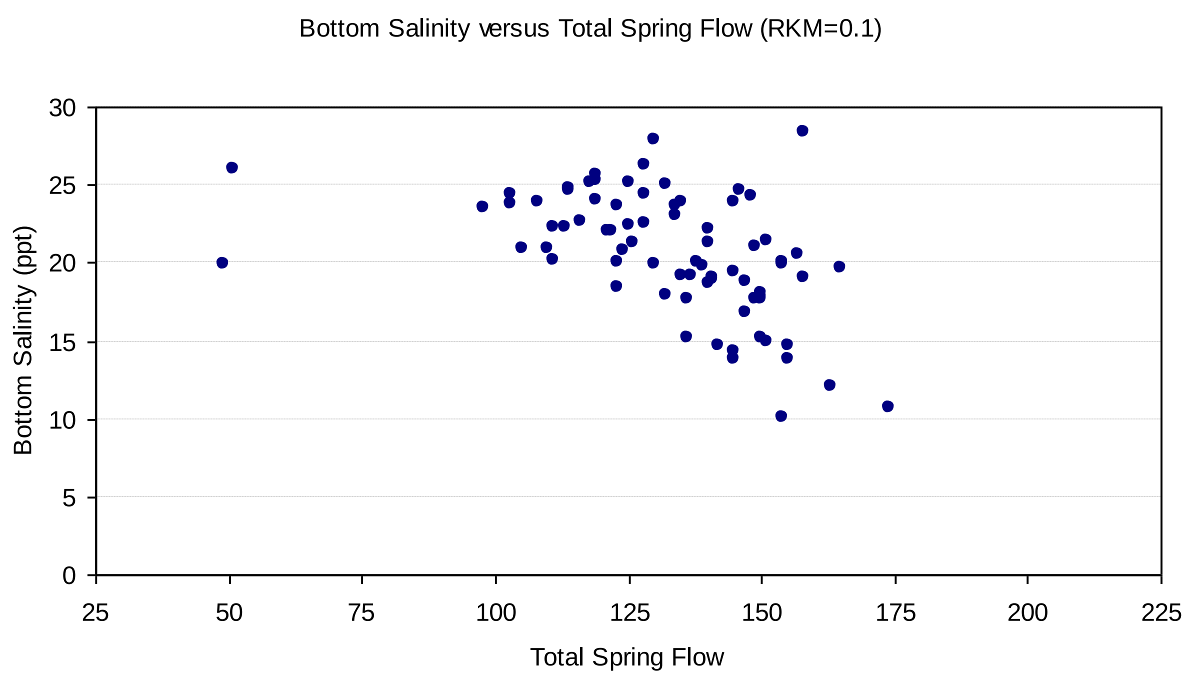


Figure F-6. Bottom salinity versus total spring flow for the river segment RKMs 0.0 to 0.2

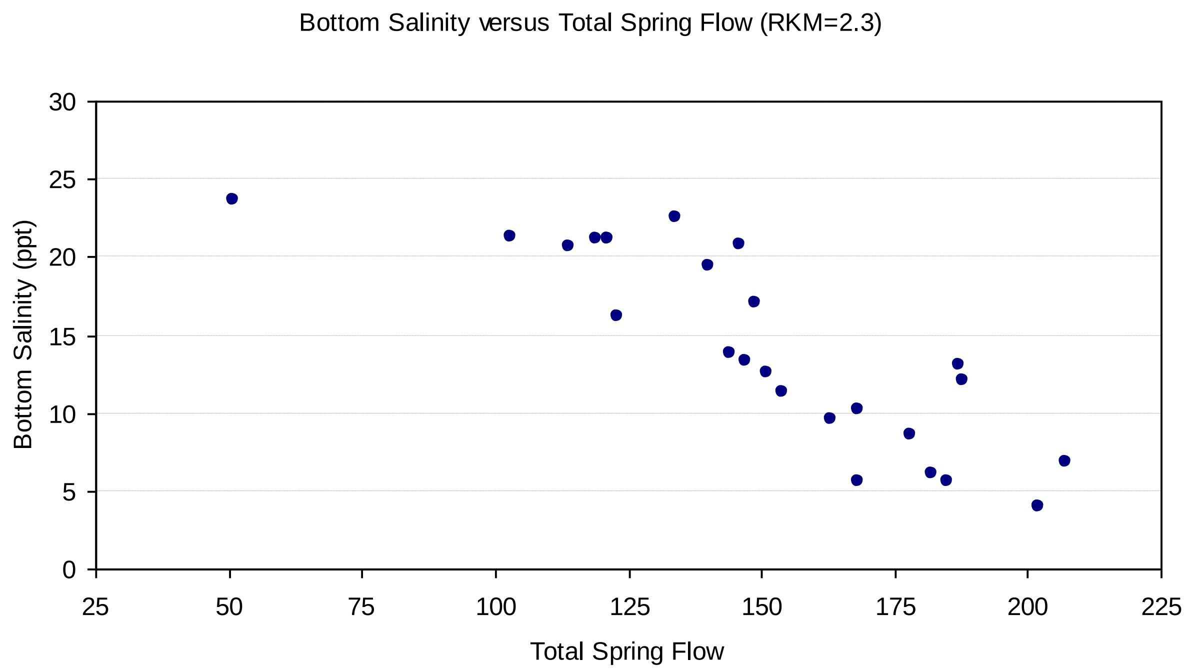


Figure F-7. Bottom salinity versus total spring flow for the river segment RKMs 2.2 to 2.4

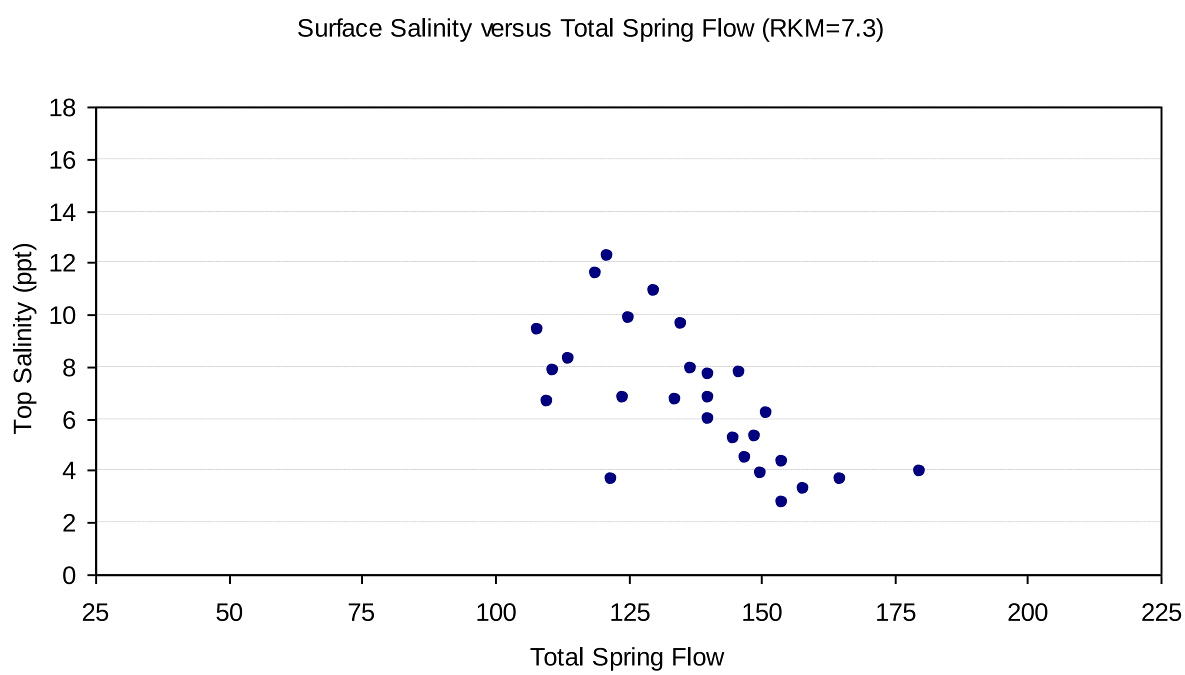


Figure F-8. Surface salinity versus total spring flow for the river segment RKMs 7.2 to 7.4

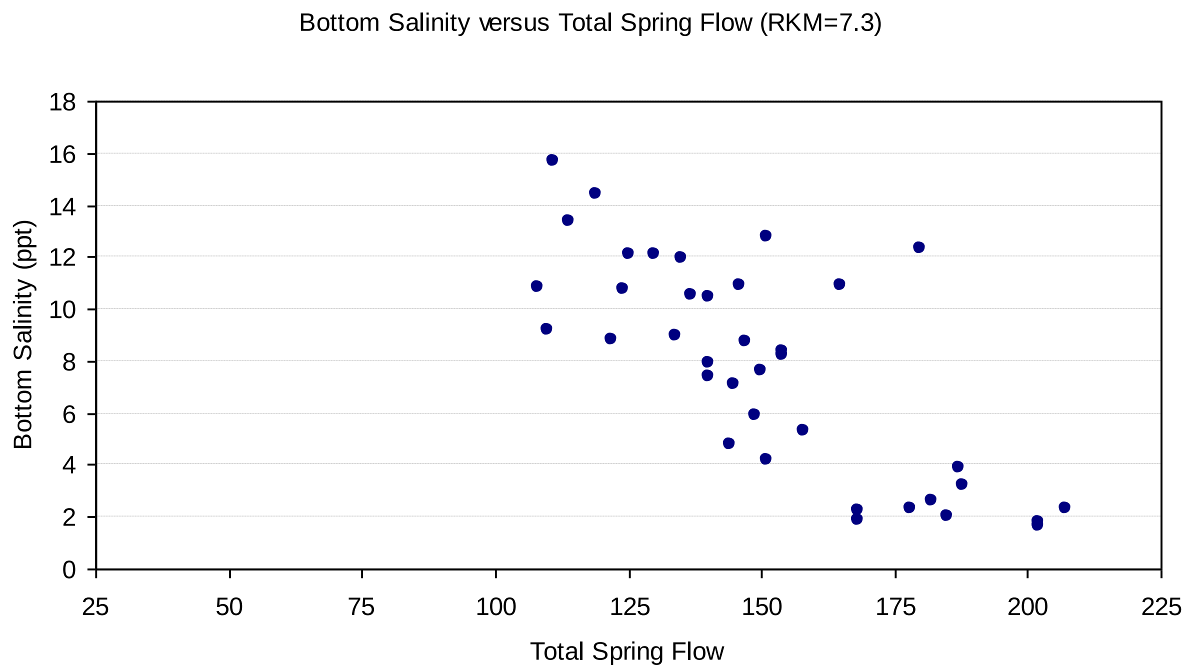


Figure F-9. Bottom salinity versus total spring flow for the river segment RKMs 7.2 to 7.4

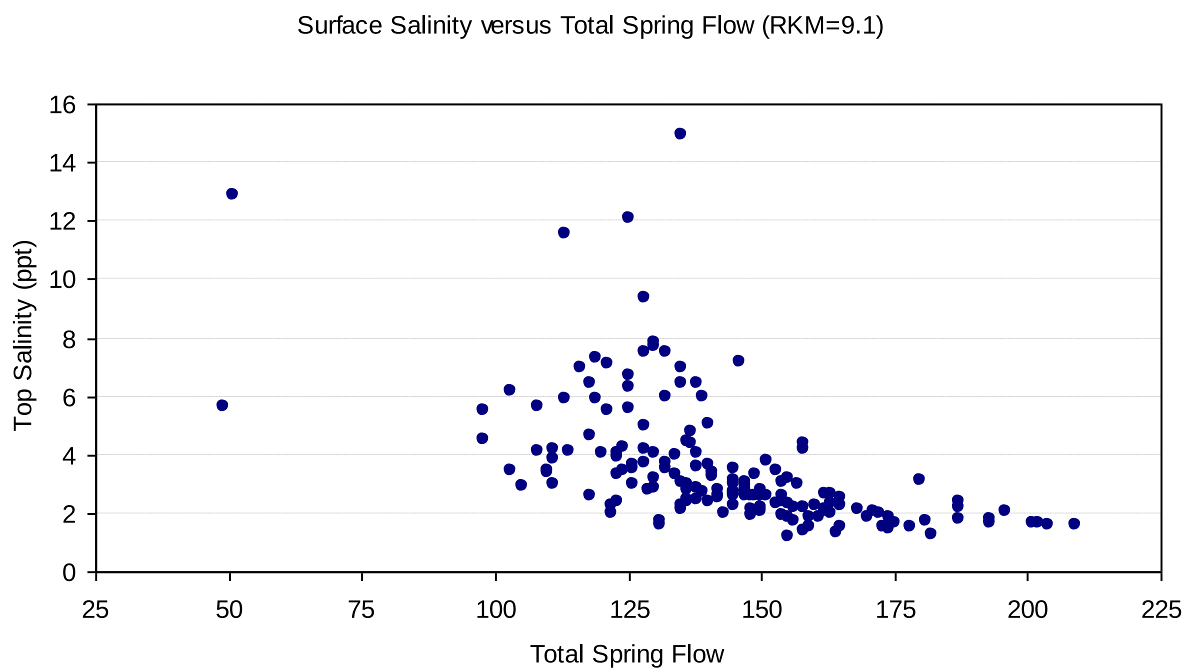


Figure F-10. Surface salinity versus total spring flow for the river segment RKMs 9.0 to 9.2

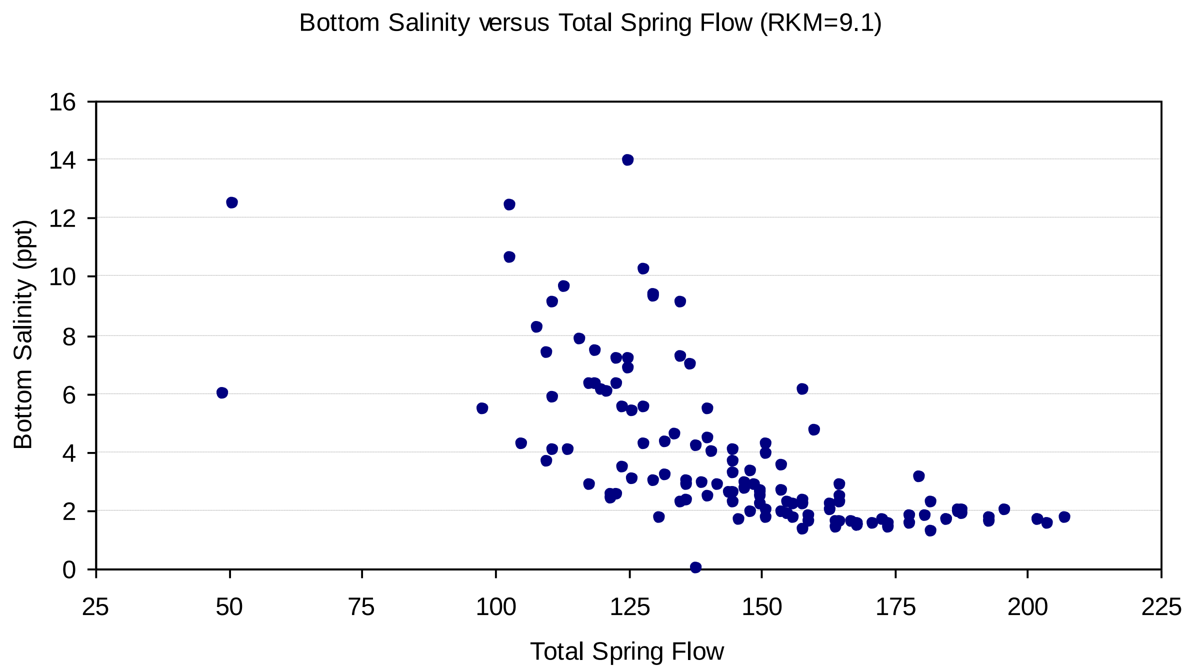


Figure F-11. Bottom salinity versus total spring flow for the river segment RKMs 9.0 to 9.2

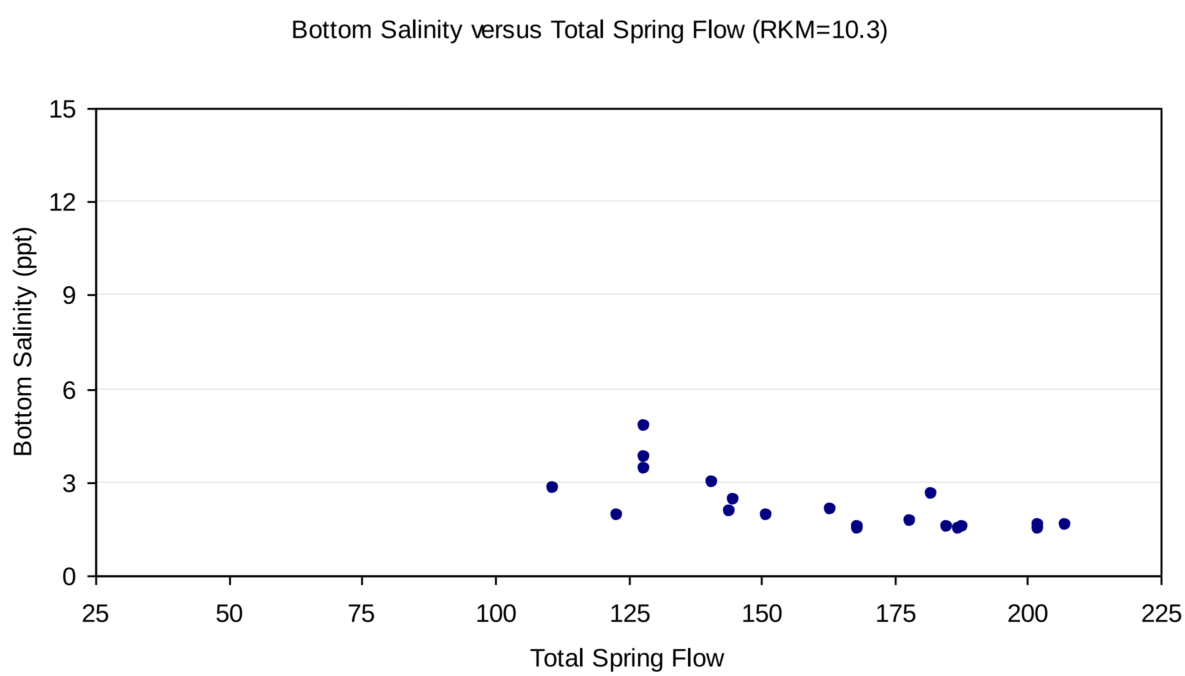


Figure F-12. Bottom salinity versus total spring flow for the river segment RKMs 10.2 to 10.4

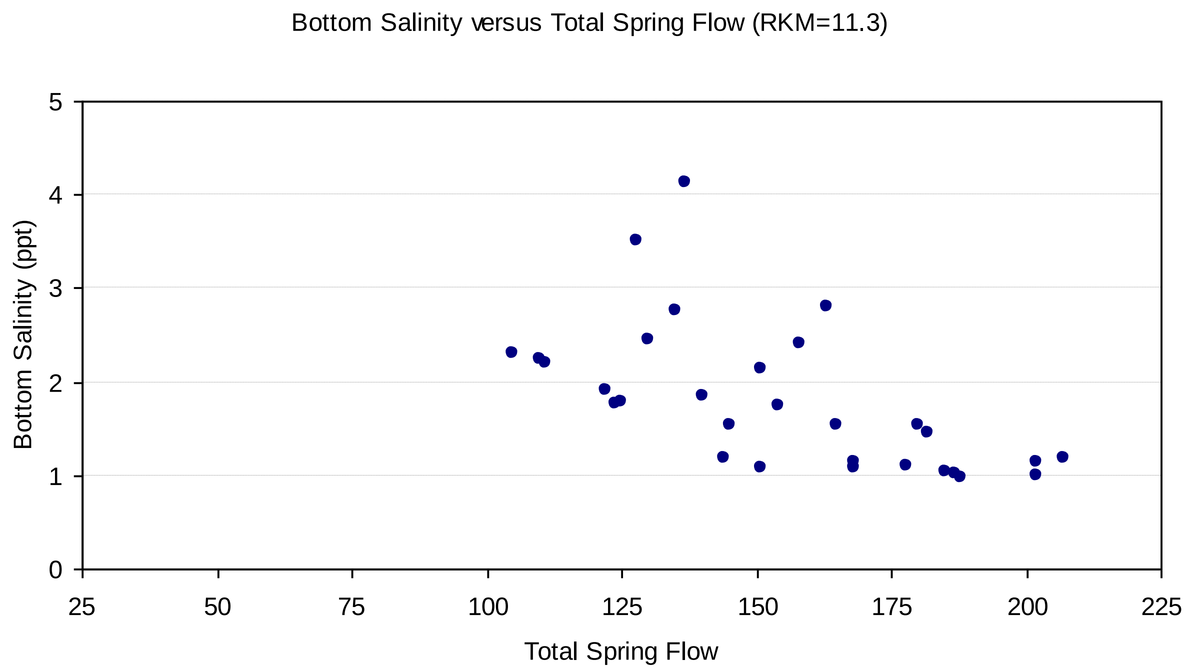


Figure F-13. Bottom salinity versus total spring flow for the river segment RKMs 10.2 to 10.4

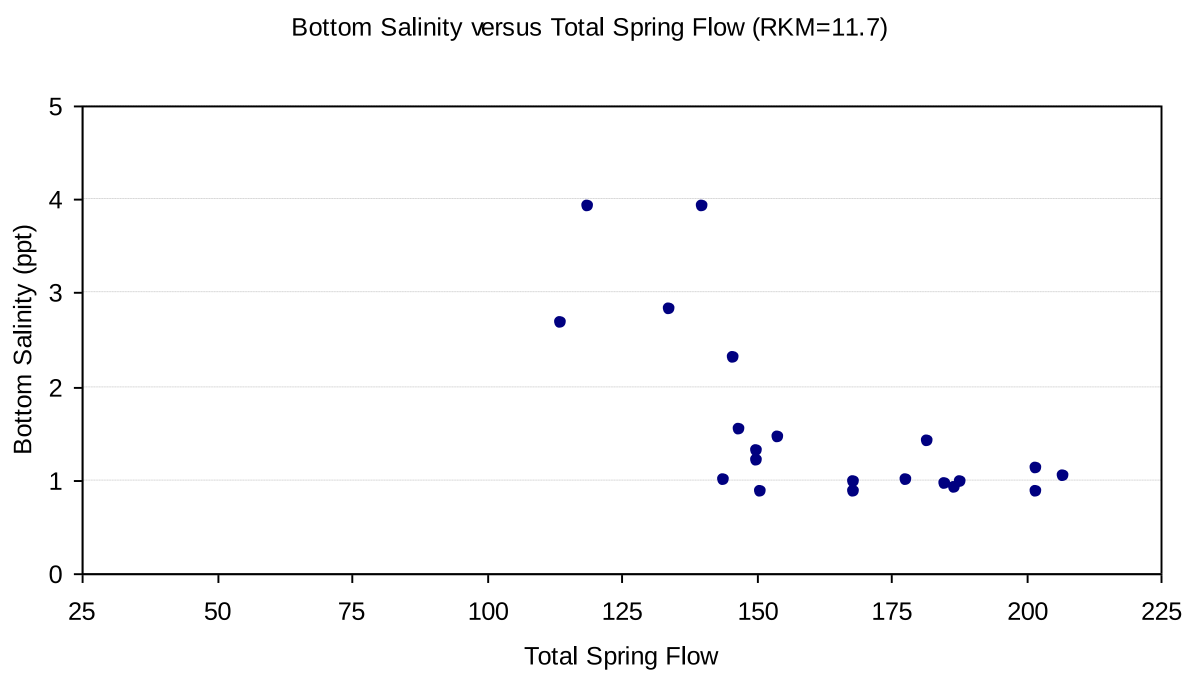


Figure F-14. Bottom salinity versus total spring flow for the river segment RKMs 11.6 to 11.8

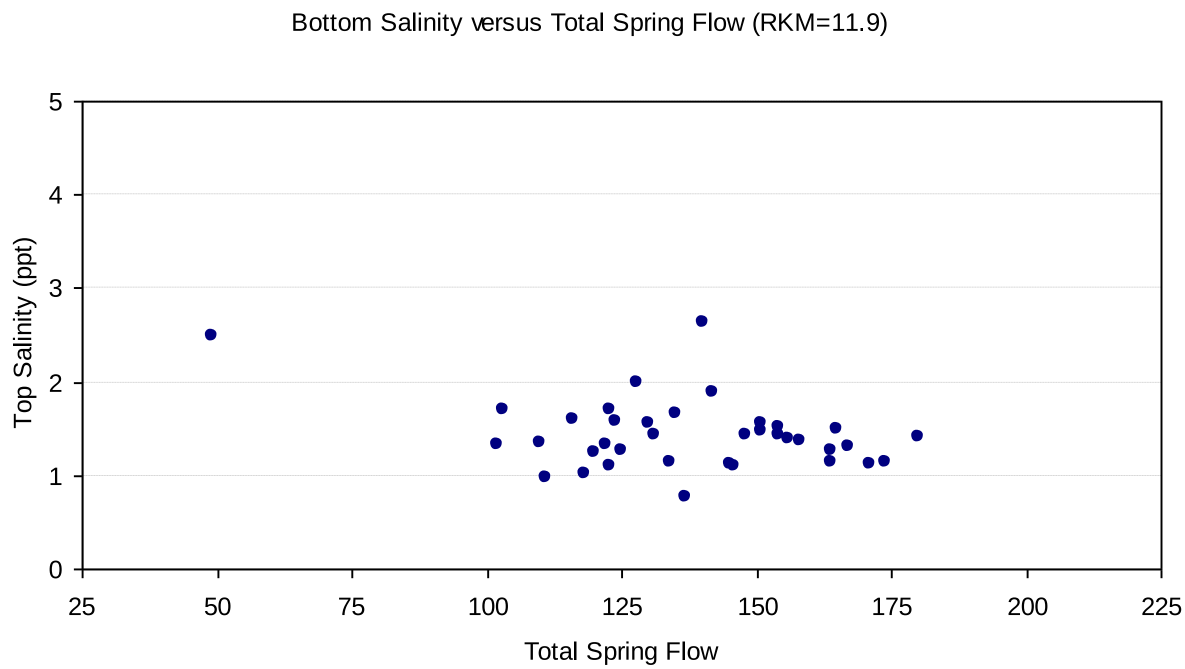


Figure F-15. Bottom salinity versus total spring flow for the river segment RKMs 11.8 to 12.0

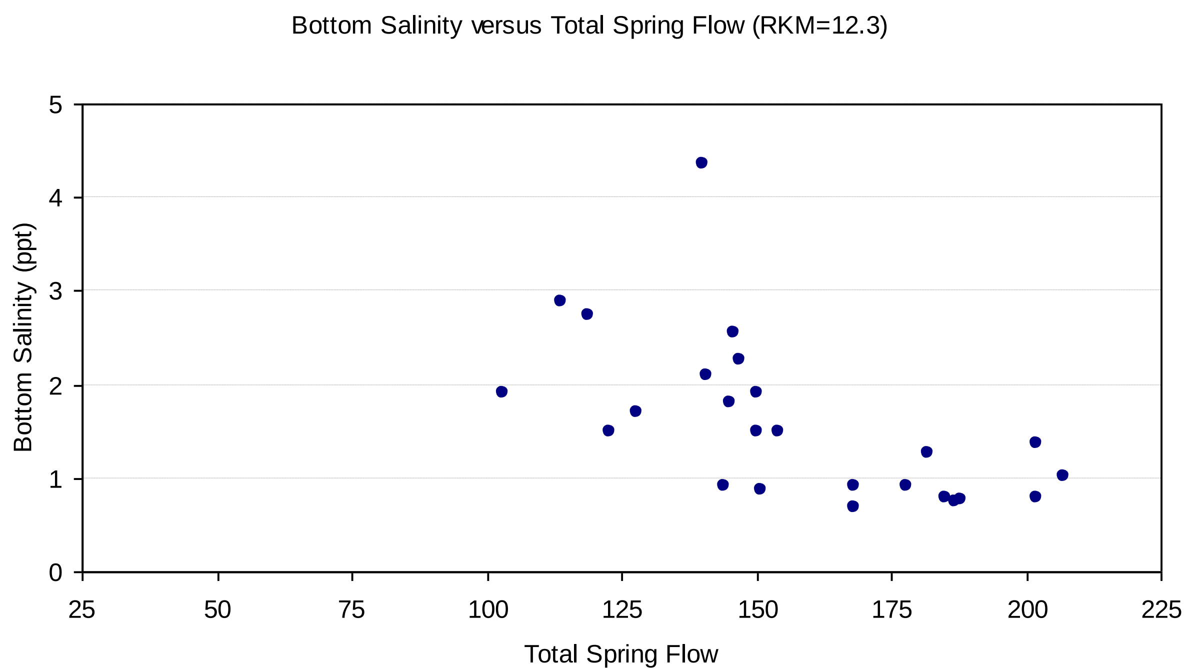


Figure F-16. Bottom salinity versus total spring flow for the river segment RKMs 12.2 to 12.4

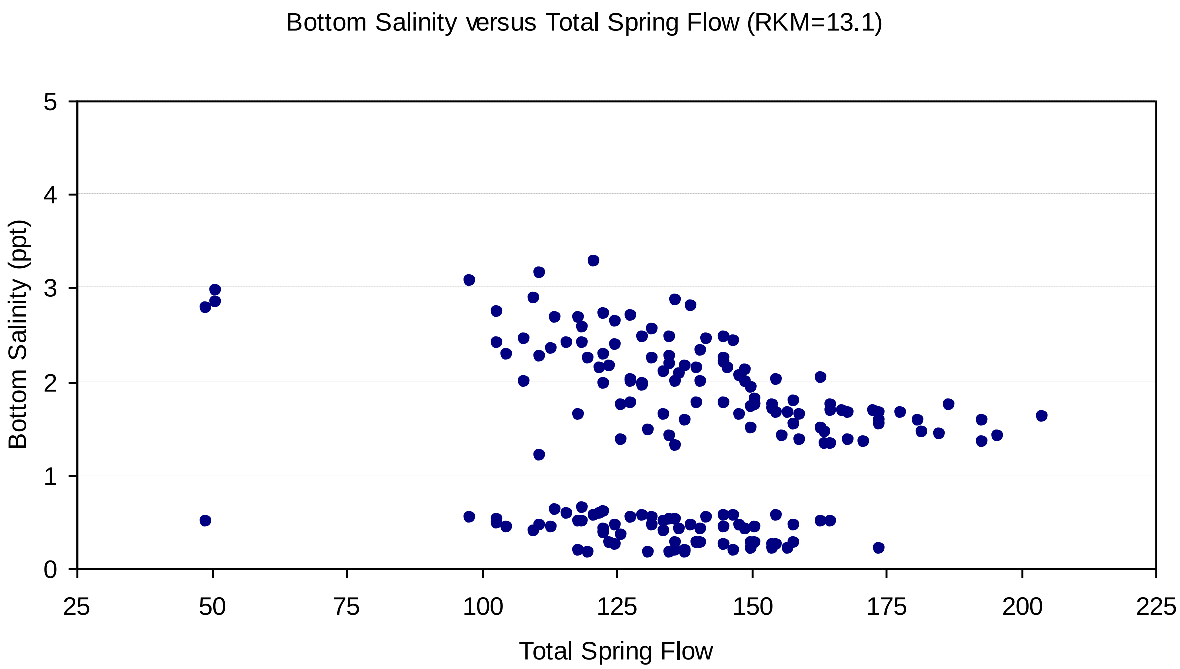


Figure F-17. Bottom salinity versus total spring flow for the river segment RKMs 13.2 to 13.4

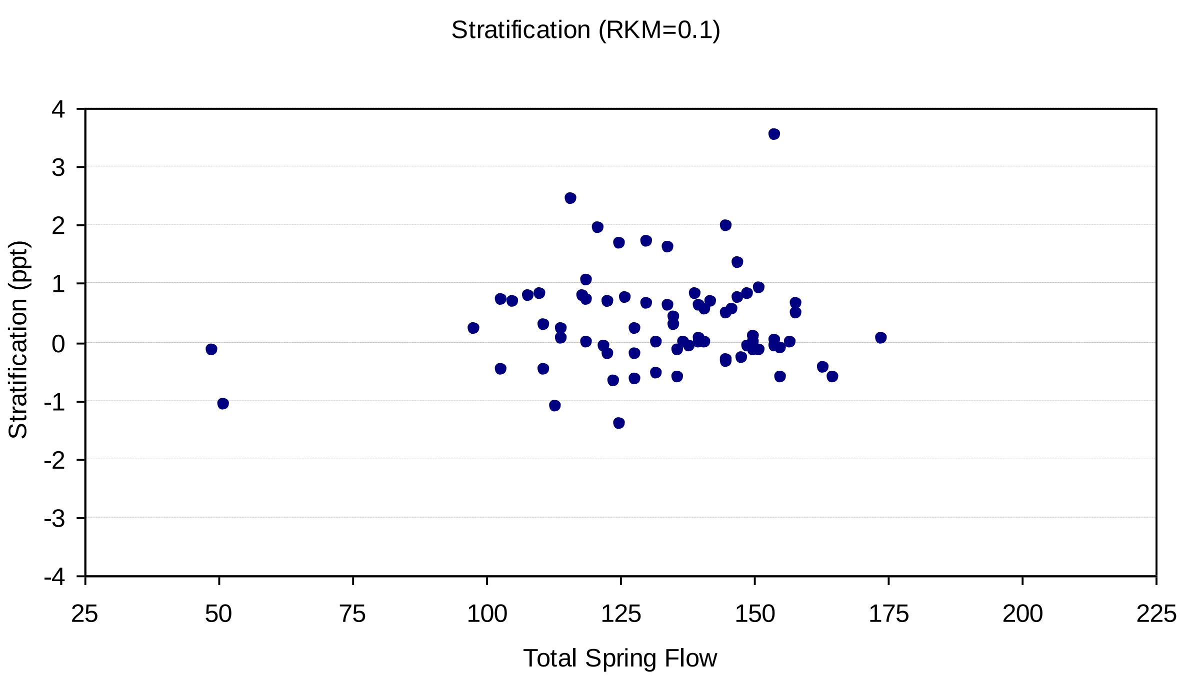


Figure F-18. Stratification versus total spring flow for the river segment RKMs 0.0 to 0.2

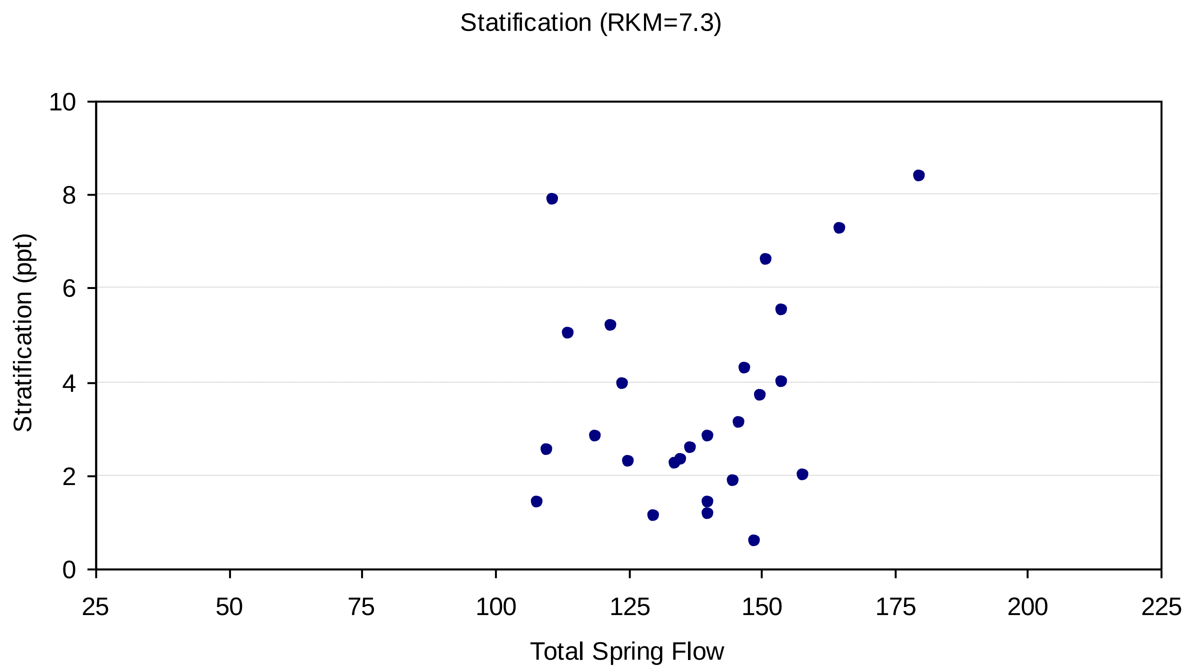


Figure F-19. Stratification versus total spring flow for the river segment RKMs 7.2 to 7.4

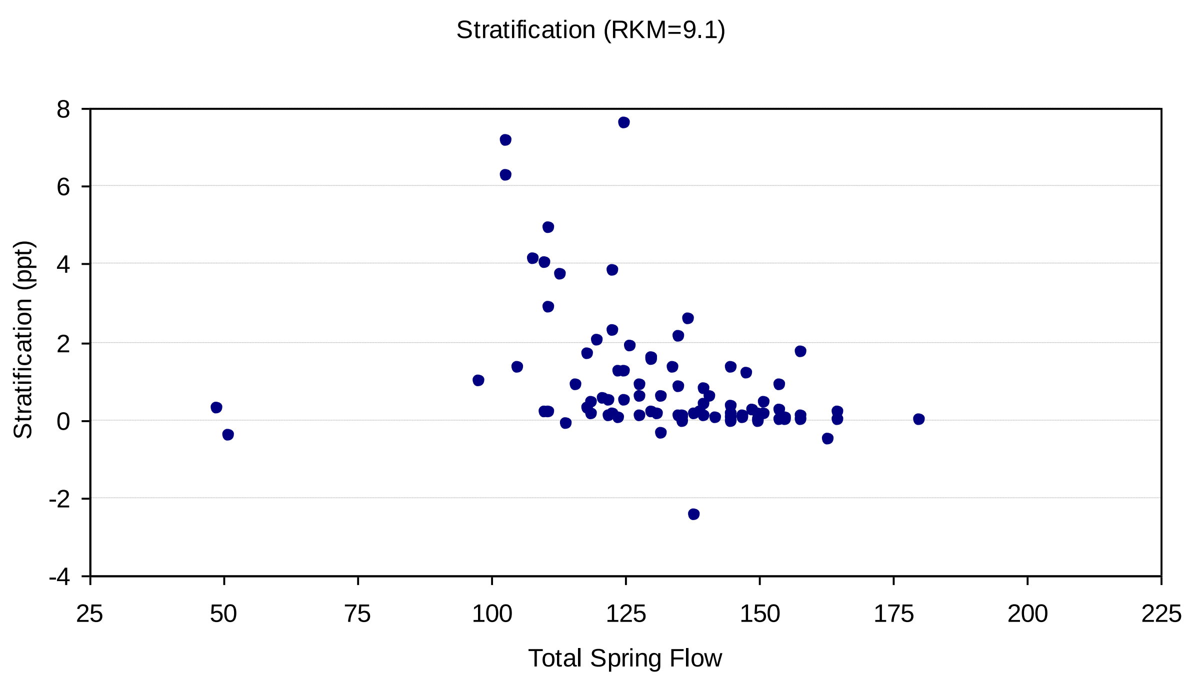


Figure F-20. Stratification versus total spring flow for the river segment RKMs 9.0 to 9.2

Appendix G

Model Calibration Results

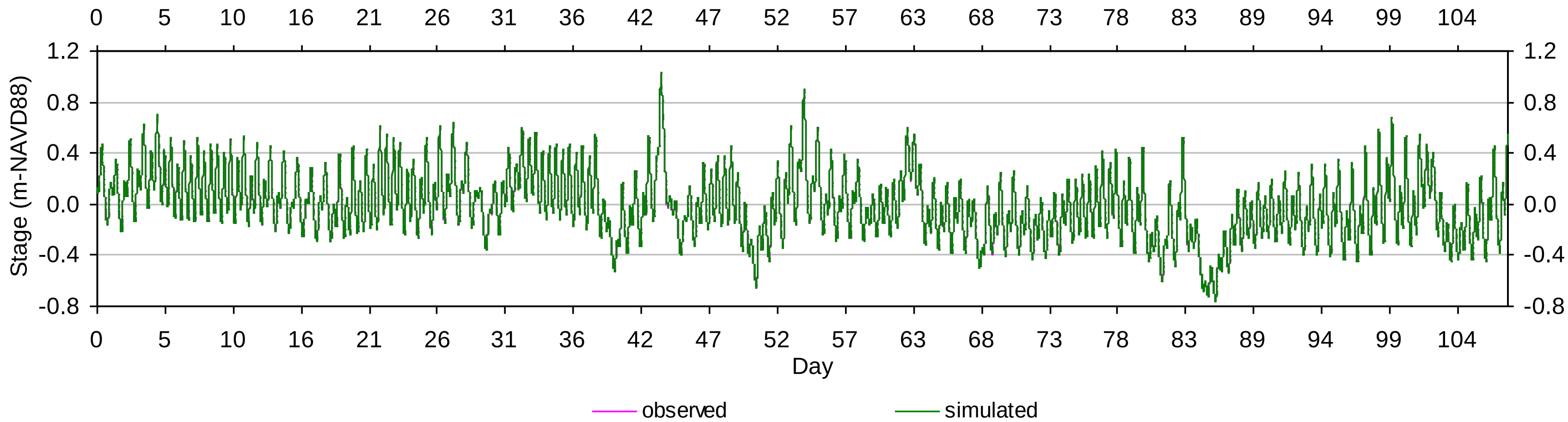


Figure G-1. Observed and simulated tidal stages at Shell Island gauge

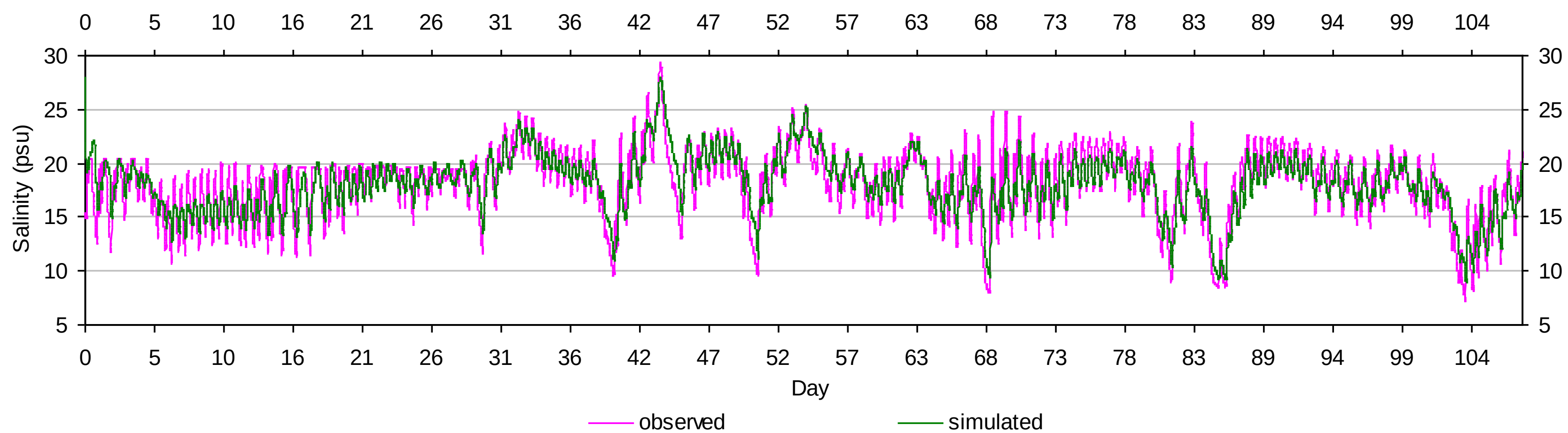


Figure G-2. Observed and simulated surface salinities at Shell Island gauge

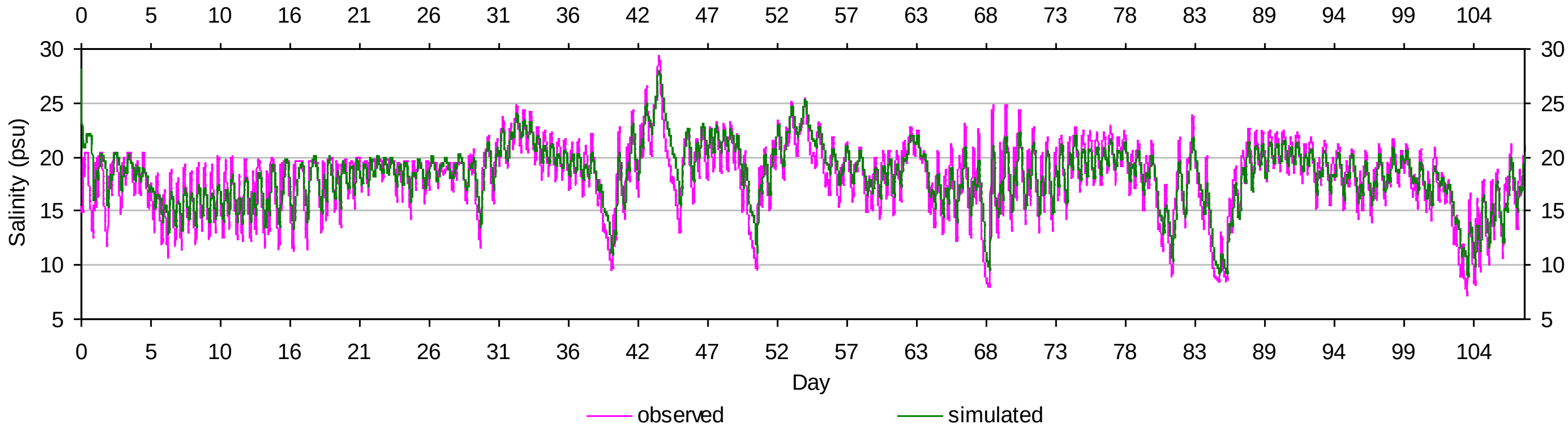


Figure G-3. Observed and simulated middle salinity at Shell Island gauge

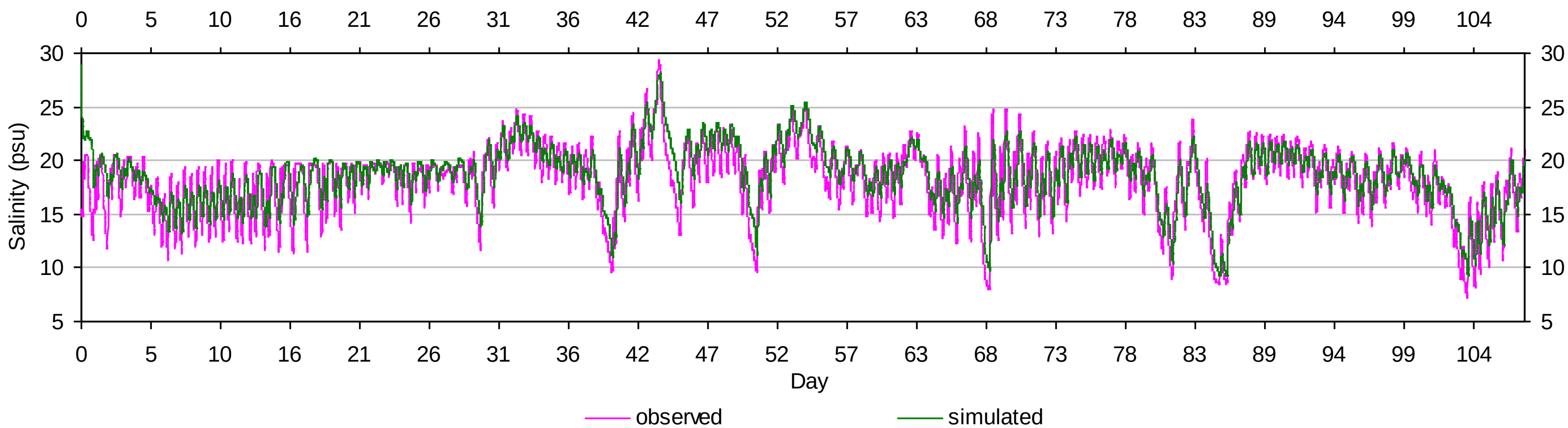


Figure G-4. Observed and simulated bottom salinity at Shell Island gauge

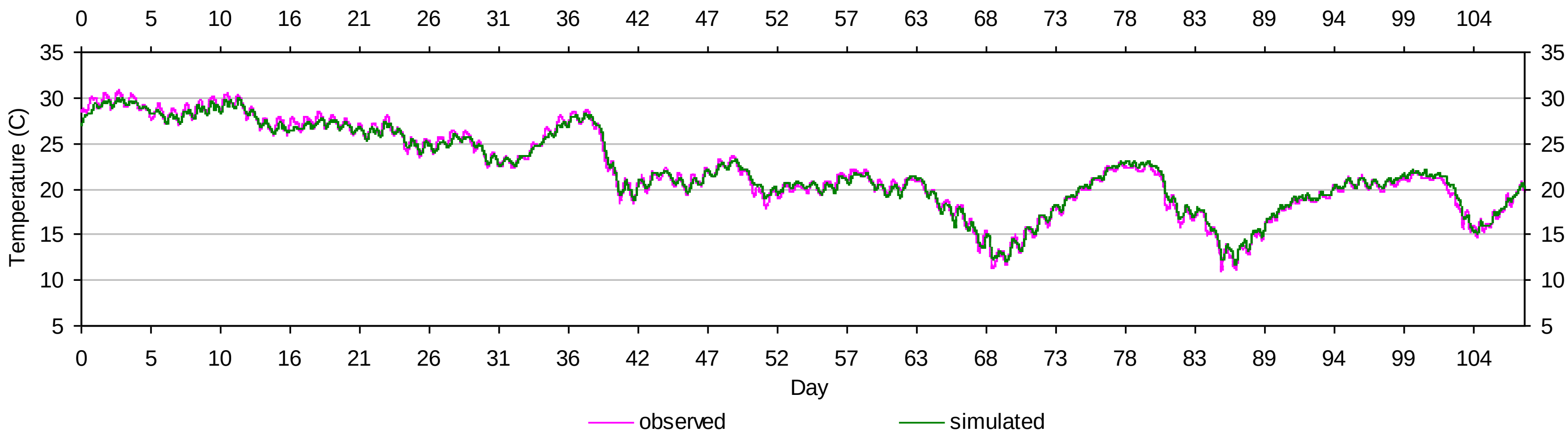


Figure G-5. Observed and simulated surface temperature at Shell Island gauge

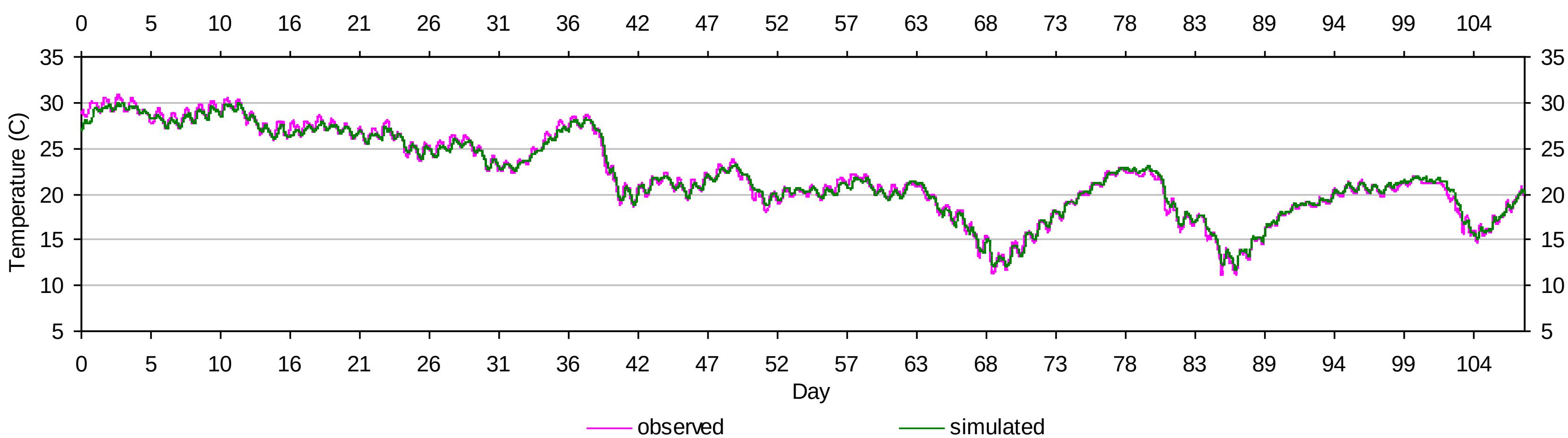


Figure G-6. Observed and simulated middle temperature at Shell Island gauge

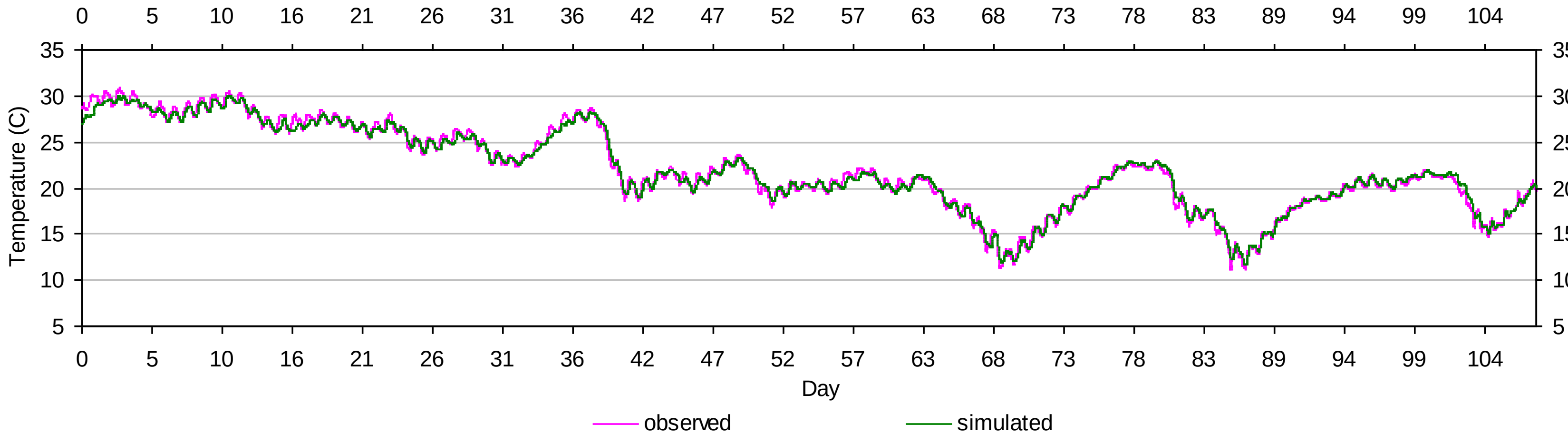


Figure G-7. Observed and simulated bottom temperature at Shell Island gauge

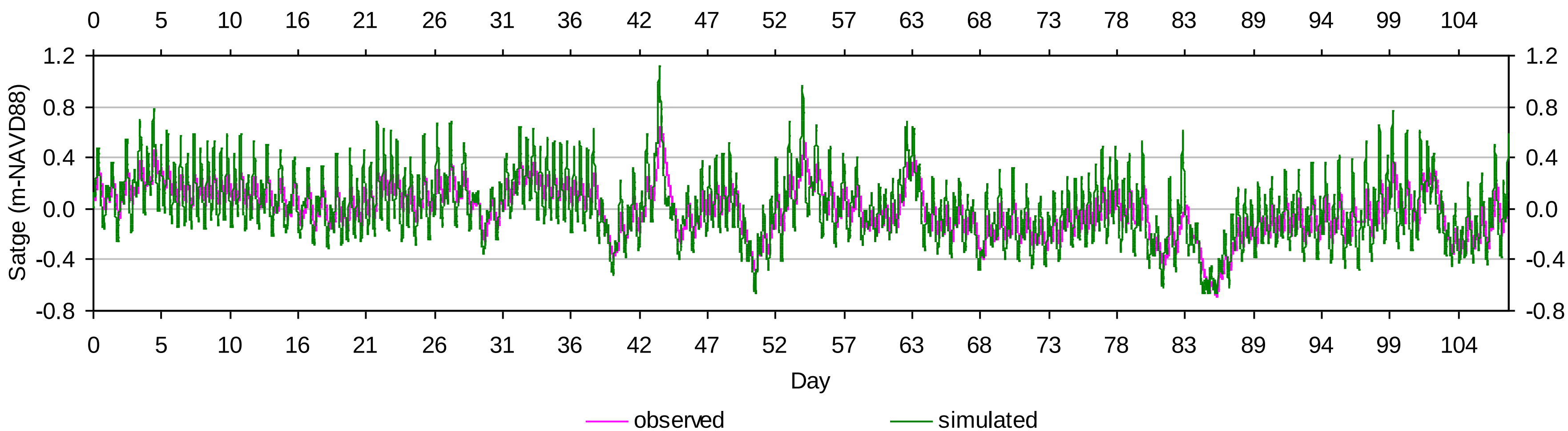


Figure G-8. Observed and simulated tidal stage at Halls River gauge

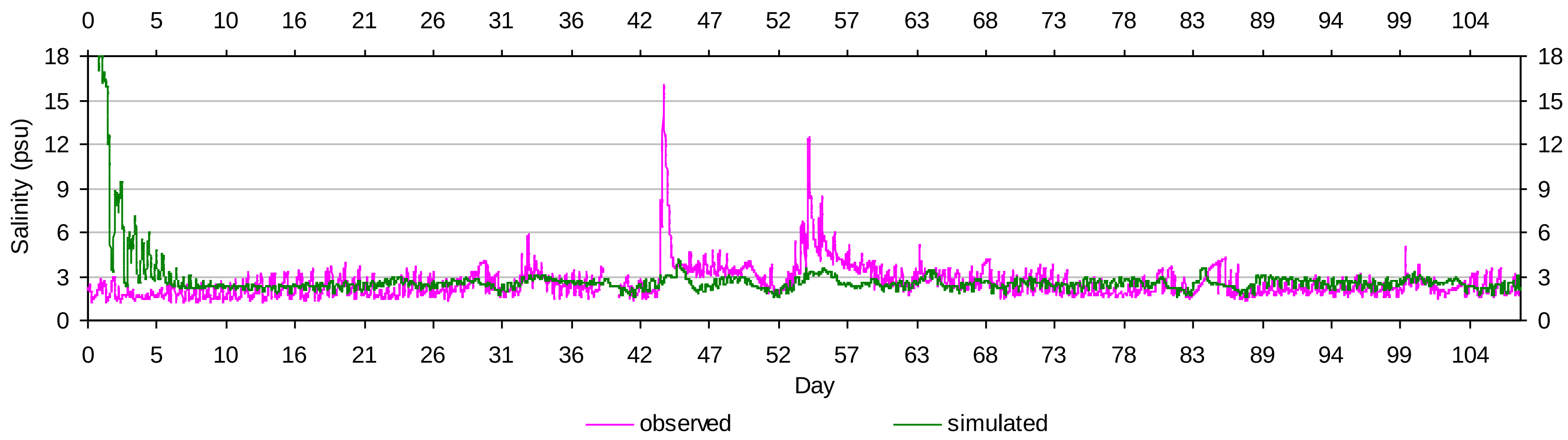


Figure G-9. Observed and simulated bottom salinity at Halls River gauge

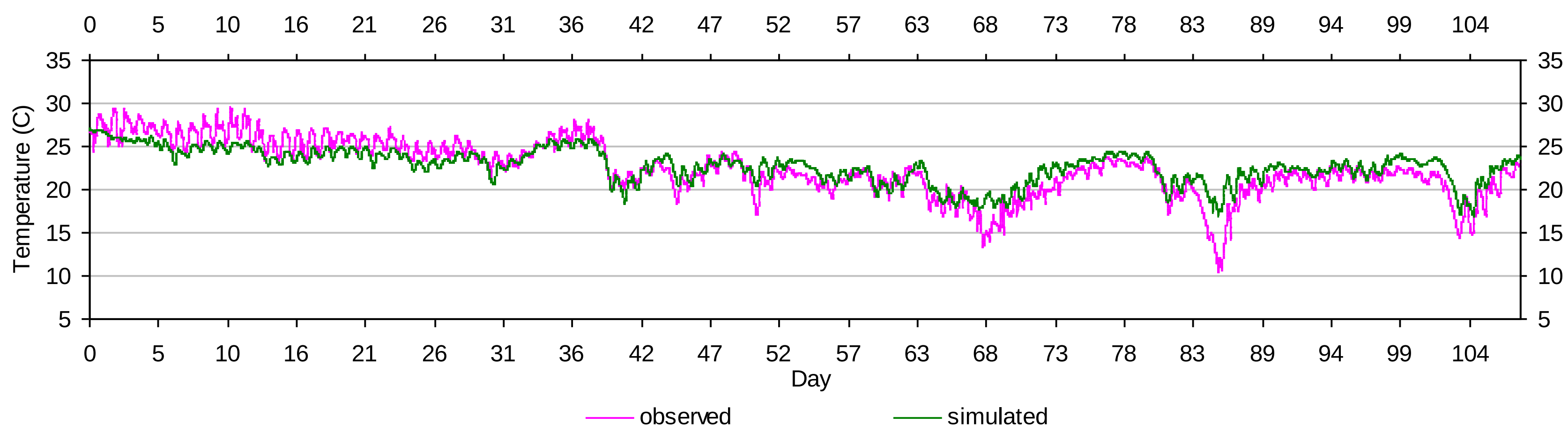


Figure G-10. Observed and simulated bottom temperature at Halls River gauge

Appendix H

Model Validation Results

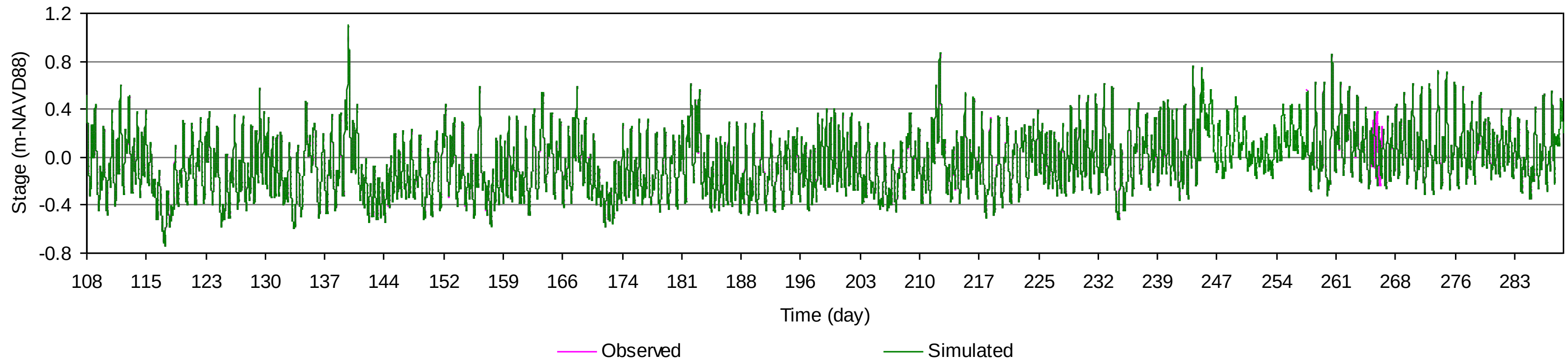


Figure H-1. Observed and simulated stages at Shell Island gauge

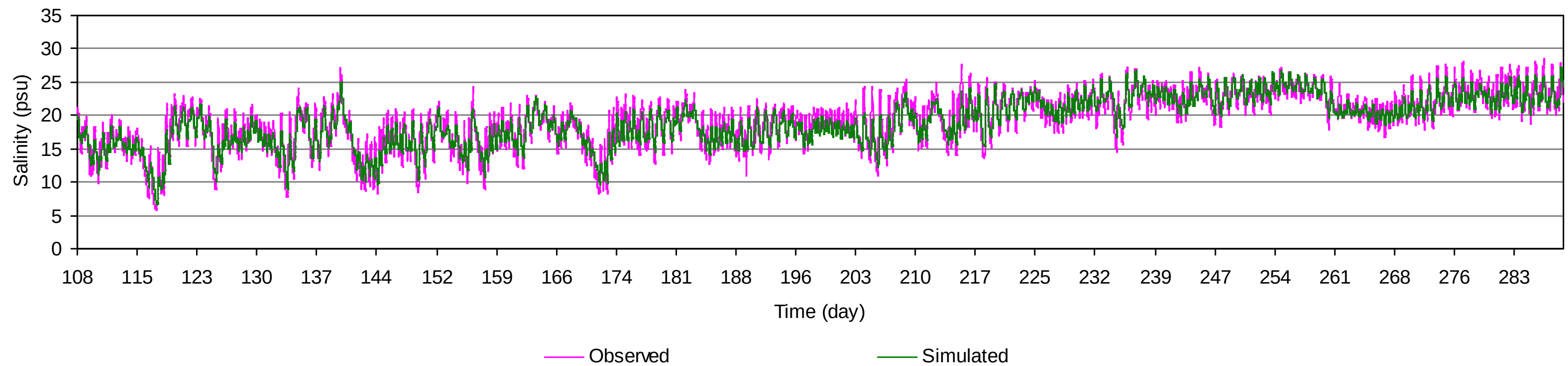


Figure H-2. Observed and simulated surface salinities at Shell Island gauge

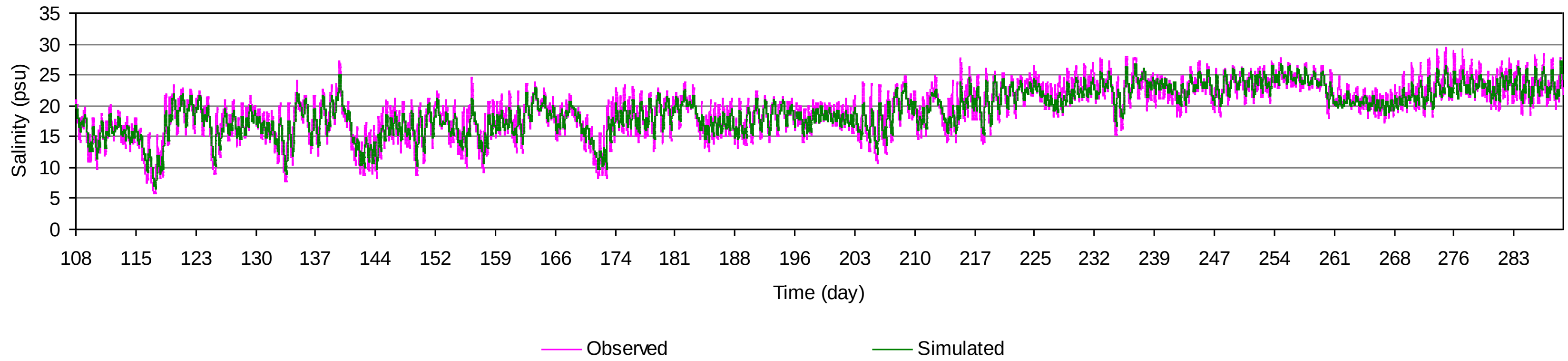


Figure H-3. Observed and simulated middle salinities at Shell Island gauge

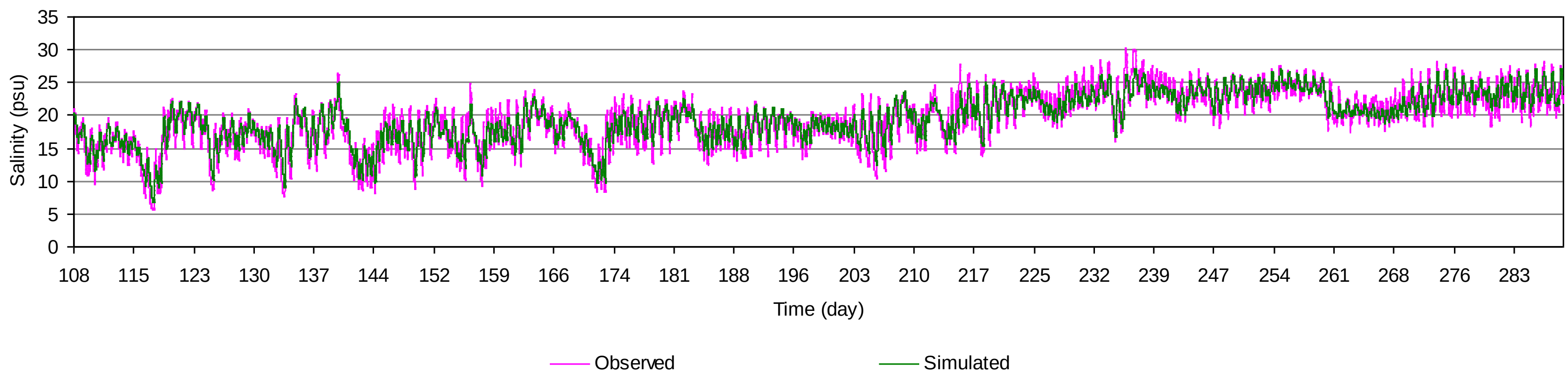


Figure H-4. Observed and simulated bottom salinities at Shell Island gauge

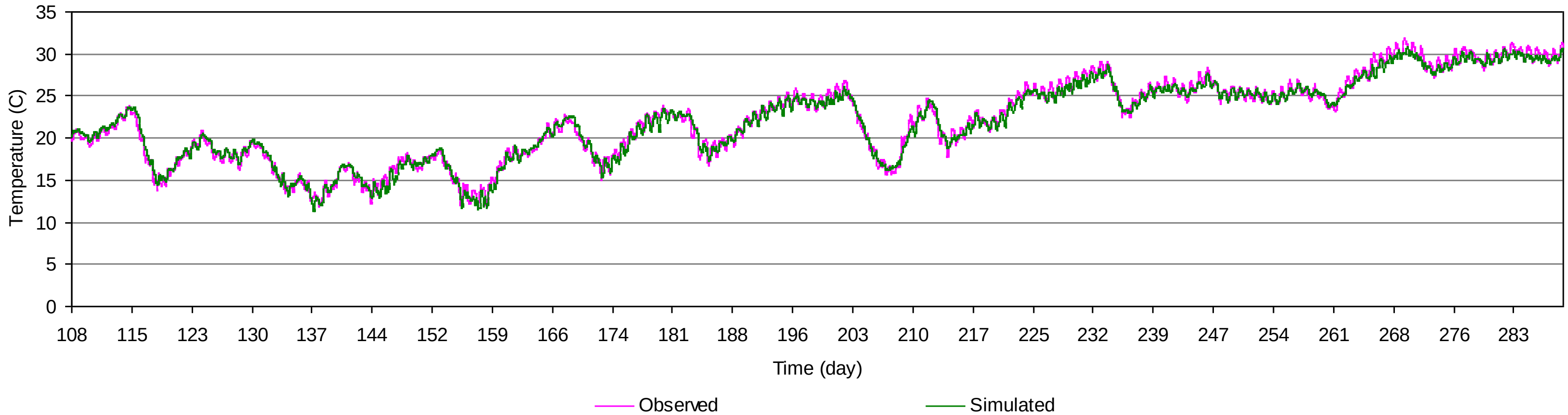


Figure H-5. Observed and simulated surface temperatures at Shell Island gauge

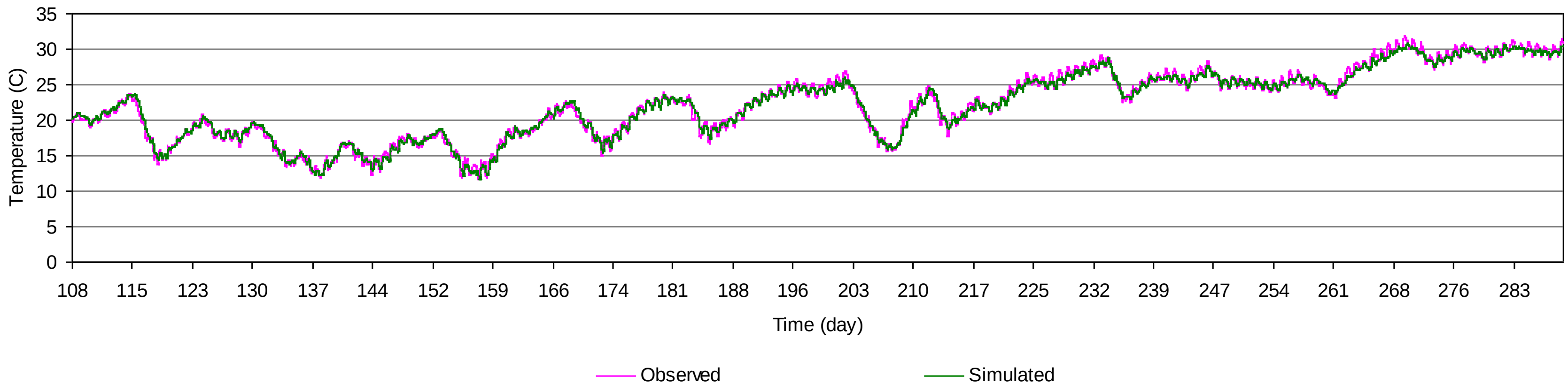


Figure H-6. Observed and simulated middle temperatures at Shell Island gauge

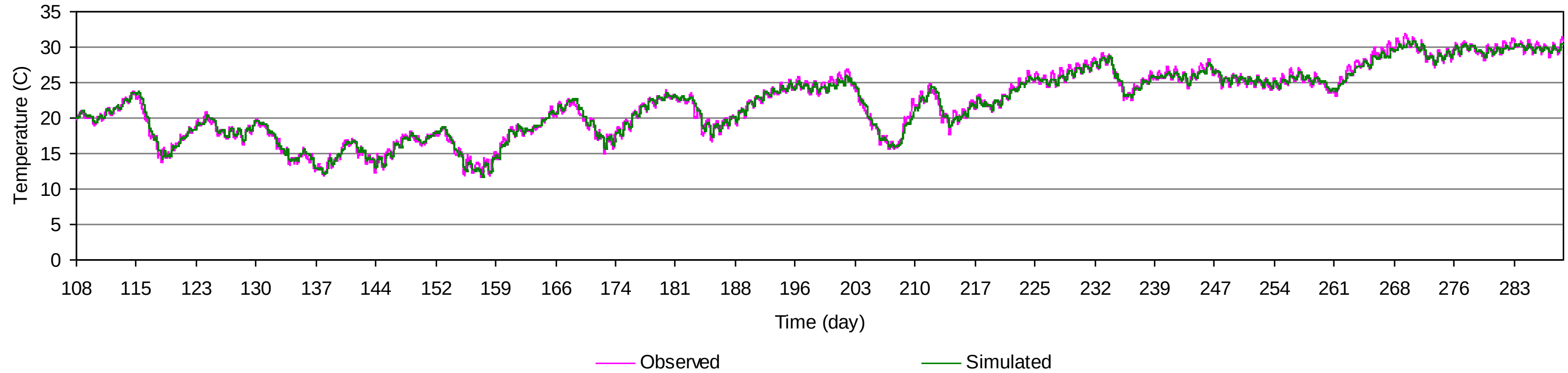


Figure H-7. Observed and simulated bottom temperatures at Shell Island gauge

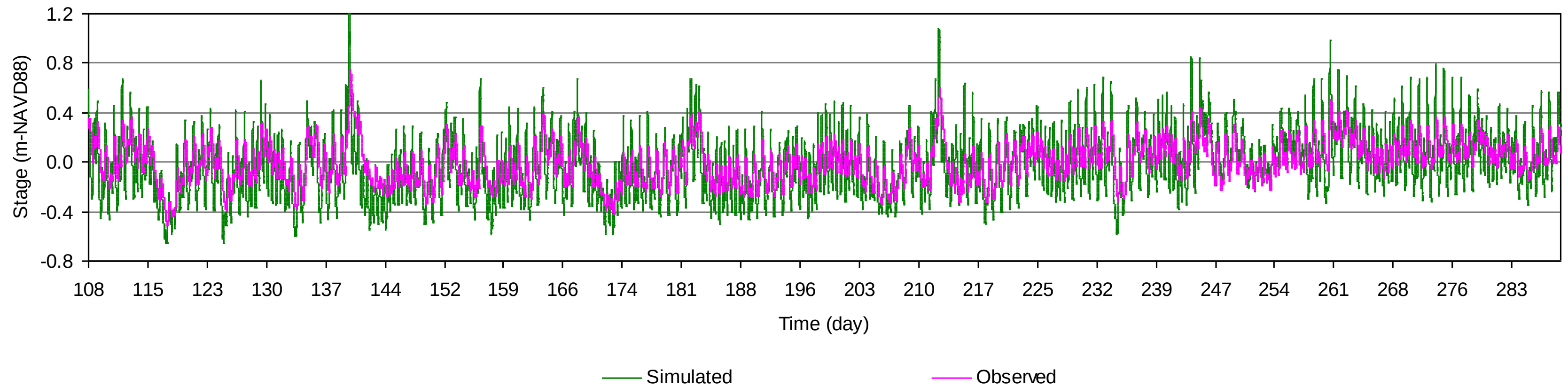


Figure H-8. Observed and simulated stages at Halls River gauge

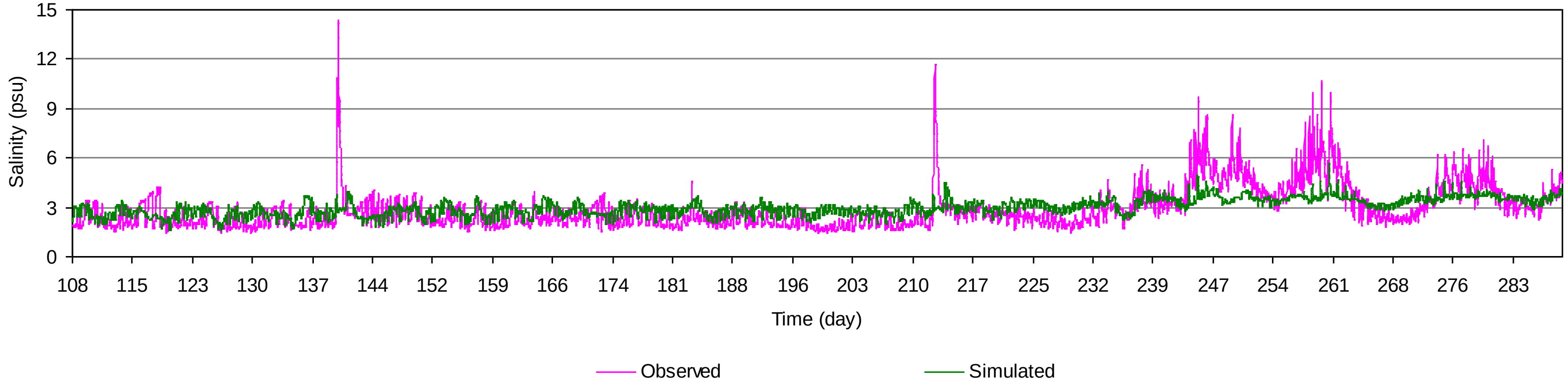


Figure H-9. Observed and simulated bottom salinities at Halls River gauge

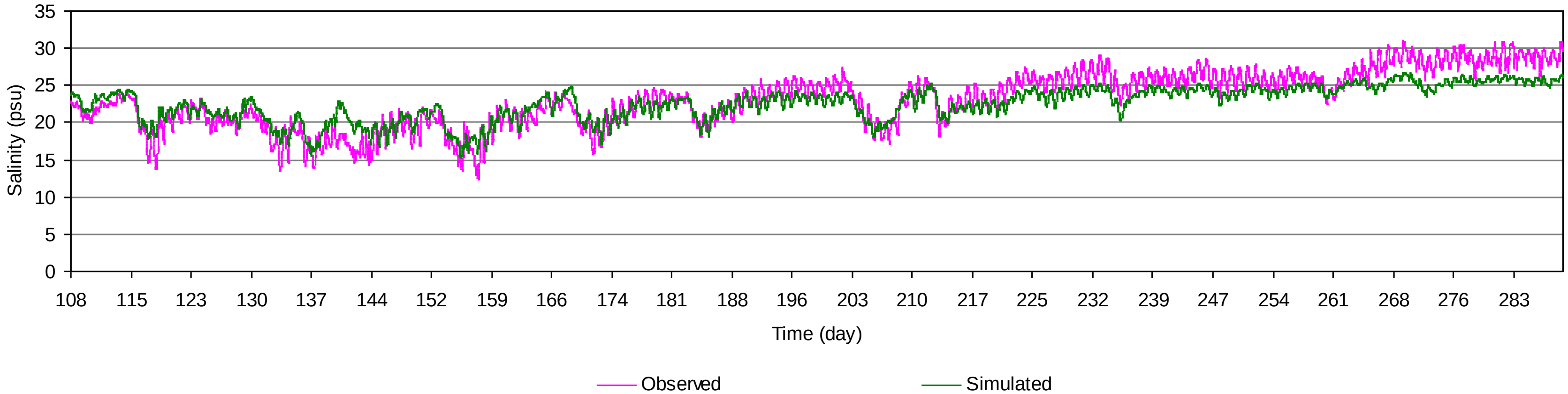


Figure H-10. Observed and simulated bottom temperatures at Halls River gauge

Appendix I

Statistical Modeling Results – SPSS Outputs

Appendix I

Statistical Modeling Results – SPSS Outputs

I-1
Fixed Location Mean Salinity Models

```
REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT shell_mean_sal
  /METHOD=STEPWISE TotSpring_Q homRiv_mean_ght
  /PARTIALPLOT ALL
  /RESIDUALS HIST(ZRESID) NORM(ZRESID)
  /SAVE PRED.
```

Regression

Notes

Output Created		2010-01-05T09:15:00.231
Comments		
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	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	3060
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used.
Syntax		REGRESSION /MISSING LISTWISE /STATISTICS COEFF OUTS R ANOVA /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT shell_mean_sal /METHOD=STEPWISE TotSpring_Q homRiv_mean_ght /PARTIALPLOT ALL /RESIDUALS HIST(ZRESID) NORM (ZRESID) /SAVE PRED.
Resources	Processor Time	0:00:00.922
	Elapsed Time	0:00:01.062
	Memory Required	3052 bytes
	Additional Memory Required for Residual Plots	1368 bytes
Variables Created or Modified	PRE_1	Unstandardized Predicted Value

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flow
s\Alldailydata.sav
```

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	TotSpring_Q	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	homRiv_mean_ght	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: shell_mean_sal

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.748[a]	.559	.558	2.21146233E0
2	.776[b]	.602	.600	2.10371746E0

a. Predictors: (Constant), TotSpring_Q

b. Predictors: (Constant), TotSpring_Q, homRiv_mean_ght

c. Dependent Variable: shell_mean_sal

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3818.539	1	3818.539	780.797	.000[a]
	Residual	3012.588	616	4.891		
	Total	6831.128	617			
2	Regression	4109.367	2	2054.684	464.269	.000[b]
	Residual	2721.761	615	4.426		
	Total	6831.128	617			

a. Predictors: (Constant), TotSpring_Q

b. Predictors: (Constant), TotSpring_Q, homRiv_mean_ght

c. Dependent Variable: shell_mean_sal

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	39.396	.683		57.642	.000
	TotSpring_Q	-.142	.005	-.748	-27.943	.000
2	(Constant)	47.302	1.172		40.355	.000

a. Dependent Variable: shell_mean_sal

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
2	TotSpring_Q	-.199	.009	-1.050	-23.255	.000
	homRiv_mean_ght	-2.277	.281	-.366	-8.106	.000

a. Dependent Variable: shell_mean_sal

Excluded Variables[b]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	homRiv_mean_ght	-.366[a]	-8.106	.000	-.311	.318

a. Predictors in the Model: (Constant), TotSpring_Q

b. Dependent Variable: shell_mean_sal

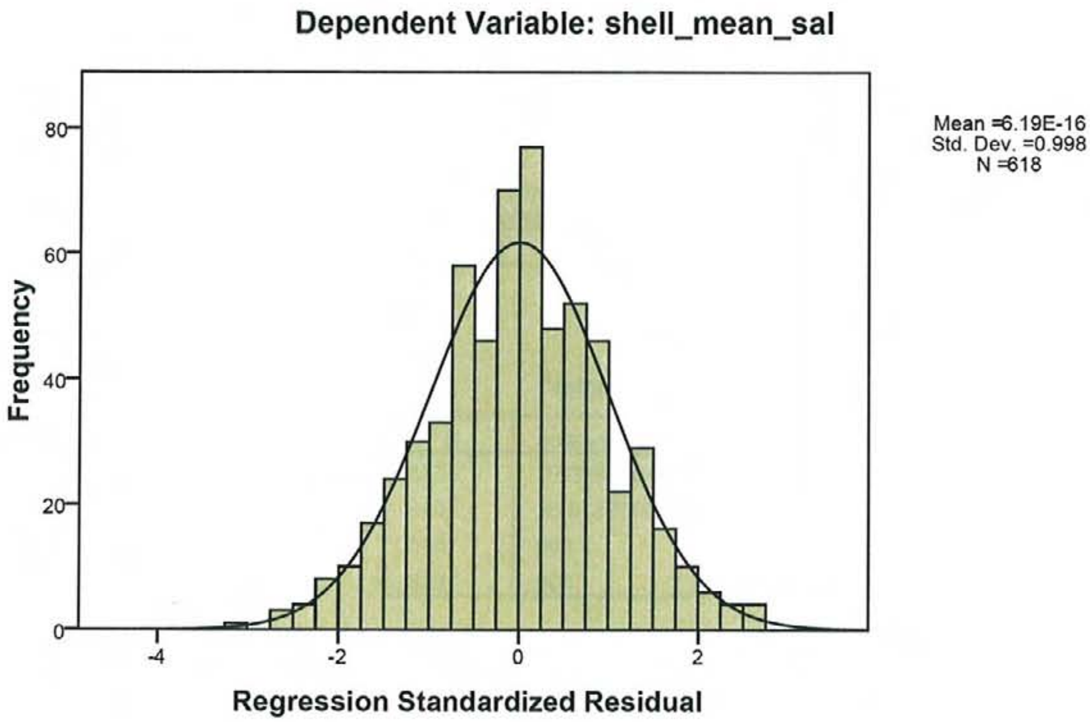
Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	1.1946E1	2.72034E1	2.0460E1	2.58074380E0	618
Residual	-6.8040E0	5.77577E0	...	2.10030510E0	618
Std. Predicted Value	-3.299	2.613	.000	1.000	618
Std. Residual	-3.234	2.746	.000	.998	618

a. Dependent Variable: shell_mean_sal

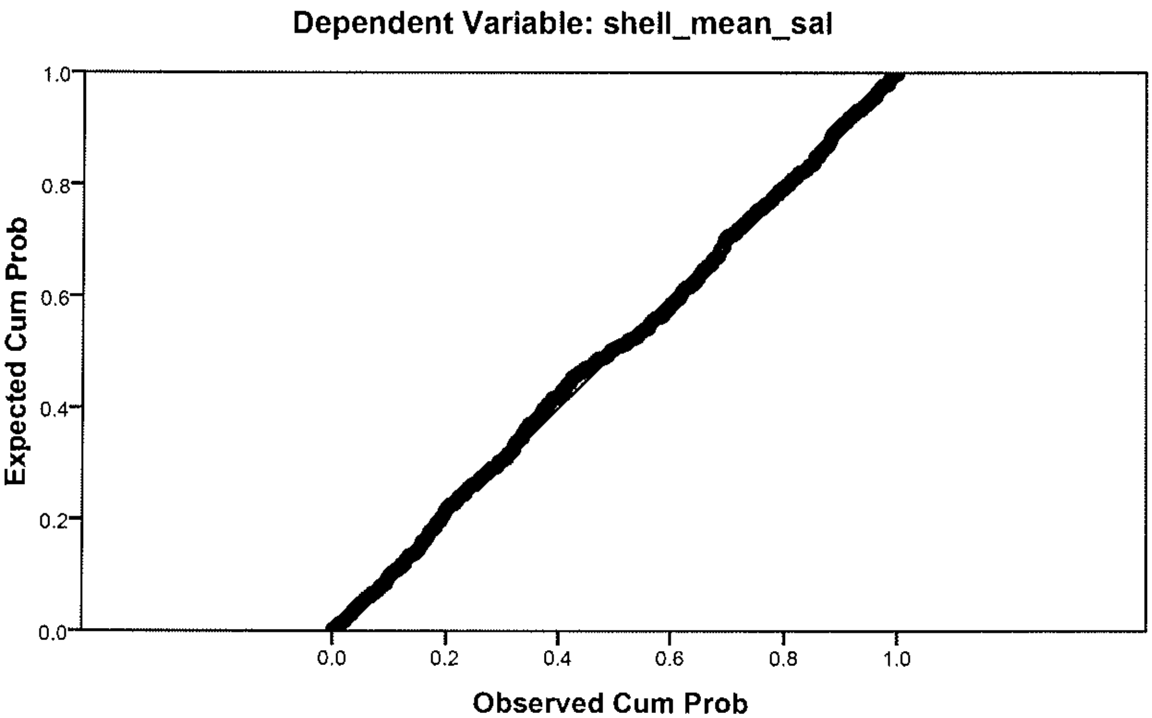
Charts

Histogram

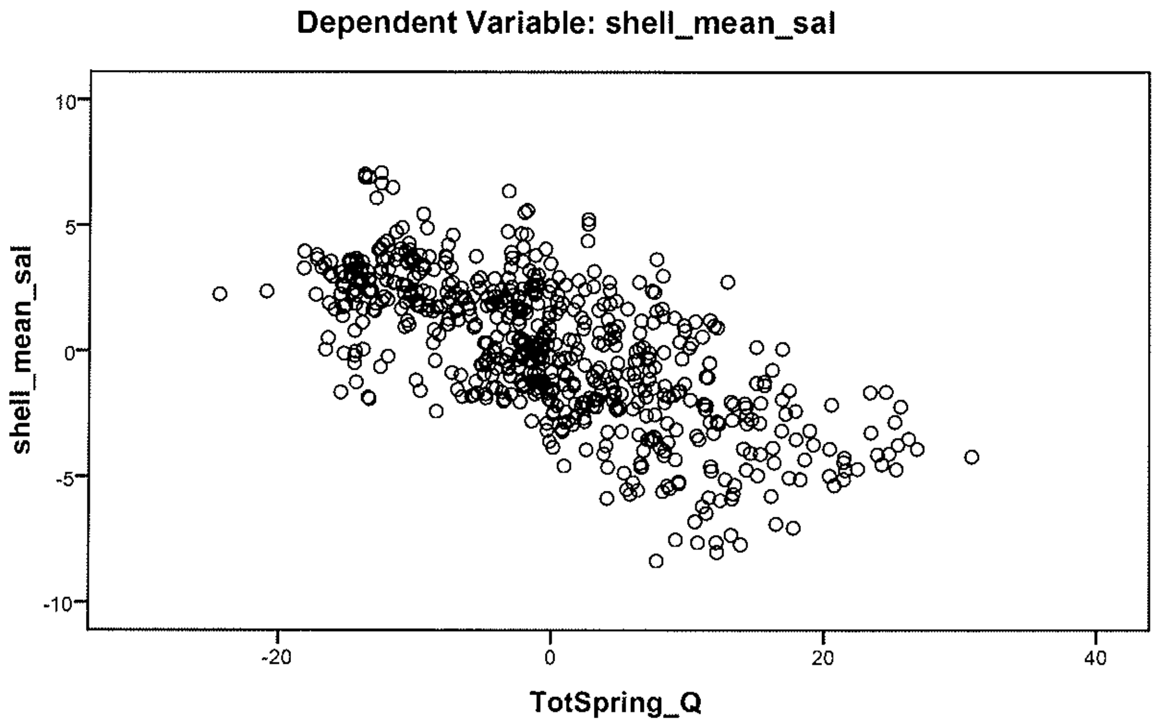


Dependent Variable: shell_mean_sal
Mean =6.19E-16
Std. Dev. =0.998
N =618
Frequency
80
60
40
20
0
-4
-2
0
2
Regression Standardized Residual

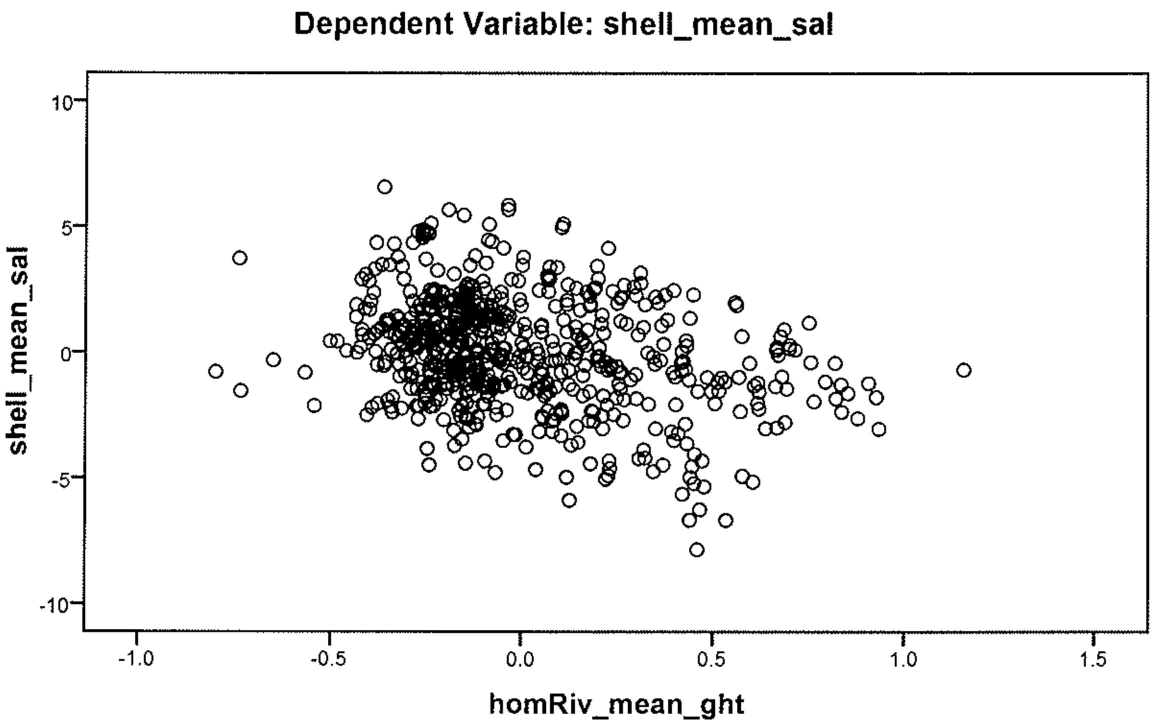
Normal P-P Plot of Regression Standardized Residual



Partial Regression Plot



Partial Regression Plot




```
GRAPH
  /SCATTERPLOT(OVERLAY)=TotSpring_Q TotSpring_Q WITH shell_mean_sal PRE_1 (PAIR)
  /MISSING=LISTWISE.
```

Graph

Notes

Output Created		2010-01-05T09:15:23.163
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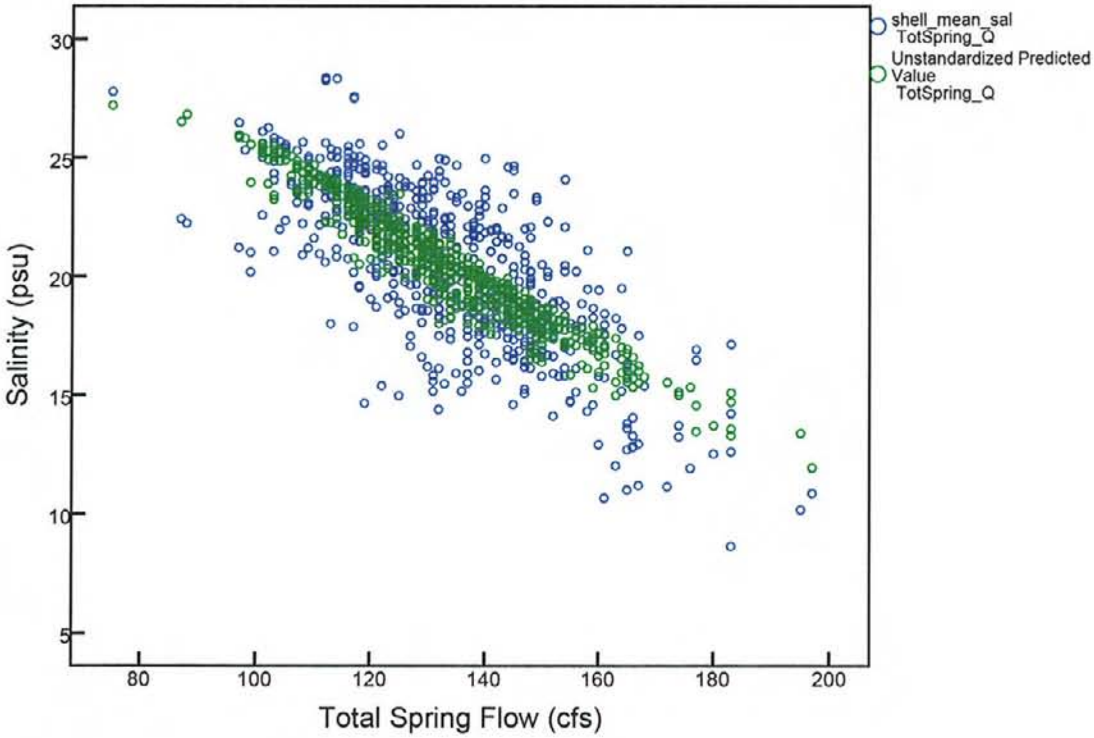
	N of Rows in Working Data File	3060

Notes

Syntax		GRAPH /SCATTERPLOT(OVERLAY) =TotSpring_Q TotSpring_Q WITH shell_mean_sal PRE_1 (PAIR) /MISSING=LISTWISE.
Resources	Processor Time	0:00:00.406
	Elapsed Time	0:00:00.407

[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flow s\Alldailydata.sav




```
COMPUTE xa=totspring_Q.
Compute xb=homRiv_mean_ght.
COMPUTE y1=homRiv_mean_sal.
MODEL PROGRAM ba0=22 ba1=-.1 bb1=1 ba2=0 knot1=150.
COMPUTE predex1 = ba0 +bb1*xb+ ba1*xa + ba2*(xa-knot1)*(xa ge knot1).
        CNLR y1 / PRED = predex1 /SAVE pred resid (residex1)
             /CRITERIA=ITER 100
        /BOUNDS knot1>10.
```

Constrained Nonlinear Regression Analysis

Notes

Output Created	2010-01-05T09:17:33.247
Comments	

Notes

Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flows\Alldailydata.sav
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	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	3060
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used. Predicted values are calculated for cases with missing values on the dependent variable.
Syntax		MODEL PROGRAM ba0=22 ba1=-.1 bb1=1 ba2=0 knot1=150. COMPUTE predex1 = ba0 +bb1*xb+ ba1*xa + ba2*(xa-knot1)*(xa ge knot1). CNLR y1 / PRED = predex1 /SAVE pred resid (residex1) /CRITERIA=ITER 100 /BOUNDS knot1>10.
Resources	Processor Time	0:00:00.219
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Variables Created or Modified	predex1	Predicted Values
	residex1	Residuals

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flow
s\Alldailydata.sav
```

Iteration History[b]

Iteration Number[a]	Residual Sum of Squares	Parameter				
		ba0	ba1	bb1	ba2	knot1
0.1	15575.361	22.000	-.100	1.000	.000	150.000
1.1	2222.113	22.000	-.133	1.000	.000	150.000
2.1	1583.010	21.992	-.136	.962	.252	150.000
3.1	1257.501	21.683	-.131	-.777	.123	149.893
4.1	1239.401	24.023	-.148	-1.069	.157	146.848
5.1	1216.234	24.094	-.150	-.783	.161	142.015
6.1	1138.760	27.762	-.178	-.971	.122	135.007
7.1	1112.304	25.711	-.165	-.523	.104	133.705
8.1	1090.580	26.328	-.171	-.560	.135	133.142
9.1	1084.883	28.031	-.184	-.738	.130	130.778
10.1	1082.123	28.792	-.190	-.826	.128	130.187

Derivatives are calculated numerically.

a. Major iteration number is displayed to the left of the decimal, and minor iteration number is to the right of the decimal.

b. Run stopped after 21 iterations. Optimal solution is found.

Iteration History[b]

Iteration Number[a]	Residual Sum of Squares	Parameter				
		ba0	ba1	bb1	ba2	knot1
11.1	1078.607	28.952	-.192	-.718	.134	129.351
12.1	1075.039	29.708	-.200	-.657	.141	127.642
13.1	1073.458	30.121	-.203	-.678	.144	127.364
14.1	1072.832	30.485	-.206	-.720	.144	127.144
15.1	1072.813	30.562	-.207	-.727	.145	127.050
16.1	1072.810	30.628	-.207	-.746	.145	127.074
17.1	1072.806	30.601	-.207	-.739	.144	127.057
18.1	1072.806	30.599	-.207	-.739	.144	127.057
19.1	1072.806	30.598	-.207	-.739	.144	127.057
20.1	1072.806	30.598	-.207	-.739	.144	127.057
21.1	1072.806	30.598	-.207	-.739	.144	127.057

Derivatives are calculated numerically.

a. Major iteration number is displayed to the left of the decimal, and minor iteration number is to the right of the decimal.

b. Run stopped after 21 iterations. Optimal solution is found.

Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
ba0	30.598	1.172	28.297	32.898
ba1	-.207	.010	-.226	-.188
bb1	-.739	.191	-1.115	-.363
ba2	.144	.011	.124	.165
knot1	127.057	1.107	124.883	129.232

Correlations of Parameter Estimates

	ba0	ba1	bb1	ba2	knot1
ba0	1.000	-.995	-.514	.617	-.519
ba1	-.995	1.000	.450	-.658	.564
bb1	-.514	.450	1.000	.158	.127
ba2	.617	-.658	.158	1.000	-.147
knot1	-.519	.564	.127	-.147	1.000

ANOVA[a]

Source	Sum of Squares	df	Mean Squares
Regression	15712.373	5	3142.475
Residual	1072.806	677	1.585
Uncorrected Total	16785.180	682	
Corrected Total	3097.175	681	

Dependent variable: y1

a. R squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares) = .654.

GRAPH

```
/SCATTERPLOT(OVERLAY)=TotSpring_Q TotSpring_Q WITH homRiv_mean_sal predex1 (PAIR)
/MISSING=LISTWISE.
```

Graph

Notes

Output Created		2010-01-05T09:18:46.373
Comments		
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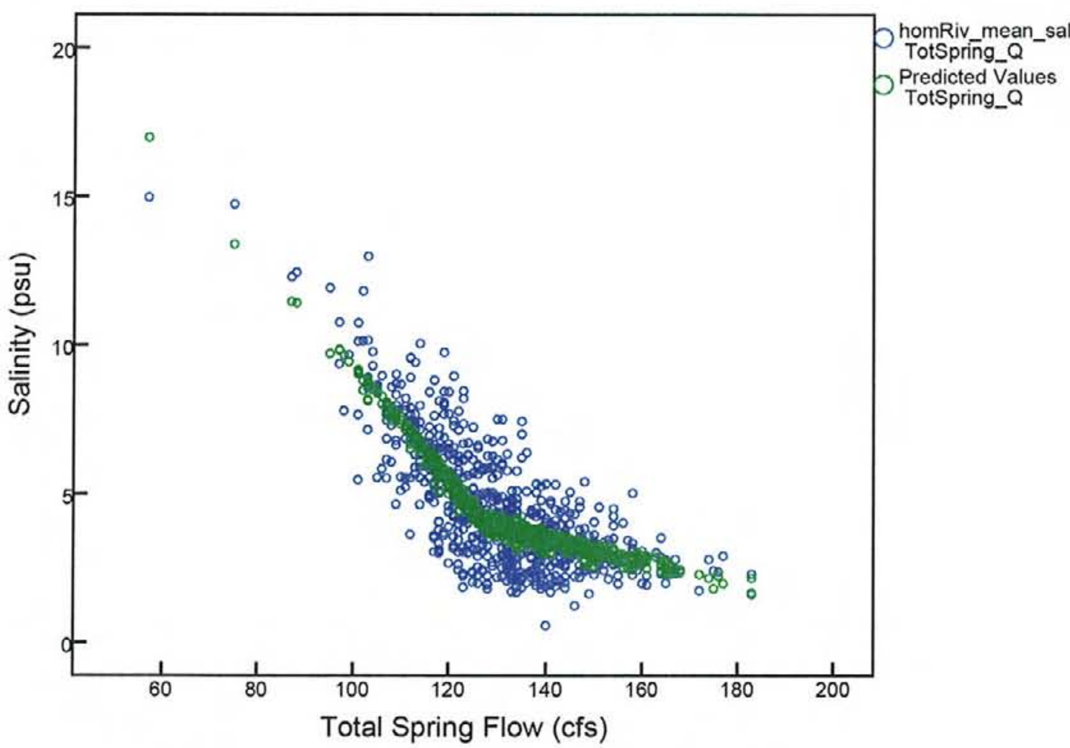
	Split File	<none>
	N of Rows in Working Data File	3060
Syntax		GRAPH /SCATTERPLOT(OVERLAY) =TotSpring_Q TotSpring_Q WITH homRiv_mean_sal predex1 (PAIR) /MISSING=LISTWISE.
Resources	Processor Time	0:00:00.390
	Elapsed Time	0:00:00.407

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flow
s\Alldailydata.sav
```



```
COMPUTE xa=totspring_Q.
Compute xb=homRiv_mean_ght.
COMPUTE y1=halls_bot_mean_sal.
MODEL PROGRAM ba0=22 ba1=-.1 bb1=1 ba2=0 knot1=150.
COMPUTE predex1 = ba0 +bb1*xb+ ba1*xa + ba2*(xa-knot1)*(xa ge knot1).
        CNLR y1 / PRED = predex1 /SAVE pred resid (residex1)
             /CRITERIA=ITER 100
        /BOUNDS knot1>10.
```

Constrained Nonlinear Regression Analysis

Notes

Output Created		2010-01-05T09:20:06.982
Comments		
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	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	3060
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used. Predicted values are calculated for cases with missing values on the dependent variable.
Syntax		MODEL PROGRAM ba0=22 ba1=-.1 bb1=1 ba2=0 knot1=150. COMPUTE predex1 = ba0 +bb1*xb+ ba1*xa + ba2*(xa-knot1)*(xa ge knot1). CNLR y1 / PRED = predex1 /SAVE pred resid (residex1) /CRITERIA=ITER 100 /BOUNDS knot1>10.
Resources	Processor Time	0:00:00.265
	Elapsed Time	0:00:00.281
Variables Created or Modified	predex1_1	Predicted Values
	residex1_1	Residuals

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flow
s\Alldailydata.sav
```

Iteration History[b]

Iteration Number[a]	Residual Sum of Squares	Parameter				
		ba0	ba1	bb1	ba2	knot1
0.1	29568.781	22.000	-.100	1.000	.000	150.000
1.1	5188.689	22.000	-.143	1.000	-8.877E-5	150.000
2.1	2793.274	21.987	-.148	.953	.360	150.000
3.1	2031.655	20.308	-.127	-4.983	-.023	149.434
4.1	973.833	.770	.015	-.495	.011	141.532
5.1	568.280	4.973	-.017	.103	-.012	145.614
6.1	453.120	8.582	-.044	.035	.065	141.472
7.1	438.405	8.058	-.042	.173	.088	139.042
8.1	437.278	7.220	-.036	.190	.072	141.034
9.1	426.078	7.891	-.041	.203	.078	140.150
10.1	424.255	8.064	-.042	.220	.082	139.346
11.1	420.643	8.410	-.045	.249	.085	137.649
12.1	418.041	8.880	-.050	.284	.089	135.302
13.1	405.020	9.488	-.055	.261	.081	132.377
14.1	396.170	10.552	-.064	.263	.084	128.754
15.1	394.529	10.953	-.068	.260	.085	127.390
16.1	393.227	11.325	-.071	.213	.087	126.928
17.1	390.662	11.981	-.076	.138	.091	126.135
18.1	388.618	12.498	-.081	.133	.096	125.397
19.1	387.642	12.822	-.084	.162	.100	125.179
20.1	387.430	13.117	-.087	.196	.103	124.815
21.1	387.372	13.132	-.087	.205	.104	125.142
22.1	387.338	13.114	-.087	.198	.104	125.066
23.1	387.336	13.127	-.087	.198	.104	125.046
24.1	387.336	13.130	-.087	.198	.104	125.044
25.1	387.336	13.130	-.087	.198	.104	125.045

Derivatives are calculated numerically.

a. Major iteration number is displayed to the left of the decimal, and minor iteration number is to the right of the decimal.

b. Run stopped after 25 iterations. Optimal solution is found.

Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
ba0	13.130	.763	11.633	14.628
ba1	-.087	.006	-.100	-.074
bb1	.198	.097	.008	.389
ba2	.104	.007	.091	.117
knot1	125.045	.915	123.247	126.842

Correlations of Parameter Estimates

	ba0	ba1	bb1	ba2	knot1
ba0	1.000	-.996	-.404	.777	-.582

Correlations of Parameter Estimates

	ba0	ba1	bb1	ba2	knot1
ba1	-.996	1.000	.348	-.806	.618
bb1	-.404	.348	1.000	.115	.167
ba2	.777	-.806	.115	1.000	-.315
knot1	-.582	.618	.167	-.315	1.000

ANOVA[a]

Source	Sum of Squares	df	Mean Squares
Regression	5661.483	5	1132.297
Residual	387.336	719	.539
Uncorrected Total	6048.819	724	
Corrected Total	589.987	723	

Dependent variable: y1

a. R squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares) = .343.

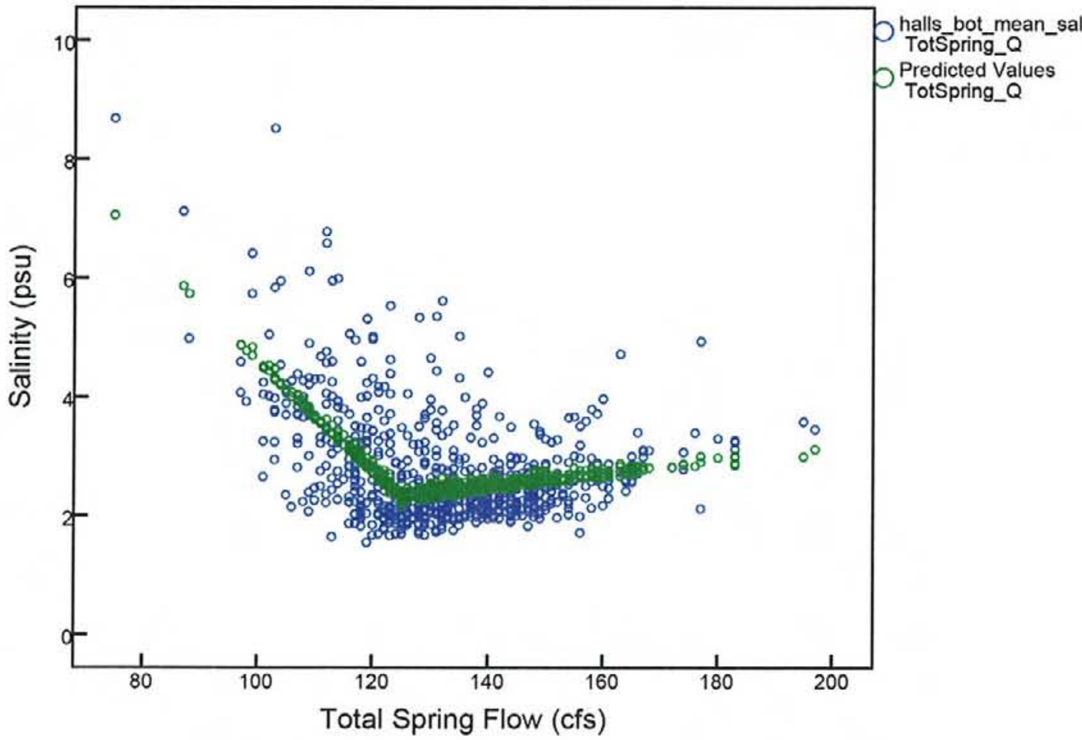
```
GRAPH
  /SCATTERPLOT(OVERLAY)=TotSpring_Q TotSpring_Q WITH halls_bot_mean_sal predex1_1 (PAIR)
  /MISSING=LISTWISE.
```

Graph

Notes

Output Created		2010-01-05T09:20:41.288
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flows\Alldailydata.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	3060
Syntax		GRAPH /SCATTERPLOT(OVERLAY) =TotSpring_Q TotSpring_Q WITH halls_bot_mean_sal predex1_1 (PAIR) /MISSING=LISTWISE.
Resources	Processor Time	0:00:00.453
	Elapsed Time	0:00:00.469

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flow
s\Alldailydata.sav
```



halls_bot_mean_sal
TotSpring_Q
Predicted Values
TotSpring_Q
Salinity (psu)
Total Spring Flow (cfs)
0
2
4
6
8
10
80
100
120
140
160
180
200

I-2
Fixed Location Models for Homosassa River and Shell Island Gauge

```
GET
  FILE='\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flows\A
lldailydata.sav'.
DATASET NAME DataSet1 WINDOW=FRONT.
COMPUTE xa=totspring_Q.
Compute xb=homRiv_mean_ght.
COMPUTE y1=homRiv_top_mean_sal.
MODEL PROGRAM ba0=22 ba1=-.1 bb1=1 ba2=0 knot1=150.
COMPUTE predex1 = ba0 +bb1*xb+ ba1*xa + ba2*(xa-knot1)*(xa ge knot1).
        CNLR y1 / PRED = predex1 /SAVE pred resid (residex1)
             /CRITERIA=ITER 100
        /BOUNDS knot1>10.
```

Constrained Nonlinear Regression Analysis

Notes

Output Created		2010-01-05T10:51:25.812
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flows\Alldailydata.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	3060
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used. Predicted values are calculated for cases with missing values on the dependent variable.
Syntax		MODEL PROGRAM ba0=22 ba1=-.1 bb1=1 ba2=0 knot1=150. COMPUTE predex1 = ba0 +bb1*xb+ ba1*xa + ba2*(xa-knot1)*(xa ge knot1). CNLR y1 / PRED = predex1 /SAVE pred resid (residex1) /CRITERIA=ITER 100 /BOUNDS knot1>10.
Resources	Processor Time	0:00:00.203
	Elapsed Time	0:00:00.500
Variables Created or Modified	predex1_2	Predicted Values
	residex1_2	Residuals

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flow
s\Alldailydata.sav
```

Iteration History[b]

Iteration Number[a]	Residual Sum of Squares	Parameter				
		ba0	ba1	bb1	ba2	knot1
0.1	18881.486	22.000	-.100	1.000	.000	150.000
1.1	2475.376	22.000	-.136	1.000	.000	150.000
2.1	1702.596	21.991	-.138	.960	.265	150.000
3.1	1288.675	21.606	-.132	-.938	.126	149.876
4.1	1264.302	19.255	-.115	-.374	.139	147.300
5.1	1236.851	21.023	-.129	-.416	.156	143.829
6.1	1168.951	23.382	-.148	-.150	.137	136.500
7.1	1146.168	23.626	-.151	-.156	.122	136.069
8.1	1106.644	23.961	-.155	-.209	.122	132.450
9.1	1103.468	24.584	-.161	-.231	.128	131.388
10.1	1101.421	25.147	-.166	-.247	.131	130.777
11.1	1093.511	27.773	-.188	-.297	.144	127.304
12.1	1093.207	27.497	-.186	-.251	.145	127.452
13.1	1093.046	27.417	-.186	-.247	.144	127.385
14.1	1092.912	27.393	-.185	-.259	.142	127.274
15.1	1092.899	27.121	-.183	-.266	.140	127.484
16.1	1092.847	27.249	-.184	-.263	.141	127.318
17.1	1092.845	27.249	-.184	-.263	.141	127.344
18.1	1092.845	27.247	-.184	-.263	.141	127.345
19.1	1092.845	27.247	-.184	-.263	.141	127.345

Derivatives are calculated numerically.

a. Major iteration number is displayed to the left of the decimal, and minor iteration number is to the right of the decimal.

b. Run stopped after 19 iterations. Optimal solution is found.

Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
ba0	27.247	1.098	25.091	29.402
ba1	-.184	.009	-.202	-.166
bb1	-.263	.165	-.586	.060
ba2	.141	.010	.121	.161
knot1	127.345	1.075	125.235	129.455

Correlations of Parameter Estimates

	ba0	ba1	bb1	ba2	knot1
ba0	1.000	-.995	-.456	.664	-.544
ba1	-.995	1.000	.392	-.701	.589
bb1	-.456	.392	1.000	.155	.118
ba2	.664	-.701	.155	1.000	-.197
knot1	-.544	.589	.118	-.197	1.000

ANOVA[a]

Source	Sum of Squares	df	Mean Squares
Regression	14206.801	5	2841.360
Residual	1092.845	722	1.514
Uncorrected Total	15299.646	727	
Corrected Total	2860.634	726	

Dependent variable: y1

a. R squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares) = .618.

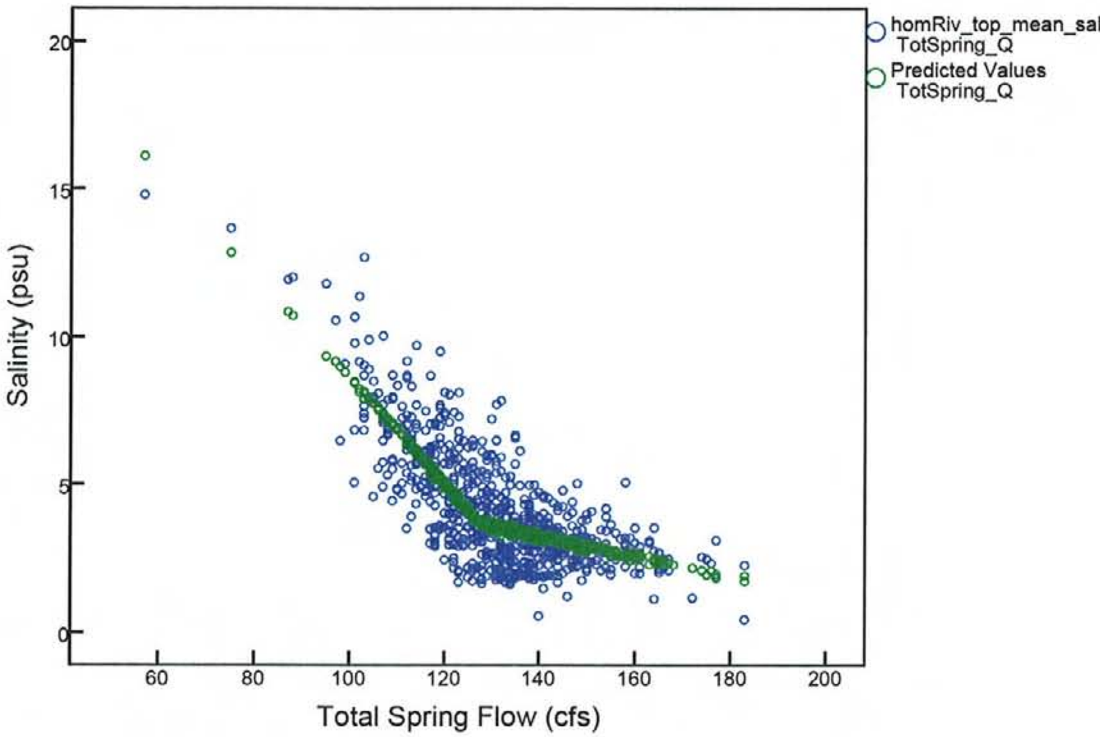
```
GRAPH
  /SCATTERPLOT(OVERLAY)=TotSpring_Q TotSpring_Q WITH homRiv_top_mean_sal predex1_2 (PAIR)
  /MISSING=LISTWISE.
```

Graph

Notes

Output Created		2010-01-05T10:52:20.521
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flows\Alldailydata.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	3060
Syntax		GRAPH /SCATTERPLOT(OVERLAY) =TotSpring_Q TotSpring_Q WITH homRiv_top_mean_sal predex1_2 (PAIR) /MISSING=LISTWISE.
Resources	Processor Time	0:00:00.515
	Elapsed Time	0:00:00.687

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flow
s\Alldailydata.sav
```




```
COMPUTE xa=totspring_Q.
Compute xb=homRiv_mean_ght.
COMPUTE y1=homRiv_bot_mean_sal.
MODEL PROGRAM ba0=22 ba1=-.1 bb1=1 ba2=0 ba3=0 knot1=130 knot2=150.
COMPUTE predex1 = ba0 +bb1*xb+ ba1*xa + ba2*(xa-knot1)*(xa ge knot1)
                + ba3*(xa-knot2)*(xa ge knot2).
        CNLR y1 / PRED = predex1 /SAVE pred resid (residex1)
             /CRITERIA=ITER 100
        /BOUNDS knot1>10.
```

Constrained Nonlinear Regression Analysis

Notes

Output Created		2010-01-05T10:59:37.789
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flows\Alldailydata.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	3060
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.

Notes

Missing Value Handling	Cases Used	Statistics are based on cases with no missing values for any variable used. Predicted values are calculated for cases with missing values on the dependent variable.
Syntax		MODEL PROGRAM ba0=22 ba1=-.1 bb1=1 ba2=0 ba3=0 knot1=130 knot2=150. COMPUTE predex1 = ba0 +bb1*xb+ ba1*xa + ba2*(xa-knot1)*(xa ge knot1) + ba3*(xa-knot2)*(xa ge knot2). CNLR y1 / PRED = predex1 /SAVE pred resid (residex1) /CRITERIA=ITER 100 /BOUNDS knot1>10.
Resources	Processor Time	0:00:00.328
	Elapsed Time	0:00:00.625
Variables Created or Modified	predex1_3	Predicted Values
	residex1_3	Residuals

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flow
s\Alldailydata.sav
```

Iteration History[b]

Iteration Number[a]	Residual Sum of Squares	Parameter						
		ba0	ba1	bb1	ba2	ba3	knot1	knot2
0.1	24902.175	22.000	-.100	1.000	.000	.000	130.000	150.000
1.1	8436.911	22.000	-.122	1.000	-.002	.000	130.000	150.000
2.1	2464.138	21.999	-.139	.999	.068	.057	130.000	150.000
3.1	2437.365	22.000	-.137	.982	.046	.084	130.000	150.000
4.1	2099.130	22.026	-.134	-.105	.032	.084	130.001	150.013
5.1	1994.148	28.454	-.186	-.281	.106	.058	130.327	151.016
6.1	1985.476	28.990	-.190	-.294	.111	.058	129.442	151.103
7.1	1969.256	29.396	-.194	-.271	.115	.060	127.084	157.605
8.1	1951.786	29.225	-.193	-.261	.114	.064	127.193	158.254
9.1	1945.097	29.839	-.199	-.260	.126	.061	126.845	159.737
10.1	1940.320	30.227	-.202	-.256	.128	.068	126.253	162.573
11.1	1939.050	30.470	-.204	-.266	.132	.065	126.590	162.118
12.1	1938.774	30.567	-.205	-.267	.133	.064	126.608	162.521
13.1	1938.644	30.625	-.206	-.270	.135	.063	126.739	162.742
14.1	1938.640	30.609	-.206	-.270	.134	.063	126.723	162.773
15.1	1938.637	30.593	-.205	-.270	.134	.063	126.740	162.821
16.1	1938.632	30.567	-.205	-.269	.134	.063	126.786	162.813
17.1	1938.632	30.566	-.205	-.269	.134	.063	126.790	162.815

Derivatives are calculated numerically.

a. Major iteration number is displayed to the left of the decimal, and minor iteration number is to the right of the decimal.

b. Run stopped after 19 iterations. Optimal solution is found.

Iteration History[b]

Iteration Number[a]	Residual Sum of Squares	Parameter						
		ba0	ba1	bb1	ba2	ba3	knot1	knot2
18.1	1938.632	30.560	-.205	-.269	.134	.063	126.794	162.839
19.1	1938.632	30.560	-.205	-.269	.134	.063	126.794	162.838

Derivatives are calculated numerically.

a. Major iteration number is displayed to the left of the decimal, and minor iteration number is to the right of the decimal.

b. Run stopped after 19 iterations. Optimal solution is found.

Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
ba0	30.560	.987	28.624	32.495
ba1	-.205	.008	-.222	-.189
bb1	-.269	.073	-.413	-.126
ba2	.134	.009	.116	.153
ba3	.063	.006	.052	.075
knot1	126.794	1.074	124.686	128.902
knot2	162.838	2.047	158.822	166.855

Correlations of Parameter Estimates

	ba0	ba1	bb1	ba2	ba3	knot1	knot2
ba0	1.000	-.997	-.232	.880	-.016	-.543	.001
ba1	-.997	1.000	.195	-.885	.014	.587	-.001
bb1	-.232	.195	1.000	-.136	.070	-.005	-.006
ba2	.880	-.885	-.136	1.000	-.362	-.271	.285
ba3	-.016	.014	.070	-.362	1.000	-.414	-.113
knot1	-.543	.587	-.005	-.271	-.414	1.000	.230
knot2	.001	-.001	-.006	.285	-.113	.230	1.000

ANOVA[a]

Source	Sum of Squares	df	Mean Squares
Regression	21759.724	7	3108.532
Residual	1938.632	1382	1.403
Uncorrected Total	23698.356	1389	
Corrected Total	6713.981	1388	

Dependent variable: y1

a. R squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares) = .711.

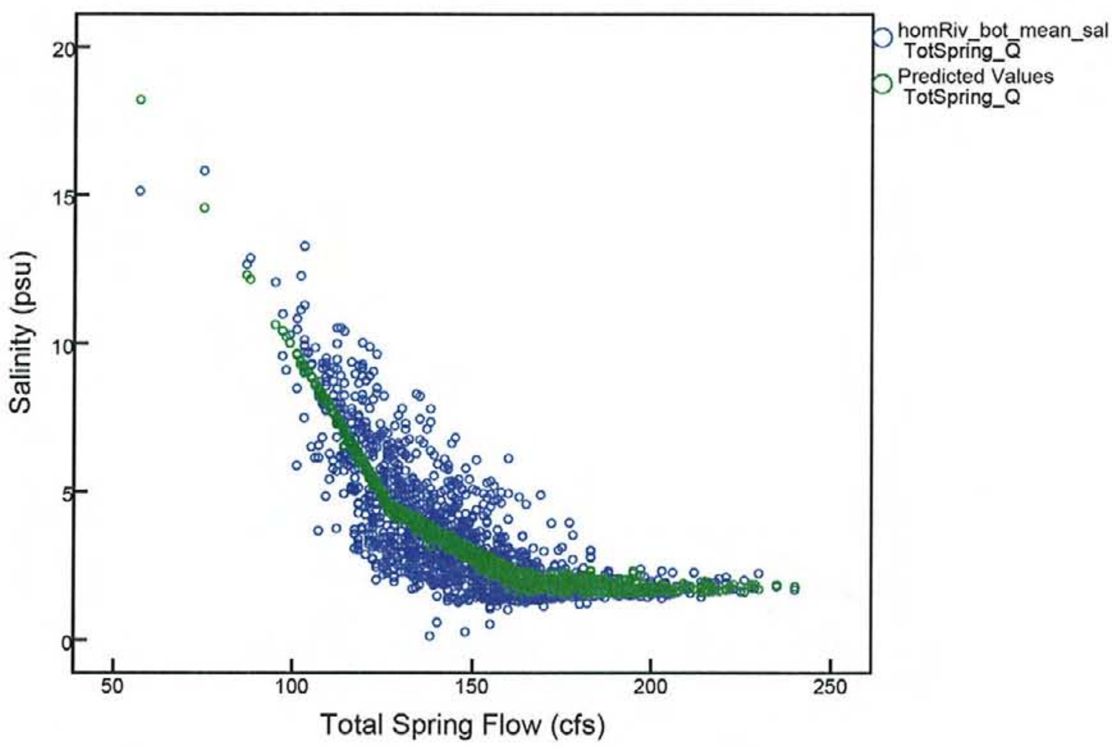
```
GRAPH
  /SCATTERPLOT(OVERLAY)=TotSpring_Q TotSpring_Q WITH homRiv_bot_mean_sal predex1_3 (PAIR)
  /MISSING=LISTWISE.
```

Graph

Notes

Output Created		2010-01-05T11:01:01.354
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flows\Alldailydata.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	3060
Syntax		GRAPH /SCATTERPLOT(OVERLAY) =TotSpring_Q TotSpring_Q WITH homRiv_bot_mean_sal predex1_3 (PAIR) /MISSING=LISTWISE.
Resources	Processor Time	0:00:00.453
	Elapsed Time	0:00:00.609

[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flows\Alldailydata.sav




```
REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
```

```
 /NOORIGIN
 /DEPENDENT shell_top_mean_sal
 /METHOD=STEPWISE TotSpring_Q homRiv_mean_ght
 /PARTIALPLOT ALL
 /RESIDUALS HIST(ZRESID) NORM(ZRESID)
 /SAVE PRED.
```

Regression

Notes

Output Created		2010-01-05T11:10:11.572
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flows\Alldailydata.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	3060
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used.
Syntax		REGRESSION /MISSING LISTWISE /STATISTICS COEFF OUTS R ANOVA /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT shell_top_mean_sal /METHOD=STEPWISE TotSpring_Q homRiv_mean_ght /PARTIALPLOT ALL /RESIDUALS HIST(ZRESID) NORM (ZRESID) /SAVE PRED.
Resources	Processor Time	0:00:00.922
	Elapsed Time	0:00:00.953
	Memory Required	3292 bytes
	Additional Memory Required for Residual Plots	1368 bytes
Variables Created or Modified	PRE_2	Unstandardized Predicted Value

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flow
s\Alldailydata.sav
```

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	TotSpring_Q	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	homRiv_mean_ght	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: shell_top_mean_sal

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.739[a]	.546	.545	2.25481990E0
2	.766[b]	.587	.586	2.15121578E0

a. Predictors: (Constant), TotSpring_Q

b. Predictors: (Constant), TotSpring_Q, homRiv_mean_ght

c. Dependent Variable: shell_top_mean_sal

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3954.664	1	3954.664	777.832	.000[a]
	Residual	3294.570	648	5.084		
	Total	7249.234	649			
2	Regression	4255.093	2	2127.546	459.739	.000[b]
	Residual	2994.141	647	4.628		
	Total	7249.234	649			

a. Predictors: (Constant), TotSpring_Q

b. Predictors: (Constant), TotSpring_Q, homRiv_mean_ght

c. Dependent Variable: shell_top_mean_sal

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	39.261	.685		57.321	.000
	TotSpring_Q	-.142	.005	-.739	-27.890	.000
2	(Constant)	47.028	1.165		40.382	.000

a. Dependent Variable: shell_top_mean_sal

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
2	TotSpring_Q	-.198	.009	-1.031	-23.303	.000
	homRiv_mean_ght	-2.251	.279	-.357	-8.057	.000

a. Dependent Variable: shell_top_mean_sal

Excluded Variables[b]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	homRiv_mean_ght	-.357[a]	-8.057	.000	-.302	.326

a. Predictors in the Model: (Constant), TotSpring_Q

b. Dependent Variable: shell_top_mean_sal

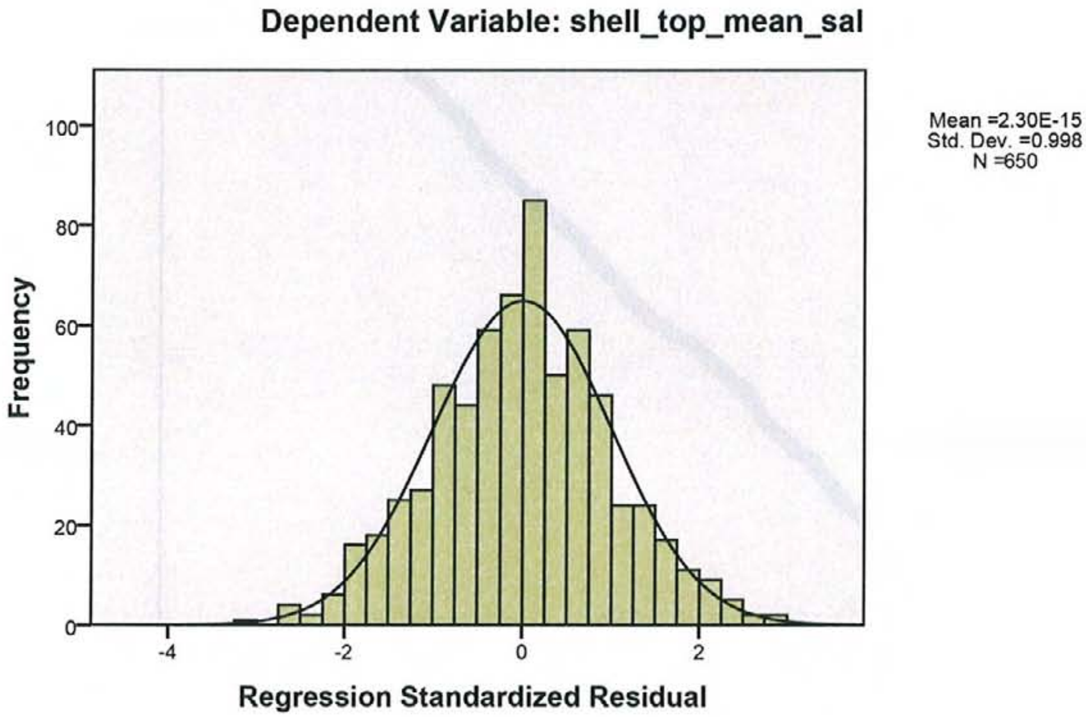
Residuals Statistics[a]

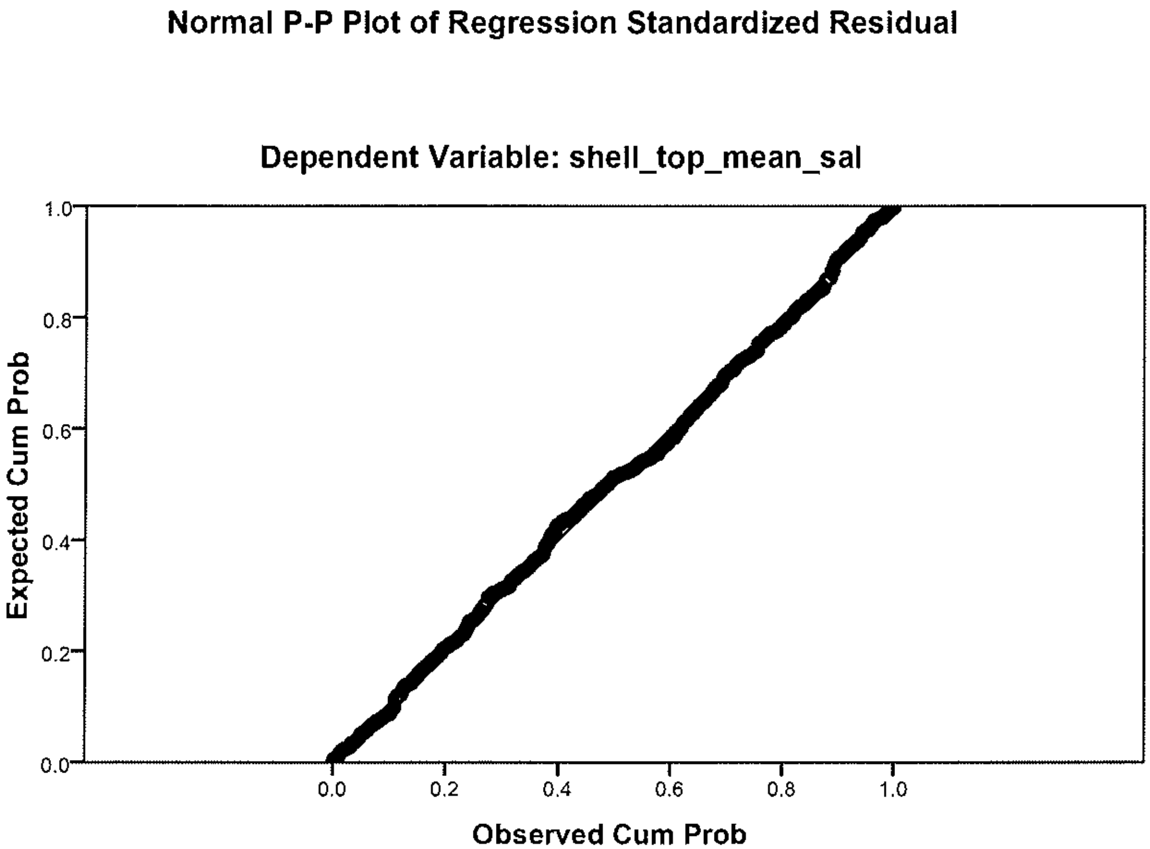
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	1.1809E1	2.70550E1	2.0318E1	2.56054352E0	650
Residual	-6.9261E0	6.05967E0	...	2.14789856E0	650
Std. Predicted Value	-3.323	2.631	.000	1.000	650
Std. Residual	-3.220	2.817	.000	.998	650

a. Dependent Variable: shell_top_mean_sal

Charts

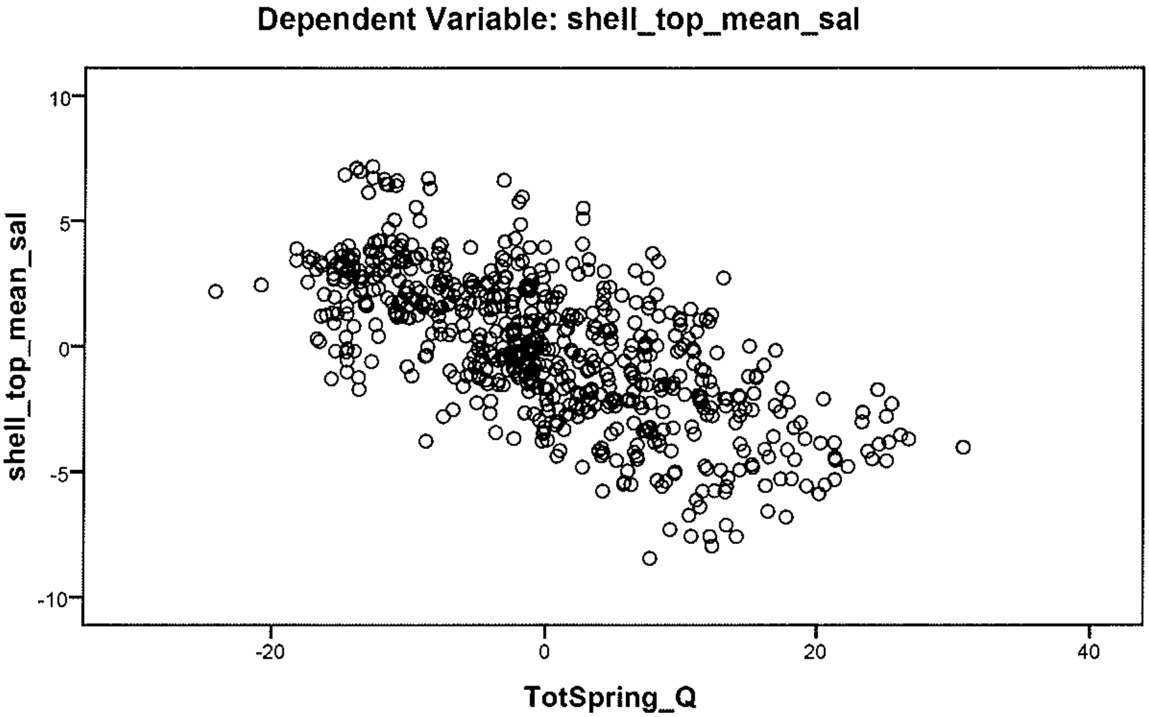
Histogram


Dependent Variable: shell_top_mean_sal
Mean =2.30E-15
Std. Dev. =0.998
N =650
Frequency
100
80
60
40
20
0
-4
-2
0
2
Regression Standardized Residual

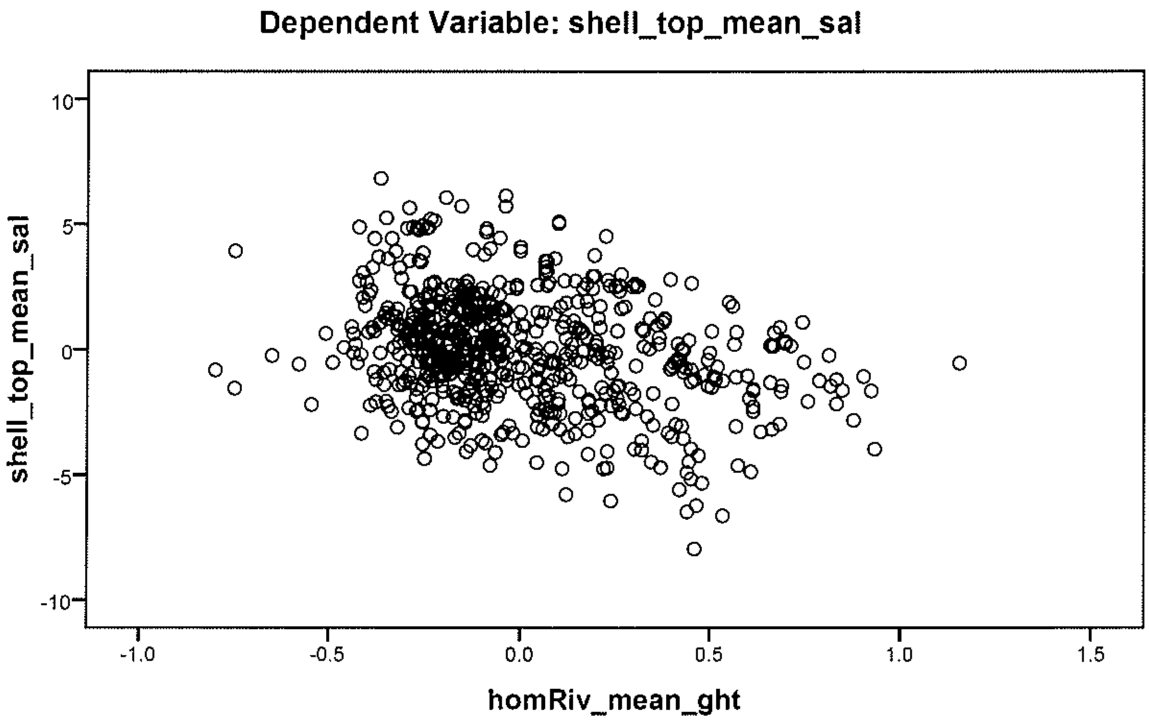


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: shell_top_mean_sal
Expected Cum Prob
Observed Cum Prob
0.0
0.2
0.4
0.6
0.8
1.0

Partial Regression Plot



Partial Regression Plot




```
GRAPH
  /SCATTERPLOT(OVERLAY)=TotSpring_Q TotSpring_Q WITH shell_top_mean_sal PRE_2 (PAIR)
  /MISSING=LISTWISE.
```

Graph

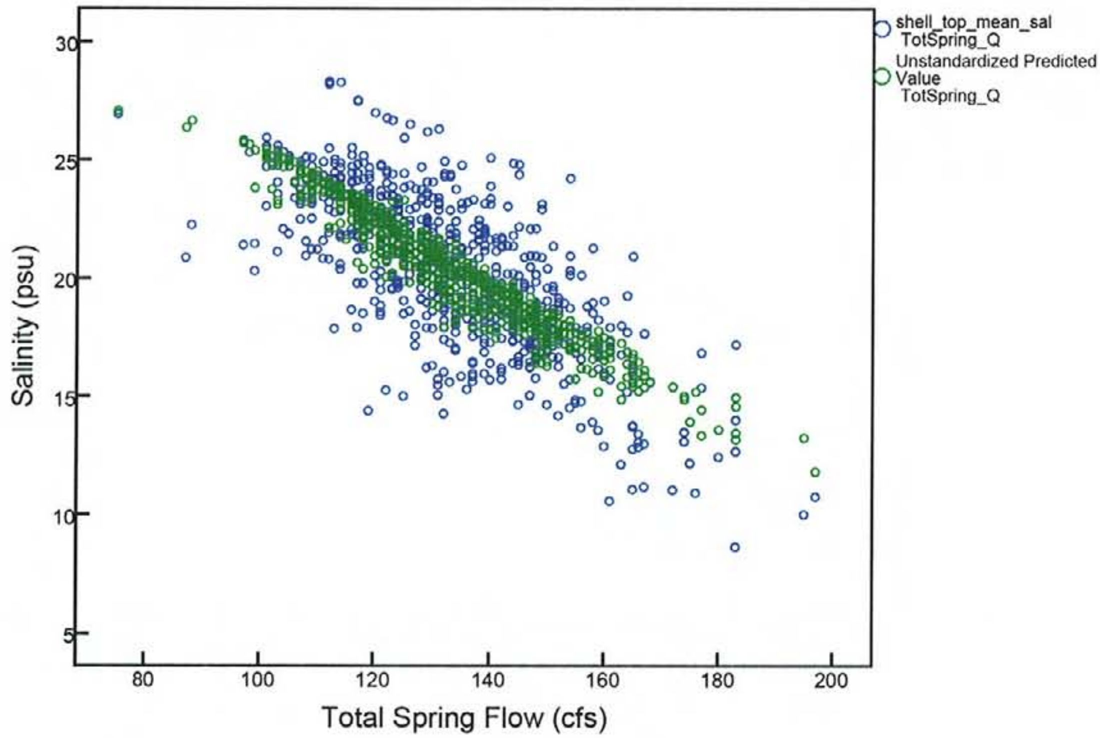
Notes

Output Created		2010-01-05T11:11:15.388
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flows\Alldailydata.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	3060

Notes

Syntax		GRAPH /SCATTERPLOT(OVERLAY) =TotSpring_Q TotSpring_Q WITH shell_top_mean_sal PRE_2 (PAIR) /MISSING=LISTWISE.
Resources	Processor Time	0:00:00.312
	Elapsed Time	0:00:00.313

[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flows\Alldailydata.sav




```
REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT shell_bot_mean_sal
  /METHOD=STEPWISE TotSpring_Q homRiv_mean_ght
  /PARTIALPLOT ALL
  /RESIDUALS HIST(ZRESID) NORM(ZRESID)
  /SAVE PRED.
```

Regression

Notes

Output Created	2010-01-05T11:11:59.224

Notes

Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flows\Alldailydata.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	3060
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used.
Syntax		REGRESSION /MISSING LISTWISE /STATISTICS COEFF OUTS R ANOVA /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT shell_bot_mean_sal /METHOD=STEPWISE TotSpring_Q homRiv_mean_ght /PARTIALPLOT ALL /RESIDUALS HIST(ZRESID) NORM (ZRESID) /SAVE PRED.
Resources	Processor Time	0:00:01.109
	Elapsed Time	0:00:01.109
	Memory Required	3316 bytes
	Additional Memory Required for Residual Plots	1368 bytes
Variables Created or Modified	PRE_3	Unstandardized Predicted Value

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flow
s\Alldailydata.sav
```

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	TotSpring_Q	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: shell_bot_mean_sal

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
2	homRiv_mean_ght	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: shell_bot_mean_sal

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.740[a]	.548	.548	2.32805659E0
2	.770[b]	.593	.591	2.21275728E0

a. Predictors: (Constant), TotSpring_Q

b. Predictors: (Constant), TotSpring_Q, homRiv_mean_ght

c. Dependent Variable: shell_bot_mean_sal

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4098.425	1	4098.425	756.188	.000[a]
	Residual	3376.565	623	5.420		
	Total	7474.990	624			
2	Regression	4429.495	2	2214.748	452.331	.000[b]
	Residual	3045.495	622	4.896		
	Total	7474.990	624			

a. Predictors: (Constant), TotSpring_Q

b. Predictors: (Constant), TotSpring_Q, homRiv_mean_ght

c. Dependent Variable: shell_bot_mean_sal

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	40.171	.718		55.963	.000
	TotSpring_Q	-.147	.005	-.740	-27.499	.000
2	(Constant)	48.518	1.223		39.667	.000
	TotSpring_Q	-.207	.009	-1.046	-23.174	.000
	homRiv_mean_ght	-2.415	.294	-.371	-8.223	.000

a. Dependent Variable: shell_bot_mean_sal

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	1.1797E1	2.74966E1	2.0598E1	2.66431036E0	625

a. Dependent Variable: shell_bot_mean_sal

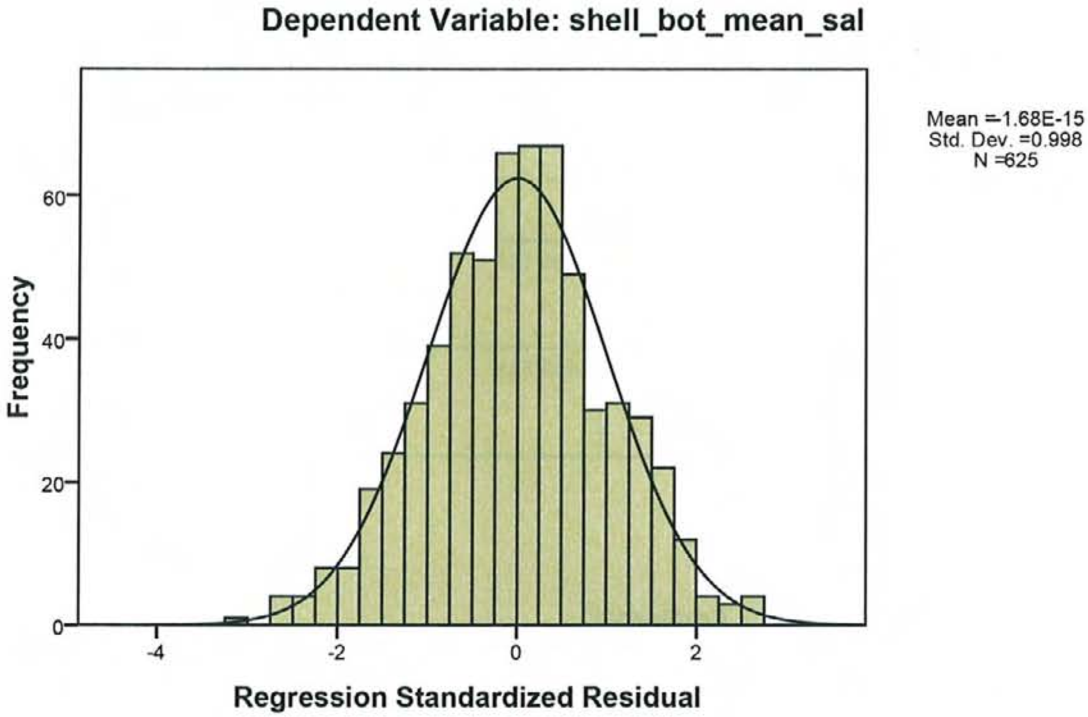
Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Residual	-7.0497E0	5.97831E0	-3.40E-15	2.20920835E0	625
Std. Predicted Value	-3.303	2.589	.000	1.000	625
Std. Residual	-3.186	2.702	.000	.998	625

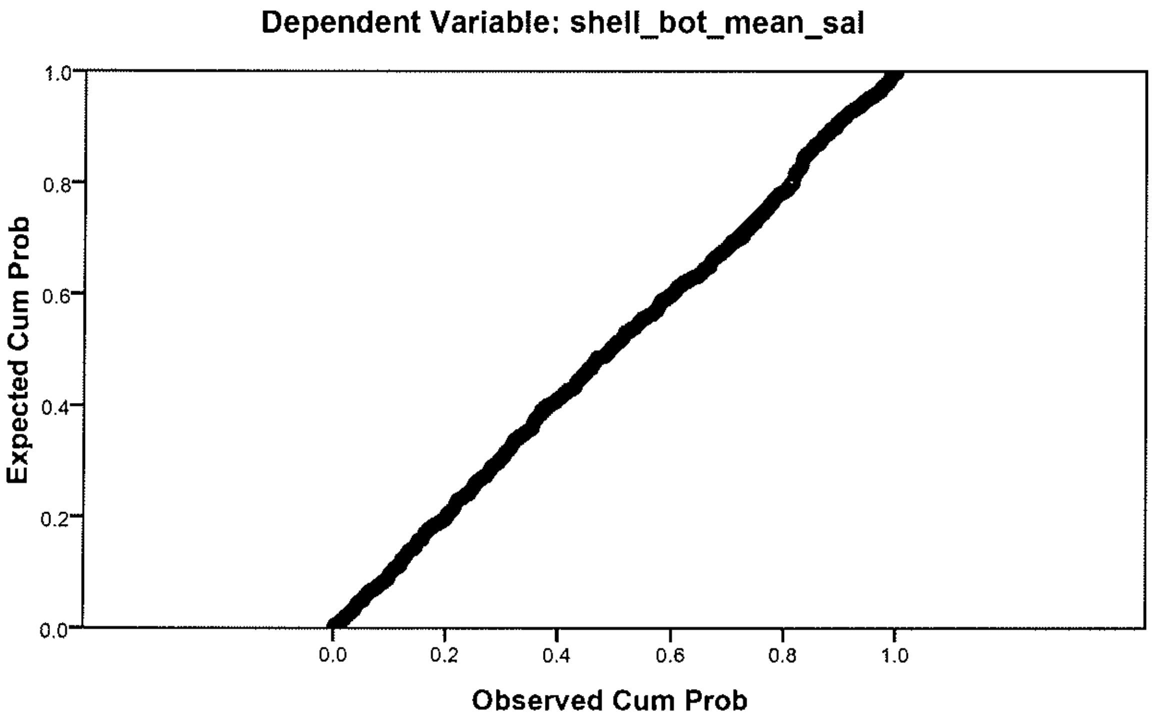
a. Dependent Variable: shell_bot_mean_sal

Charts

Histogram

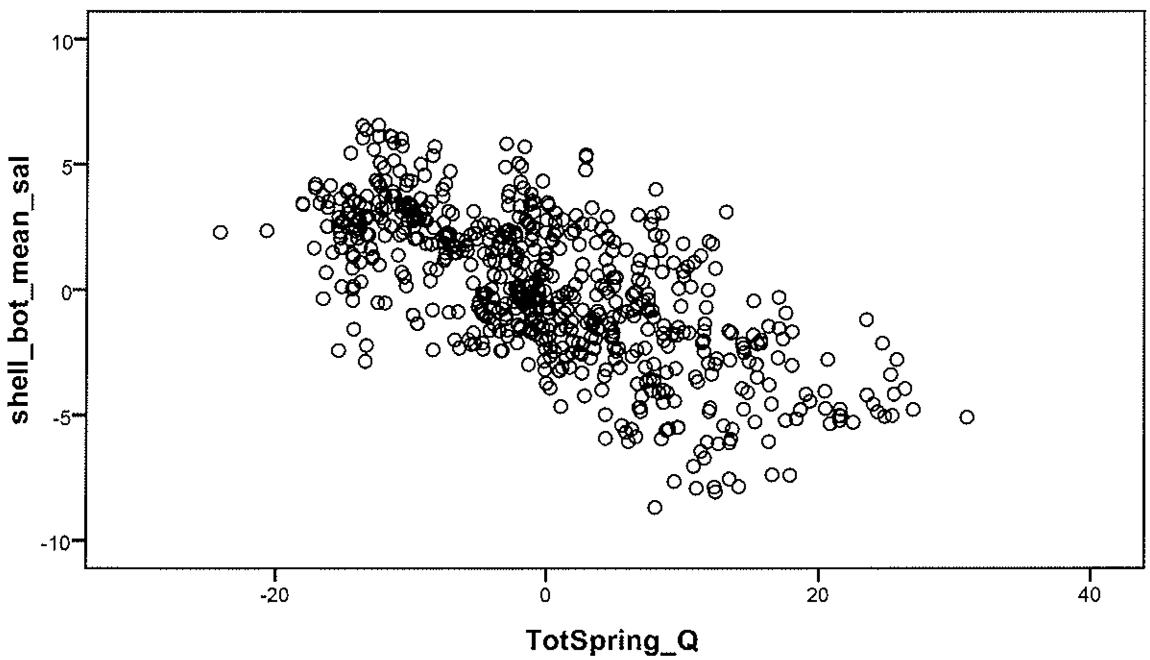


Normal P-P Plot of Regression Standardized Residual

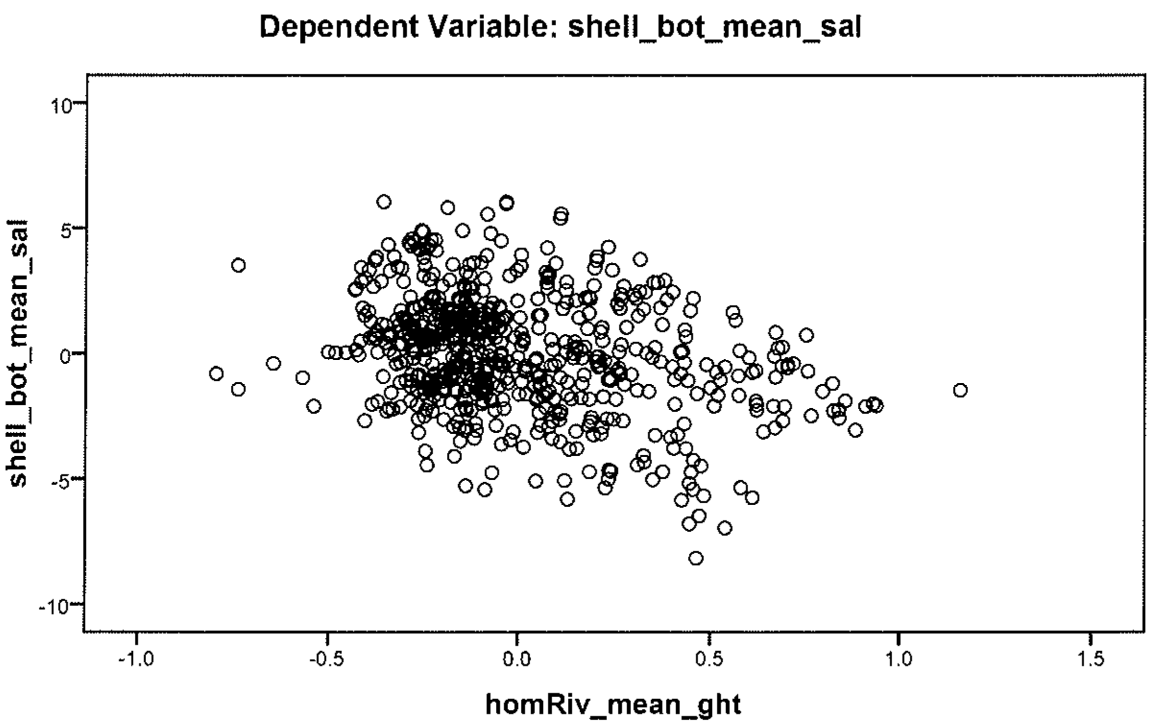


Partial Regression Plot

Dependent Variable: shell_bot_mean_sal



Partial Regression Plot




```
GRAPH
  /SCATTERPLOT(OVERLAY)=TotSpring_Q TotSpring_Q WITH shell_bot_mean_sal PRE_3 (PAIR)
  /MISSING=LISTWISE.
```

Graph

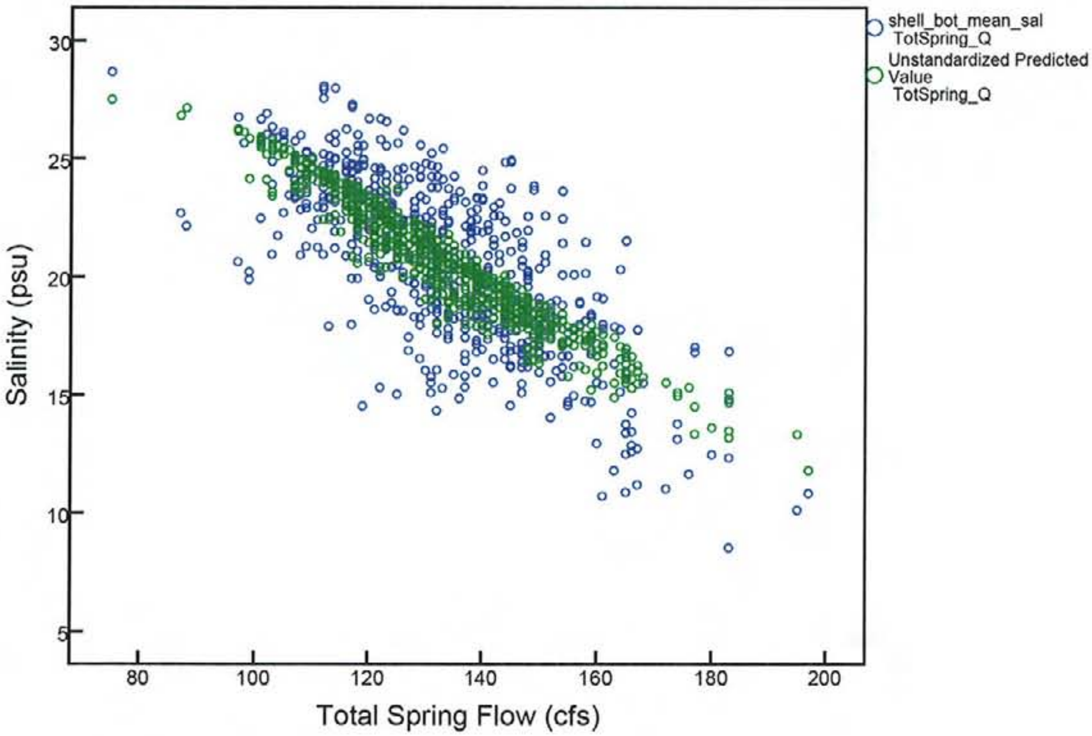
Notes

Output Created		2010-01-05T11:12:31.390
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flows\Alldailydata.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	3060

Notes

Syntax		GRAPH /SCATTERPLOT(OVERLAY) =TotSpring_Q TotSpring_Q WITH shell_bot_mean_sal PRE_3 (PAIR) /MISSING=LISTWISE.
Resources	Processor Time	0:00:00.297
	Elapsed Time	0:00:00.312

[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 4 Characterization of Flow s\Alldailydata.sav



I-3
Isohaline Models

```
* NonLinear Regression.
MODEL PROGRAM  a0=15 a1=-.03 a2=-.03 a3=.5 knot1=130.
COMPUTE  PRED_=a0 + a1*totSpg_Q  + a2*(totSpg_Q-knot1)*(totSpg_Q ge knot1)+ a3*homRiv_ght
.
NLR rkm_3psu
  /OUTFILE='C:\DOCUME~1\kww\LOCALS~1\Temp\spss3596\SPSSFNLR.TMP'
  /PRED PRED_
  /SAVE PRED RESID
  /CRITERIA SSCONVERGENCE 1E-8 PCON 1E-8.
```

Nonlinear Regression Analysis

Notes

Output Created		2009-12-14T10:24:39.204
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_top_isohaline_ dataset.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	2006
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used. Predicted values are calculated for cases with missing values on the dependent variable.
Syntax		MODEL PROGRAM a0=15 a1=-.03 a2=-.03 a3=.5 knot1=130. COMPUTE PRED_=a0 + a1*totSpg_Q + a2*(totSpg_Q-knot1) *(totSpg_Q ge knot1)+ a3*homRiv_ght. NLR rkm_3psu /OUTFILE='C: \DOCUME~1\kww\LOCALS~1\Temp \spss3596\SPSSFNLR.TMP' /PRED PRED_ /SAVE PRED RESID /CRITERIA SSCONVERGENCE 1E-8 PCON 1E-8.
Resources	Processor Time	0:00:00.281
	Elapsed Time	0:00:00.766
Variables Created or Modified	PRED_	Predicted Values
	RESID	Residuals
Files Saved	Parameter Estimates File	C: \DOCUME~1\kww\LOCALS~1\Temp \spss3596\SPSSFNLR.TMP

[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_top_isohaline_dataset.sav

Iteration History[b]

Iteration Number[a]	Residual Sum of Squares	Parameter				
		a0	a1	a2	a3	knot1
1.0	154.329	15.000	-.030	-.030	.500	130.000
1.1	40.791	11.929	-.017	-.029	.433	129.203
2.0	40.791	11.929	-.017	-.029	.433	129.203
2.1	40.928	11.815	-.016	-.029	.428	126.597
2.2	40.928	11.815	-.016	-.029	.428	126.597
2.3	40.845	11.926	-.017	-.028	.425	127.327
2.4	40.782	11.932	-.017	-.029	.431	128.751
3.0	40.782	11.932	-.017	-.029	.431	128.751
3.1	40.784	11.935	-.017	-.029	.426	127.885
3.2	40.776	11.934	-.017	-.029	.429	128.362
4.0	40.776	11.934	-.017	-.029	.429	128.362
4.1	40.815	11.935	-.017	-.028	.425	127.602
4.2	40.774	11.934	-.017	-.029	.428	128.279
5.0	40.774	11.934	-.017	-.029	.428	128.279
5.1	40.772	11.935	-.017	-.029	.427	128.116
6.0	40.772	11.935	-.017	-.029	.427	128.116
6.1	40.794	11.936	-.017	-.029	.426	127.792
6.2	40.772	11.935	-.017	-.029	.427	128.083
7.0	40.772	11.935	-.017	-.029	.427	128.083
7.1	40.771	11.936	-.017	-.029	.427	128.021
8.0	40.771	11.936	-.017	-.029	.427	128.021
8.1	40.782	11.936	-.017	-.029	.426	127.899
8.2	40.771	11.936	-.017	-.029	.427	128.009
9.0	40.771	11.936	-.017	-.029	.427	128.009
9.1	40.773	11.936	-.017	-.029	.426	127.985
9.2	40.771	11.936	-.017	-.029	.427	128.006
10.0	40.771	11.936	-.017	-.029	.427	128.006
10.1	40.771	11.936	-.017	-.029	.427	128.002
11.0	40.771	11.936	-.017	-.029	.427	128.002
11.1	40.772	11.936	-.017	-.029	.426	127.992
11.2	40.771	11.936	-.017	-.029	.427	128.001
12.0	40.771	11.936	-.017	-.029	.427	128.001
12.1	40.771	11.936	-.017	-.029	.427	127.999
12.2	40.771	11.936	-.017	-.029	.427	128.000
13.0	40.771	11.936	-.017	-.029	.427	128.000
13.1	40.771	11.936	-.017	-.029	.427	128.000

Derivatives are calculated numerically.

a. Major iteration number is displayed to the left of the decimal, and minor iteration number is to the right of the decimal.

b. Run stopped after 40 model evaluations and 14 derivative evaluations because the relative reduction between successive residual sums of squares is at most SSCON = 1.00E-008.

Iteration History[b]

Iteration Number[a]	Residual Sum of Squares	Parameter				
		a0	a1	a2	a3	knot1
13.2	40.771	11.936	-.017	-.029	.427	128.000
14.0	40.771	11.936	-.017	-.029	.427	128.000
14.1	40.771	11.936	-.017	-.029	.427	128.000
14.2	40.771	11.936	-.017	-.029	.427	128.000

Derivatives are calculated numerically.

a. Major iteration number is displayed to the left of the decimal, and minor iteration number is to the right of the decimal.

b. Run stopped after 40 model evaluations and 14 derivative evaluations because the relative reduction between successive residual sums of squares is at most SSCON = 1.00E-008.

Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
a0	11.936	1.359	9.212	14.660
a1	-.017	.012	-.041	.006
a2	-.029	.018	-.064	.007
a3	.427	.263	-.101	.954
knot1	128.000	13.162	101.611	154.389

Correlations of Parameter Estimates

	a0	a1	a2	a3	knot1
a0	1.000	-.987	.580	-.176	.338
a1	-.987	1.000	-.613	.110	-.425
a2	.580	-.613	1.000	.314	-.137
a3	-.176	.110	.314	1.000	.064
knot1	.338	-.425	-.137	.064	1.000

ANOVA[a]

Source	Sum of Squares	df	Mean Squares
Regression	5002.418	5	1000.484
Residual	40.771	54	.755
Uncorrected Total	5043.189	59	
Corrected Total	88.033	58	

Dependent variable: rkm_3psu

a. R squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares) = .537.

```
GRAPH
  /HISTOGRAM(NORMAL)=RESID.
```

Graph

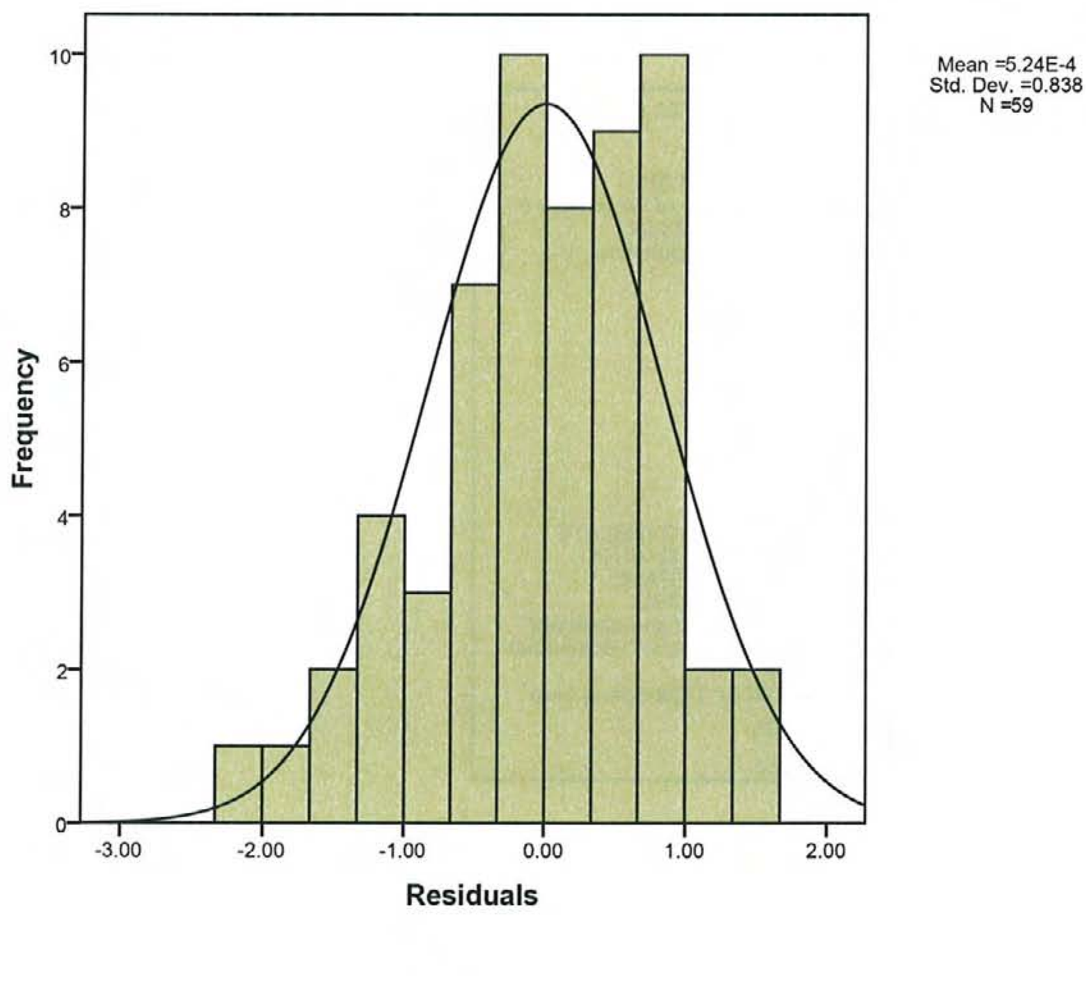
Notes

Output Created	2009-12-14T10:25:13.950

Notes

Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_top_isohaline_dataset.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	2006
Syntax		GRAPH /HISTOGRAM(NORMAL)=RESID.
Resources	Processor Time	0:00:00.328
	Elapsed Time	0:00:00.500

[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_top_isohaline_dataset.sav



Notes

Output Created		2009-12-14T10:28:29.911
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_top_isohaline_ dataset.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	2006
Syntax		GRAPH /SCATTERPLOT(OVERLAY) =totSpg_Q totSpg_Q WITH rkm_3psu PRED_ (PAIR) /MISSING=LISTWISE /TITLE='Predicted and Observed Isohaline Location'.
Resources	Processor Time	0:00:00.281
	Elapsed Time	0:00:00.281

Notes

Output Created		2009-12-14T10:30:33.505
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_top_isohaline_ dataset.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	2006
Syntax		GRAPH /SCATTERPLOT(OVERLAY) =totSpg_Q totSpg_Q WITH rkm_3psu PRED_ (PAIR) /MISSING=LISTWISE /TITLE='Predicted and observed isohaline location (km)' 'versus total spring flow' /FOOTNOTE='Total Spring Flow'.
Resources	Processor Time	0:00:00.265
	Elapsed Time	0:00:00.281

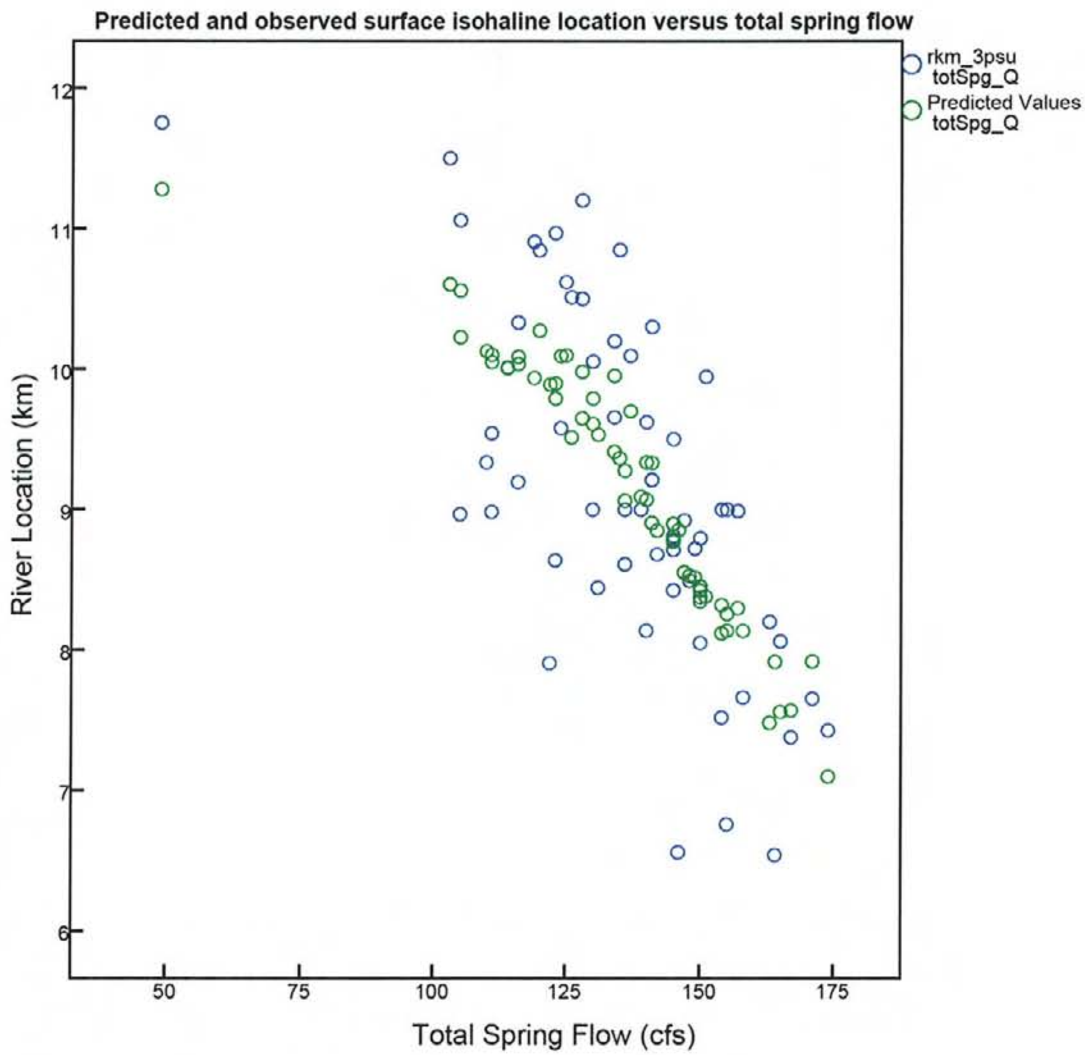
```
GRAPH
  /SCATTERPLOT(OVERLAY)=totSpg_Q totSpg_Q WITH rkm_3psu PRED_ (PAIR)
  /MISSING=LISTWISE
  /TITLE='Predicted and observed isohaline location (km)'.
```

Graph

Notes

Output Created		2009-12-14T10:32:39.768
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_top_isohaline_ dataset.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	2006
Syntax		GRAPH /SCATTERPLOT(OVERLAY) =totSpg_Q totSpg_Q WITH rkm_3psu PRED_ (PAIR) /MISSING=LISTWISE /TITLE='Predicted and observed isohaline location (km)'.
Resources	Processor Time	0:00:00.234
	Elapsed Time	0:00:00.344

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model
 Dep\task_6b_top_isohaline_dataset.sav
```




```
* NonLinear Regression.
MODEL PROGRAM  a0=15 a1=-.03 a2=-.03 a3=.5 knot1=130.
COMPUTE  PRED_=a0 + a1*totSpg_Q  + a2*(totSpg_Q-knot1)*(totSpg_Q ge knot1)+ a3*homRiv_ght
.
NLR rkm_5psu
  /OUTFILE='C:\DOCUME~1\kww\LOCALS~1\Temp\spss3596\SPSSFNLR.TMP'
  /PRED PRED_
  /SAVE PRED RESID
  /CRITERIA SSCONVERGENCE 1E-8 PCON 1E-8.
```

Nonlinear Regression Analysis

Notes

Output Created	2009-12-14T10:36:18.765
Comments	

Notes

Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_top_isohaline_ dataset.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	2006
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used. Predicted values are calculated for cases with missing values on the dependent variable.
Syntax		MODEL PROGRAM a0=15 a1=-.03 a2=-.03 a3=.5 knot1=130. COMPUTE PRED_=a0 + a1*totSpg_Q + a2*(totSpg_Q-knot1) *(totSpg_Q ge knot1)+ a3*homRiv_ght. NLR rkm_5psu /OUTFILE='C: \DOCUME~1\kww\LOCALS~1\Temp \spss3596\SPSSFNLR.TMP' /PRED PRED_ /SAVE PRED RESID /CRITERIA SSCONVERGENCE 1E-8 PCON 1E-8.
Resources	Processor Time	0:00:00.063
	Elapsed Time	0:00:00.078
Variables Created or Modified	PRED_1	Predicted Values
	RESID_1	Residuals
Files Saved	Parameter Estimates File	C: \DOCUME~1\kww\LOCALS~1\Temp \spss3596\SPSSFNLR.TMP

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model
 Dep\task_6b_top_isohaline_dataset.sav
```

Iteration History[b]

Iteration Number[a]	Residual Sum of Squares	Parameter				
		a0	a1	a2	a3	knot1
1.0	484.497	15.000	-.030	-.030	.500	130.000
1.1	36.009	11.480	-.025	-.027	.519	142.038
2.0	36.009	11.480	-.025	-.027	.519	142.038
2.1	35.977	11.116	-.021	-.019	.486	129.645

Derivatives are calculated numerically.

a. Major iteration number is displayed to the left of the decimal, and minor iteration number is to the right of the decimal.

b. Run stopped after 56 model evaluations and 21 derivative evaluations because the relative reduction between successive parameter estimates is at most PCON = 1.00E-008.

Iteration History[b]

Iteration Number[a]	Residual Sum of Squares	Parameter a0	a1	a2	a3	knot1
3.0	35.977	11.116	-.021	-.019	.486	129.645
3.1	36.769	11.651	-.026	-.025	.519	151.459
3.2	36.769	11.651	-.026	-.025	.519	151.459
3.3	36.598	11.251	-.023	-.028	.530	147.480
3.4	35.353	11.106	-.021	-.024	.536	137.460
4.0	35.353	11.106	-.021	-.024	.536	137.460
4.1	35.265	11.012	-.020	-.029	.505	133.991
5.0	35.265	11.012	-.020	-.029	.505	133.991
5.1	35.732	11.045	-.021	-.033	.525	141.406
5.2	35.185	11.002	-.020	-.030	.518	136.891
6.0	35.185	11.002	-.020	-.030	.518	136.891
6.1	35.179	10.992	-.020	-.029	.510	134.557
7.0	35.179	10.992	-.020	-.029	.510	134.557
7.1	35.158	10.986	-.020	-.030	.517	135.969
8.0	35.158	10.986	-.020	-.030	.517	135.969
8.1	35.129	10.989	-.020	-.030	.513	135.225
9.0	35.129	10.989	-.020	-.030	.513	135.225
9.1	35.272	10.990	-.020	-.029	.504	133.826
9.2	35.125	10.990	-.020	-.030	.511	135.073
10.0	35.125	10.990	-.020	-.030	.511	135.073
10.1	35.151	10.992	-.020	-.029	.509	134.779
10.2	35.124	10.990	-.020	-.030	.511	135.039
11.0	35.124	10.990	-.020	-.030	.511	135.039
11.1	35.126	10.991	-.020	-.030	.511	134.976
11.2	35.124	10.991	-.020	-.030	.511	135.025
12.0	35.124	10.991	-.020	-.030	.511	135.025
12.1	35.124	10.991	-.020	-.030	.511	134.997
13.0	35.124	10.991	-.020	-.030	.511	134.997
13.1	35.124	10.991	-.020	-.030	.511	135.029
13.2	35.124	10.991	-.020	-.030	.511	135.012
14.0	35.124	10.991	-.020	-.030	.511	135.012
14.1	35.123	10.991	-.020	-.030	.511	135.005
15.0	35.123	10.991	-.020	-.030	.511	135.005
15.1	35.124	10.991	-.020	-.030	.511	134.991
15.2	35.123	10.991	-.020	-.030	.511	135.003
16.0	35.123	10.991	-.020	-.030	.511	135.003
16.1	35.123	10.991	-.020	-.030	.511	135.000
17.0	35.123	10.991	-.020	-.030	.511	135.000
17.1	35.124	10.991	-.020	-.030	.511	135.008
17.2	35.123	10.991	-.020	-.030	.511	135.003

Derivatives are calculated numerically.

a. Major iteration number is displayed to the left of the decimal, and minor iteration number is to the right of the decimal.

b. Run stopped after 56 model evaluations and 21 derivative evaluations because the relative reduction between successive parameter estimates is at most PCON = 1.00E-008.

Iteration History[b]

Iteration Number[a]	Residual Sum of Squares	Parameter				
		a0	a1	a2	a3	knot1
17.3	35.123	10.991	-.020	-.030	.511	135.001
17.4	35.123	10.991	-.020	-.030	.511	135.001
18.0	35.123	10.991	-.020	-.030	.511	135.001
18.1	35.123	10.991	-.020	-.030	.511	135.000
19.0	35.123	10.991	-.020	-.030	.511	135.000
19.1	35.123	10.991	-.020	-.030	.511	135.000
19.2	35.123	10.991	-.020	-.030	.511	135.000
20.0	35.123	10.991	-.020	-.030	.511	135.000
20.1	35.123	10.991	-.020	-.030	.511	135.000
21.0	35.123	10.991	-.020	-.030	.511	135.000
21.1	35.123	10.991	-.020	-.030	.511	135.000
21.2	35.123	10.991	-.020	-.030	.511	135.000

Derivatives are calculated numerically.

a. Major iteration number is displayed to the left of the decimal, and minor iteration number is to the right of the decimal.

b. Run stopped after 56 model evaluations and 21 derivative evaluations because the relative reduction between successive parameter estimates is at most PCON = 1.00E-008.

Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
a0	10.991	.985	9.023	12.958
a1	-.020	.008	-.036	-.004
a2	-.030	.016	-.061	.002
a3	.511	.204	.103	.918
knot1	135.000	9.725	115.571	154.429

Correlations of Parameter Estimates

	a0	a1	a2	a3	knot1
a0	1.000	-.990	.442	-.203	.369
a1	-.990	1.000	-.462	.161	-.436
a2	.442	-.462	1.000	.280	-.285
a3	-.203	.161	.280	1.000	.026
knot1	.369	-.436	-.285	.026	1.000

ANOVA[a]

Source	Sum of Squares	df	Mean Squares
Regression	4535.288	5	907.058
Residual	35.123	64	.549
Uncorrected Total	4570.411	69	
Corrected Total	86.584	68	

Dependent variable: rkm_5psu

a. R squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares) = .594.

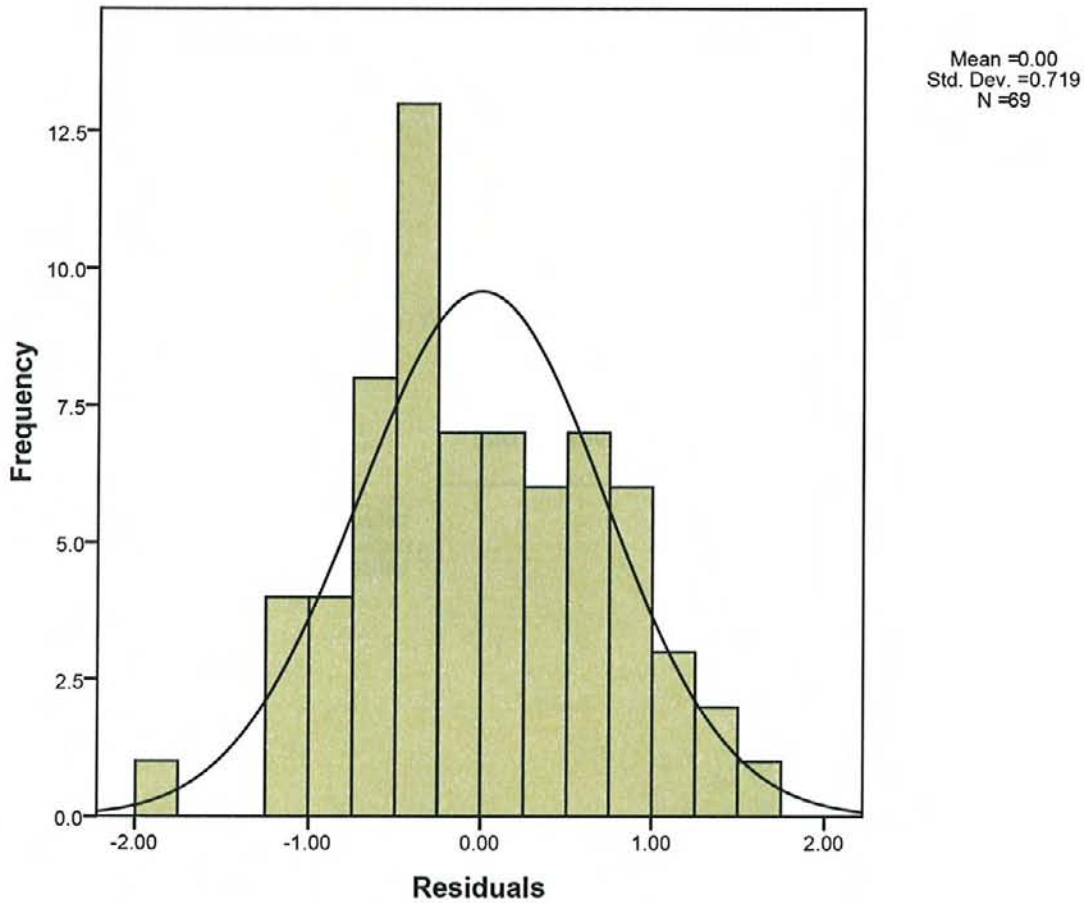
```
GRAPH
  /HISTOGRAM(NORMAL)=RESID_1.
```

Graph

Notes

Output Created		2009-12-14T10:36:53.540
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_top_isohaline_ dataset.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	2006
Syntax		GRAPH /HISTOGRAM(NORMAL)=RESID_1.
Resources	Processor Time	0:00:00.344
	Elapsed Time	0:00:00.359

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model
 Dep\task_6b_top_isohaline_dataset.sav
```




```
GRAPH
  /SCATTERPLOT(OVERLAY)=totSpg_Q totSpg_Q WITH rkm_5psu PRED_1 (PAIR)
  /MISSING=LISTWISE
  /TITLE='Predicted and observed isohaline location (km)'.
```

Graph

Notes

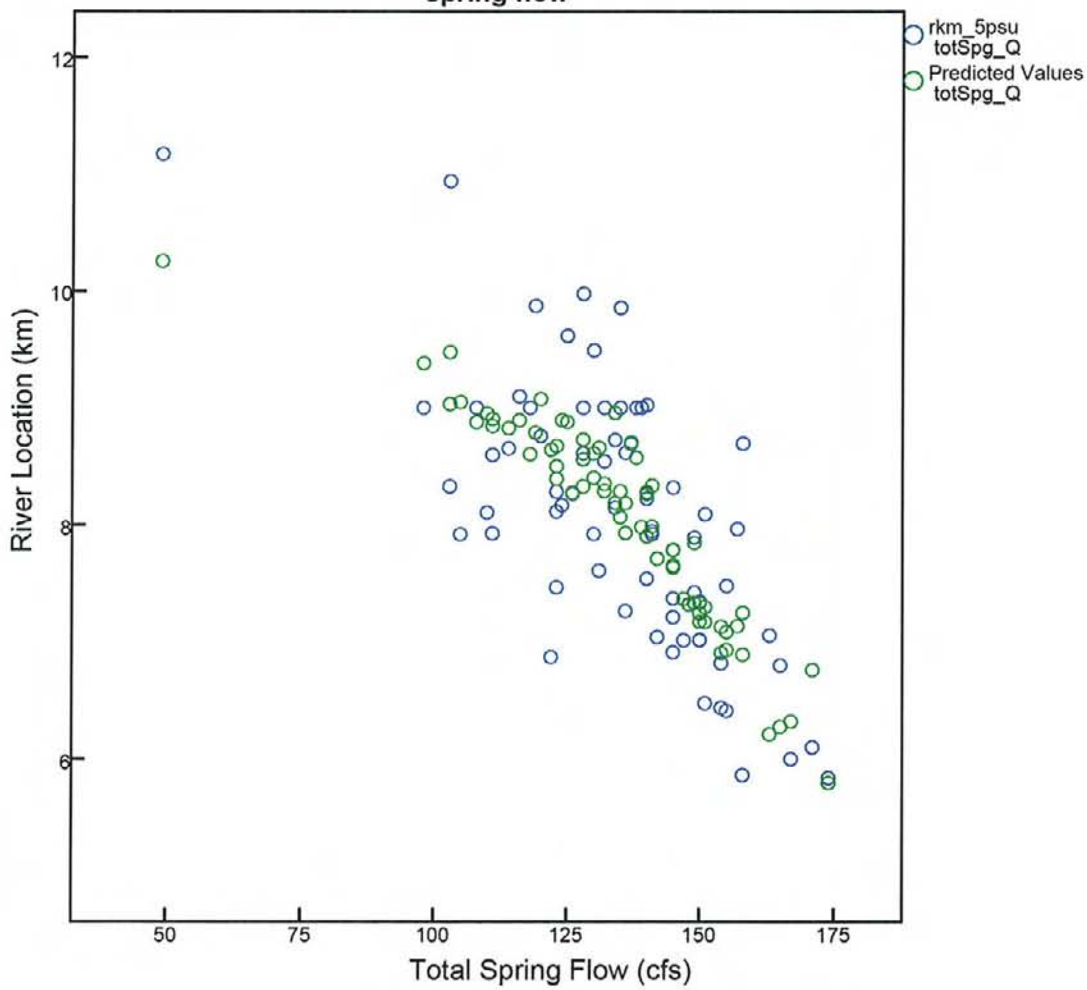
Output Created		2009-12-14T10:37:24.941
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_top_isohaline_ dataset.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	2006

Notes

Syntax		GRAPH /SCATTERPLOT(OVERLAY) =totSpg_Q totSpg_Q WITH rkm_5psu PRED_1 (PAIR) /MISSING=LISTWISE /TITLE='Predicted and observed isohaline location (km)'.
Resources	Processor Time	0:00:00.250
	Elapsed Time	0:00:00.329

[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_top_isohaline_dataset.sav

Predicted and observed surface isohaline location verus total spring flow




```
* NonLinear Regression.
MODEL PROGRAM  a0=15 a1=-.03 a2=-.03 a3=.5 knot1=130.
COMPUTE  PRED_=a0 + a1*totSpg_Q  + a2*(totSpg_Q-knot1)*(totSpg_Q ge knot1)+ a3*homRiv_ght
.
NLR rkm_12psu
```

```
/OUTFILE='C:\DOCUME~1\kww\LOCALS~1\Temp\spss3596\SPSSFNLR.TMP'
/PRED PRED_
/SAVE PRED RESID
/CRITERIA SSCONVERGENCE 1E-8 PCON 1E-8.
```

Nonlinear Regression Analysis

Notes

Output Created		2009-12-14T10:39:30.185
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_top_isohaline_ dataset.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	2006
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used. Predicted values are calculated for cases with missing values on the dependent variable.
Syntax		MODEL PROGRAM a0=15 a1=-.03 a2=-.03 a3=.5 knot1=130. COMPUTE PRED_=a0 + a1*totSpg_Q + a2*(totSpg_Q-knot1) *(totSpg_Q ge knot1)+ a3*homRiv_ght. NLR rkm_12psu /OUTFILE='C: \DOCUME~1\kww\LOCALS~1\Temp \spss3596\SPSSFNLR.TMP' /PRED PRED_ /SAVE PRED RESID /CRITERIA SSCONVERGENCE 1E-8 PCON 1E-8.
Resources	Processor Time	0:00:00.141
	Elapsed Time	0:00:00.141
Variables Created or Modified	PRED_2	Predicted Values
	RESID_2	Residuals
Files Saved	Parameter Estimates File	C: \DOCUME~1\kww\LOCALS~1\Temp \spss3596\SPSSFNLR.TMP

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model
 Dep\task_6b_top_isohaline_dataset.sav
```

Iteration History[b]

Iteration Number[a]	Residual Sum of Squares	Parameter				
		a0	a1	a2	a3	knot1
1.0	2743.425	15.000	-.030	-.030	.500	130.000
1.1	118.758	5.661	-.001	-.077	1.217	119.172
2.0	118.758	5.661	-.001	-.077	1.217	119.172
2.1	106.255	5.410	.002	-.072	1.246	121.298
3.0	106.255	5.410	.002	-.072	1.246	121.298
3.1	106.243	5.397	.002	-.072	1.250	121.604
4.0	106.243	5.397	.002	-.072	1.250	121.604
4.1	106.243	5.397	.002	-.072	1.250	121.602
5.0	106.243	5.397	.002	-.072	1.250	121.602

Derivatives are calculated numerically.

a. Major iteration number is displayed to the left of the decimal, and minor iteration number is to the right of the decimal.

b. Run stopped after 9 model evaluations and 5 derivative evaluations because the relative reduction between successive parameter estimates is at most PCON = 1.00E-008.

Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
a0	5.397	1.624	2.154	8.639
a1	.002	.015	-.027	.032
a2	-.072	.023	-.118	-.027
a3	1.250	.358	.535	1.964
knot1	121.602	7.113	107.396	135.807

Correlations of Parameter Estimates

	a0	a1	a2	a3	knot1
a0	1.000	-.978	.537	-.241	.348
a1	-.978	1.000	-.594	.145	-.473
a2	.537	-.594	1.000	.344	-.073
a3	-.241	.145	.344	1.000	-.011
knot1	.348	-.473	-.073	-.011	1.000

ANOVA[a]

Source	Sum of Squares	df	Mean Squares
Regression	1695.162	5	339.032
Residual	106.243	65	1.635
Uncorrected Total	1801.406	70	
Corrected Total	258.712	69	

Dependent variable: rkm_12psu

a. R squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares) = .589.

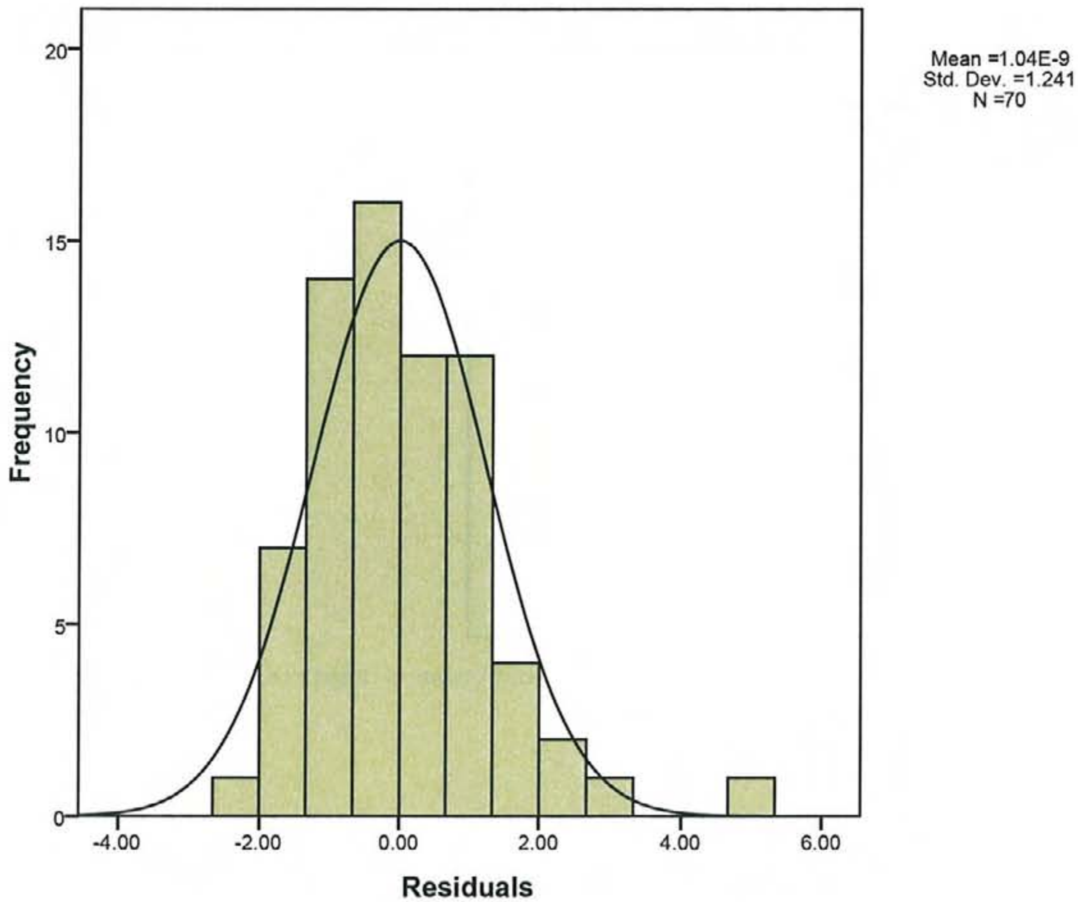
```
GRAPH
  /HISTOGRAM(NORMAL)=RESID_2.
```

Graph

Notes

Output Created		2009-12-14T10:40:04.226
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_top_isohaline_ dataset.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	2006
Syntax		GRAPH /HISTOGRAM(NORMAL)=RESID_2.
Resources	Processor Time	0:00:00.453
	Elapsed Time	0:00:00.454

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model
 Dep\task_6b_top_isohaline_dataset.sav
```




```
GRAPH
  /SCATTERPLOT(OVERLAY)=totSpg_Q totSpg_Q WITH rkm_12psu PRED_2 (PAIR)
  /MISSING=LISTWISE
  /TITLE='Predicted and observed isohaline location (km)'.
```

Graph

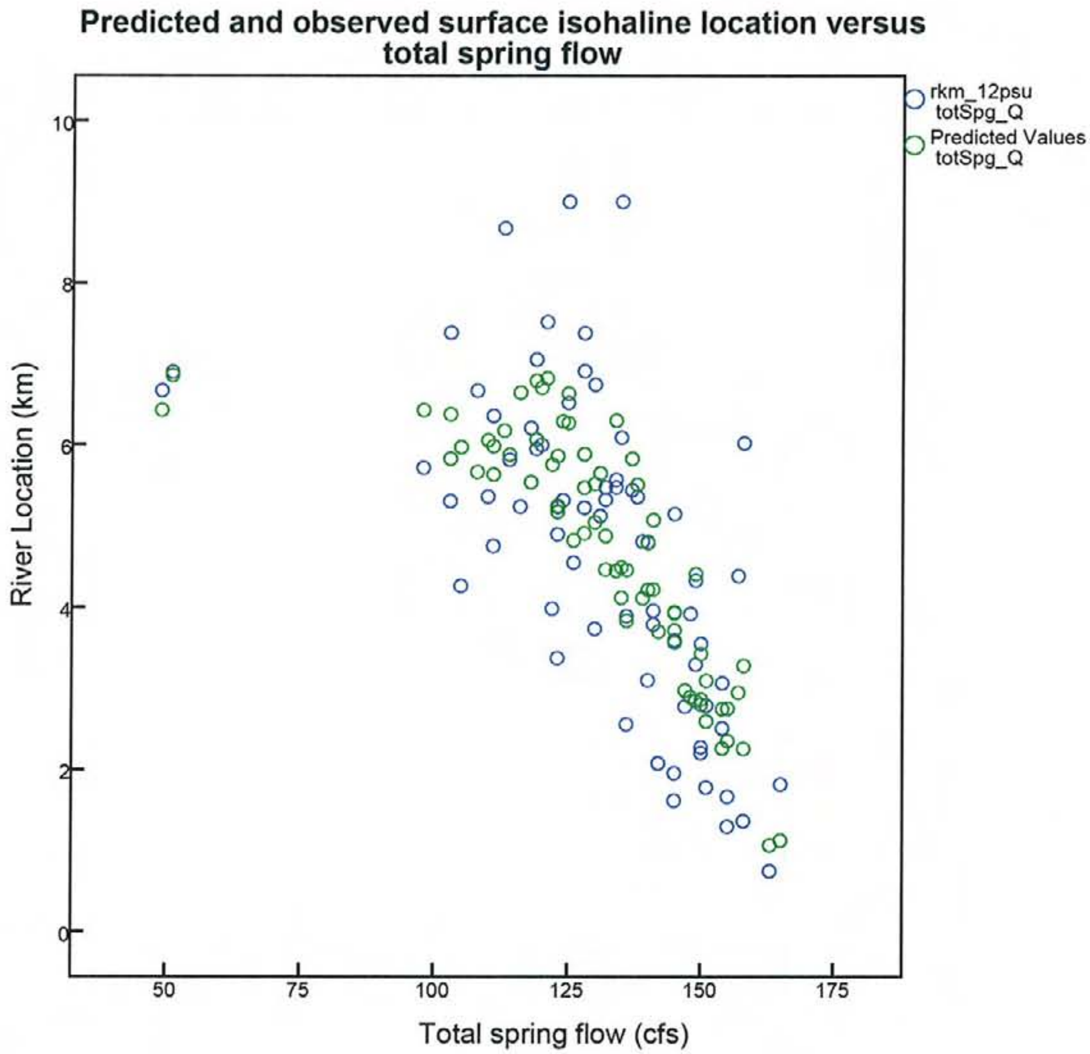
Notes

Output Created		2009-12-14T10:40:31.862
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_top_isohaline_ dataset.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	2006

Notes

Syntax		GRAPH /SCATTERPLOT(OVERLAY) =totSpg_Q totSpg_Q WITH rkm_12psu PRED_2 (PAIR) /MISSING=LISTWISE /TITLE='Predicted and observed isohaline location (km)'.
Resources	Processor Time	0:00:00.328
	Elapsed Time	0:00:00.328

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model
 Dep\task_6b_top_isohaline_dataset.sav
```




```
GET
  FILE='\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model De
p\task_6b_bot_isohaline_dataset.sav'.
DATASET NAME DataSet2 WINDOW=FRONT.
```

```
SAVE OUTFILE='\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Mo
del '+
    'Dep\Isohaline Piecewise\task_6b_top_isohaline_dataset.sav'
  /COMPRESSED.
DATASET ACTIVATE DataSet1.
DATASET CLOSE DataSet2.
GET
  FILE='\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model De
p\task_6b_bot_isohaline_dataset.sav'.
DATASET NAME DataSet1 WINDOW=FRONT.
* NonLinear Regression.
MODEL PROGRAM  a0=15 a1=-.03 a2=-.03 a3=0 knot1=130.
COMPUTE  PRED_=a0 + a1*totSpg_Q  +a2*(totSpg_Q-knot1)*(totSpg_Q ge knot1)+ a3*homRiv_ght.
NLR rkm_3psu
  /OUTFILE='C:\DOCUME~1\kww\LOCALS~1\Temp\spss2116\SPSSFNLR.TMP'
  /PRED PRED_
  /SAVE PRED RESID
  /CRITERIA SSCONVERGENCE 1E-8 PCON 1E-8.
```

Nonlinear Regression Analysis

Notes

Output Created		2009-12-14T11:22:08.672
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_bot_isohaline_dataset.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	2008
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used. Predicted values are calculated for cases with missing values on the dependent variable.
Syntax		MODEL PROGRAM a0=15 a1=-.03 a2=-.03 a3=0 knot1=130. COMPUTE PRED_=a0 + a1*totSpg_Q +a2*(totSpg_Q-knot1) *(totSpg_Q ge knot1)+ a3*homRiv_ght. NLR rkm_3psu /OUTFILE='C:\DOCUME~1\kww\LOCALS~1\Temp\spss2116\SPSSFNLR.TMP' /PRED PRED_ /SAVE PRED RESID /CRITERIA SSCONVERGENCE 1E-8 PCON 1E-8.

Notes

Resources	Processor Time	0:00:00.063
	Elapsed Time	0:00:00.375
Variables Created or Modified	PRED_	Predicted Values
	RESID	Residuals
Files Saved	Parameter Estimates File	C: \DOCUME~1\kww\LOCALS~1\Temp \spss2116\SPSSFNLR.TMP

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model
 Dep\task_6b_bot_isohaline_dataset.sav
```

Iteration History[b]

Iteration Number[a]	Residual Sum of Squares	Parameter				
		a0	a1	a2	a3	knot1
1.0	104.394	15.000	-.030	-.030	.000	130.000
1.1	94.218	14.253	-.026	-.054	.450	139.656
2.0	94.218	14.253	-.026	-.054	.450	139.656
2.1	94.130	13.845	-.021	-.047	.315	124.506
3.0	94.130	13.845	-.021	-.047	.315	124.506
3.1	92.286	14.242	-.025	-.048	.413	131.028
4.0	92.286	14.242	-.025	-.048	.413	131.028
4.1	91.920	14.253	-.026	-.054	.450	135.885
5.0	91.920	14.253	-.026	-.054	.450	135.885
5.1	92.546	14.029	-.023	-.051	.392	129.043
5.2	92.053	14.275	-.025	-.052	.407	131.790
5.3	91.763	14.267	-.026	-.054	.436	133.934
6.0	91.763	14.267	-.026	-.054	.436	133.934
6.1	91.905	14.259	-.026	-.055	.444	135.874
6.2	91.711	14.264	-.026	-.054	.436	134.541
7.0	91.711	14.264	-.026	-.054	.436	134.541
7.1	91.820	14.253	-.026	-.055	.450	135.563
7.2	91.699	14.262	-.026	-.054	.439	134.750
8.0	91.699	14.262	-.026	-.054	.439	134.750
8.1	91.717	14.257	-.026	-.054	.445	135.137
8.2	91.693	14.261	-.026	-.054	.441	134.858
9.0	91.693	14.261	-.026	-.054	.441	134.858
9.1	91.702	14.258	-.026	-.054	.444	135.069
9.2	91.690	14.260	-.026	-.054	.441	134.919
10.0	91.690	14.260	-.026	-.054	.441	134.919
10.1	91.692	14.259	-.026	-.054	.443	135.026
10.2	91.688	14.259	-.026	-.054	.442	134.961

Derivatives are calculated numerically.

a. Major iteration number is displayed to the left of the decimal, and minor iteration number is to the right of the decimal.

b. Run stopped after 57 model evaluations and 21 derivative evaluations because the relative reduction between successive residual sums of squares is at most SSCON = 1.00E-008.

Iteration History[b]

Iteration Number[a]	Residual Sum of Squares	Parameter				
		a0	a1	a2	a3	knot1
11.0	91.688	14.259	-.026	-.054	.442	134.961
11.1	91.695	14.259	-.026	-.054	.443	135.038
11.2	91.688	14.259	-.026	-.054	.442	134.976
12.0	91.688	14.259	-.026	-.054	.442	134.976
12.1	91.687	14.259	-.026	-.054	.443	135.004
13.0	91.687	14.259	-.026	-.054	.443	135.004
13.1	91.687	14.259	-.026	-.054	.443	134.986
14.0	91.687	14.259	-.026	-.054	.443	134.986
14.1	91.686	14.259	-.026	-.054	.443	134.994
15.0	91.686	14.259	-.026	-.054	.443	134.994
15.1	91.688	14.259	-.026	-.054	.443	135.009
15.2	91.686	14.259	-.026	-.054	.443	134.996
16.0	91.686	14.259	-.026	-.054	.443	134.996
16.1	91.686	14.259	-.026	-.054	.443	135.000
17.0	91.686	14.259	-.026	-.054	.443	135.000
17.1	91.686	14.259	-.026	-.054	.443	134.990
17.2	91.686	14.259	-.026	-.054	.443	134.996
17.3	91.686	14.259	-.026	-.054	.443	134.998
17.4	91.686	14.259	-.026	-.054	.443	134.999
18.0	91.686	14.259	-.026	-.054	.443	134.999
18.1	91.686	14.259	-.026	-.054	.443	135.000
19.0	91.686	14.259	-.026	-.054	.443	135.000
19.1	91.686	14.259	-.026	-.054	.443	135.000
19.2	91.686	14.259	-.026	-.054	.443	135.000
20.0	91.686	14.259	-.026	-.054	.443	135.000
20.1	91.686	14.259	-.026	-.054	.443	135.000
21.0	91.686	14.259	-.026	-.054	.443	135.000
21.1	91.686	14.259	-.026	-.054	.443	135.000
21.2	91.686	14.259	-.026	-.054	.443	135.000
21.3	91.686	14.259	-.026	-.054	.443	135.000

Derivatives are calculated numerically.

a. Major iteration number is displayed to the left of the decimal, and minor iteration number is to the right of the decimal.

b. Run stopped after 57 model evaluations and 21 derivative evaluations because the relative reduction between successive residual sums of squares is at most SSCON = 1.00E-008.

Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
a0	14.259	1.837	10.579	17.938
a1	-.026	.015	-.056	.005
a2	-.054	.022	-.098	-.011

Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
a3	.443	.334	-.225	1.111
knot1	135.000	9.520	115.930	154.070

Correlations of Parameter Estimates

	a0	a1	a2	a3	knot1
a0	1.000	-.989	.655	-.266	.357
a1	-.989	1.000	-.672	.188	-.445
a2	.655	-.672	1.000	-.009	-.058
a3	-.266	.188	-.009	1.000	.237
knot1	.357	-.445	-.058	.237	1.000

ANOVA[a]

Source	Sum of Squares	df	Mean Squares
Regression	6714.134	5	1342.827
Residual	91.686	56	1.637
Uncorrected Total	6805.820	61	
Corrected Total	215.327	60	

Dependent variable: rkm_3psu

a. R squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares) = .574.

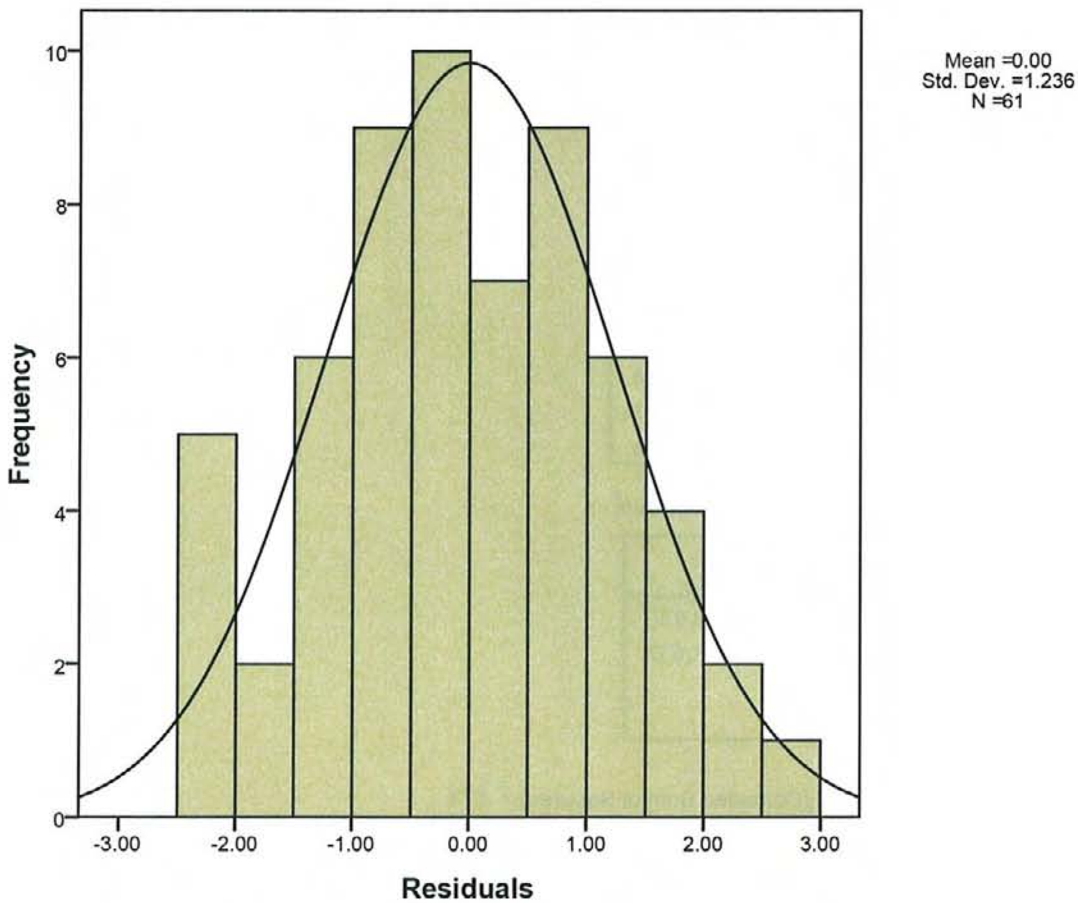
```
GRAPH
  /HISTOGRAM(NORMAL)=RESID.
```

Graph

Notes

Output Created		2009-12-14T11:22:57.491
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_bot_isohaline_ dataset.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	2008
Syntax		GRAPH /HISTOGRAM(NORMAL)=RESID.
Resources	Processor Time	0:00:00.438
	Elapsed Time	0:00:00.531

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model
 Dep\task_6b_bot_isohaline_dataset.sav
```




```
GRAPH
  /SCATTERPLOT(OVERLAY)=totSpg_Q totSpg_Q WITH rkm_3psu PRED_ (PAIR)
  /MISSING=LISTWISE
  /TITLE='Predicted and observed isohaline location (km) versus total spring flow'.
```

Graph

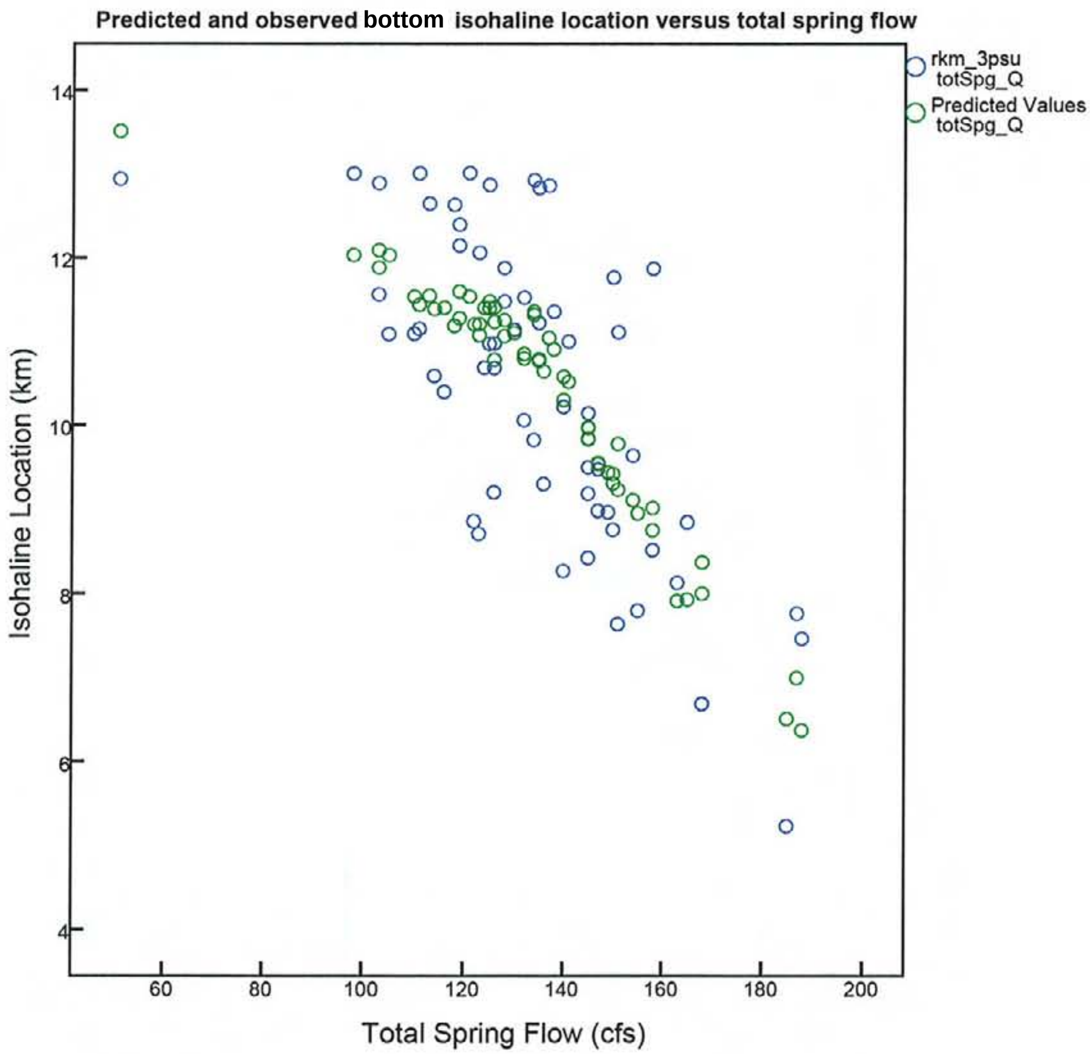
Notes

Output Created		2009-12-14T11:25:04.732
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_bot_isohaline_ dataset.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	2008

Notes

Syntax		GRAPH /SCATTERPLOT(OVERLAY) =totSpg_Q totSpg_Q WITH rkm_3psu PRED_ (PAIR) /MISSING=LISTWISE /TITLE='Predicted and observed isohaline location (km) versus total spring flow'.
Resources	Processor Time	0:00:00.235
	Elapsed Time	0:00:00.358

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model
 Dep\task_6b_bot_isohaline_dataset.sav
```




```
* NonLinear Regression.
MODEL PROGRAM  a0=15 a1=-.03 a2=-.03 a3=0 knot1=130.
COMPUTE  PRED_=a0 + a1*totSpg_Q  +a2*(totSpg_Q-knot1)*(totSpg_Q ge knot1)+ a3*homRiv_ght.
NLR rkm_5psu
```

```
/OUTFILE='C:\DOCUME~1\kww\LOCALS~1\Temp\spss2116\SPSSFNLR.TMP'
/PRED PRED_
/SAVE PRED RESID
/CRITERIA SSCONVERGENCE 1E-8 PCON 1E-8.
```

Nonlinear Regression Analysis

Notes

Output Created		2009-12-14T11:26:23.048
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_bot_isohaline_ dataset.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	2008
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used. Predicted values are calculated for cases with missing values on the dependent variable.
Syntax		MODEL PROGRAM a0=15 a1=-.03 a2=-.03 a3=0 knot1=130. COMPUTE PRED_=a0 + a1*totSpg_Q +a2*(totSpg_Q-knot1) *(totSpg_Q ge knot1)+ a3*homRiv_ght. NLR rkm_5psu /OUTFILE='C: \DOCUME~1\kww\LOCALS~1\Temp \spss2116\SPSSFNLR.TMP' /PRED PRED_ /SAVE PRED RESID /CRITERIA SSCONVERGENCE 1E-8 PCON 1E-8.
Resources	Processor Time	0:00:00.109
	Elapsed Time	0:00:00.344
Variables Created or Modified	PRED_1	Predicted Values
	RESID_1	Residuals
Files Saved	Parameter Estimates File	C: \DOCUME~1\kww\LOCALS~1\Temp \spss2116\SPSSFNLR.TMP

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model
Dep\task_6b_bot_isohaline_dataset.sav
```

Iteration History[b]

Iteration Number[a]	Residual Sum of Squares	Parameter				
		a0	a1	a2	a3	knot1
1.0	309.132	15.000	-.030	-.030	.000	130.000
1.1	157.208	11.887	-.019	-.082	.683	165.706
2.0	157.208	11.887	-.019	-.082	.683	165.706
2.1	1612.888	11.803	-.020	.114	1.125	104.225
2.2	130.952	11.818	-.020	-.063	1.056	137.306
3.0	130.952	11.818	-.020	-.063	1.056	137.306
3.1	127.788	11.716	-.015	-.067	.541	130.516
4.0	127.788	11.716	-.015	-.067	.541	130.516
4.1	127.310	11.612	-.017	-.082	.686	143.971
5.0	127.310	11.612	-.017	-.082	.686	143.971
5.1	125.075	11.447	-.015	-.079	.722	139.424
6.0	125.075	11.447	-.015	-.079	.722	139.424
6.1	126.575	11.167	-.011	-.072	.546	131.041
6.2	123.940	11.479	-.014	-.074	.608	134.400
7.0	123.940	11.479	-.014	-.074	.608	134.400
7.1	125.094	11.406	-.014	-.080	.704	139.444
7.2	123.574	11.451	-.014	-.076	.638	136.405
8.0	123.574	11.451	-.014	-.076	.638	136.405
8.1	123.450	11.383	-.013	-.077	.641	135.768
9.0	123.450	11.383	-.013	-.077	.641	135.768
9.1	123.319	11.228	-.012	-.078	.646	135.445
10.0	123.319	11.228	-.012	-.078	.646	135.445
10.1	123.175	10.914	-.009	-.081	.660	134.939
11.0	123.175	10.914	-.009	-.081	.660	134.939
11.1	126.158	11.401	-.015	-.086	.775	142.278
11.2	124.948	10.869	-.010	-.087	.747	139.214
11.3	123.240	10.897	-.009	-.082	.679	136.287
11.4	123.170	10.908	-.009	-.081	.666	135.588
12.0	123.170	10.908	-.009	-.081	.666	135.588
12.1	123.140	10.904	-.009	-.081	.667	135.258
13.0	123.140	10.904	-.009	-.081	.667	135.258
13.1	123.138	10.881	-.009	-.081	.663	134.979
14.0	123.138	10.881	-.009	-.081	.663	134.979
14.1	123.143	10.878	-.009	-.082	.665	135.362
14.2	123.131	10.880	-.009	-.081	.664	135.157

Derivatives are calculated numerically.

a. Major iteration number is displayed to the left of the decimal, and minor iteration number is to the right of the decimal.

b. Run stopped after 66 model evaluations and 25 derivative evaluations because the relative reduction between successive residual sums of squares is at most SSCON = 1.00E-008.

Iteration History[b]

Iteration Number[a]	Residual Sum of Squares	Parameter				
		a0	a1	a2	a3	knot1
15.0	123.131	10.880	-.009	-.081	.664	135.157
15.1	123.127	10.878	-.009	-.081	.665	135.079
16.0	123.127	10.878	-.009	-.081	.665	135.079
16.1	123.130	10.873	-.009	-.081	.664	134.989
16.2	123.126	10.877	-.009	-.082	.665	135.046
17.0	123.126	10.877	-.009	-.082	.665	135.046
17.1	123.124	10.875	-.009	-.081	.664	135.000
18.0	123.124	10.875	-.009	-.081	.664	135.000
18.1	123.130	10.874	-.009	-.082	.665	135.194
18.2	123.126	10.874	-.009	-.081	.664	135.097
18.3	123.125	10.874	-.009	-.081	.664	135.048
18.4	123.124	10.874	-.009	-.081	.664	135.024
18.5	123.124	10.875	-.009	-.081	.664	135.011
19.0	123.124	10.875	-.009	-.081	.664	135.011
19.1	123.124	10.874	-.009	-.081	.664	135.007
20.0	123.124	10.874	-.009	-.081	.664	135.007
20.1	123.124	10.874	-.009	-.081	.664	135.002
21.0	123.124	10.874	-.009	-.081	.664	135.002
21.1	123.128	10.874	-.009	-.081	.664	134.993
21.2	123.124	10.874	-.009	-.081	.664	135.001
22.0	123.124	10.874	-.009	-.081	.664	135.001
22.1	123.124	10.874	-.009	-.081	.664	134.999
22.2	123.124	10.874	-.009	-.081	.664	135.001
23.0	123.124	10.874	-.009	-.081	.664	135.001
23.1	123.124	10.874	-.009	-.081	.664	135.000
24.0	123.124	10.874	-.009	-.081	.664	135.000
24.1	123.124	10.874	-.009	-.081	.664	134.999
24.2	123.124	10.874	-.009	-.081	.664	135.000
25.0	123.124	10.874	-.009	-.081	.664	135.000
25.1	123.124	10.874	-.009	-.081	.664	135.000
25.2	123.124	10.874	-.009	-.081	.664	135.000

Derivatives are calculated numerically.

a. Major iteration number is displayed to the left of the decimal, and minor iteration number is to the right of the decimal.

b. Run stopped after 66 model evaluations and 25 derivative evaluations because the relative reduction between successive residual sums of squares is at most SSCON = 1.00E-008.

Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
a0	10.874	1.950	6.973	14.775
a1	-.009	.016	-.042	.023
a2	-.081	.025	-.132	-.031

Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
a3	.664	.381	-.097	1.425
knot1	135.000	7.432	120.135	149.865

Correlations of Parameter Estimates

	a0	a1	a2	a3	knot1
a0	1.000	-.989	.616	-.274	.350
a1	-.989	1.000	-.628	.200	-.426
a2	.616	-.628	1.000	-.055	-.187
a3	-.274	.200	-.055	1.000	.213
knot1	.350	-.426	-.187	.213	1.000

ANOVA[a]

Source	Sum of Squares	df	Mean Squares
Regression	5487.215	5	1097.443
Residual	123.124	60	2.052
Uncorrected Total	5610.339	65	
Corrected Total	260.443	64	

Dependent variable: rkm_5psu

a. R squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares) = .527.

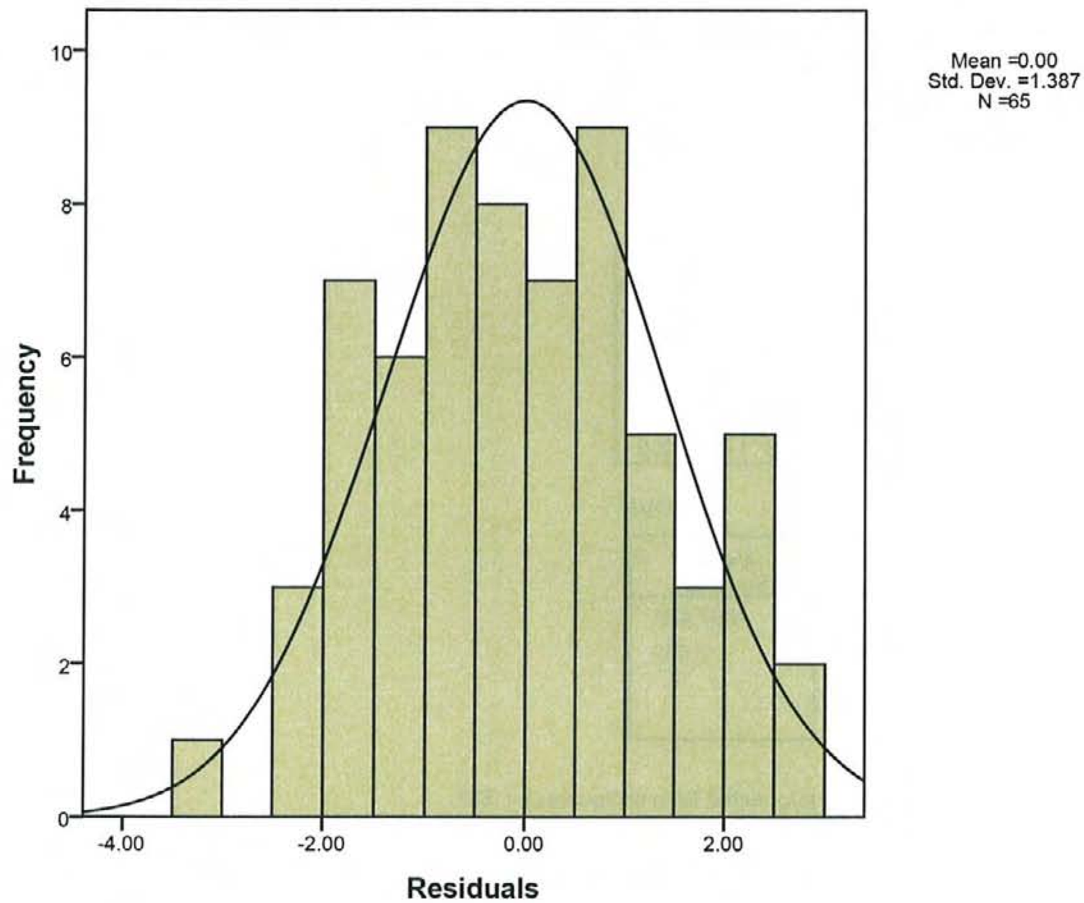
```
GRAPH
  /HISTOGRAM(NORMAL)=RESID_1.
```

Graph

Notes

Output Created		2009-12-14T11:26:36.562
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_bot_isohaline_dataset.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	2008
Syntax		GRAPH /HISTOGRAM(NORMAL)=RESID_1.
Resources	Processor Time	0:00:00.406
	Elapsed Time	0:00:00.468

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model
 Dep\task_6b_bot_isohaline_dataset.sav
```




```
GRAPH
  /SCATTERPLOT(OVERLAY)=totSpg_Q totSpg_Q WITH rkm_5psu PRED_1 (PAIR)
  /MISSING=LISTWISE
  /TITLE='Predicted and observed isohaline location (km) versus total spring flow'.
```

Graph

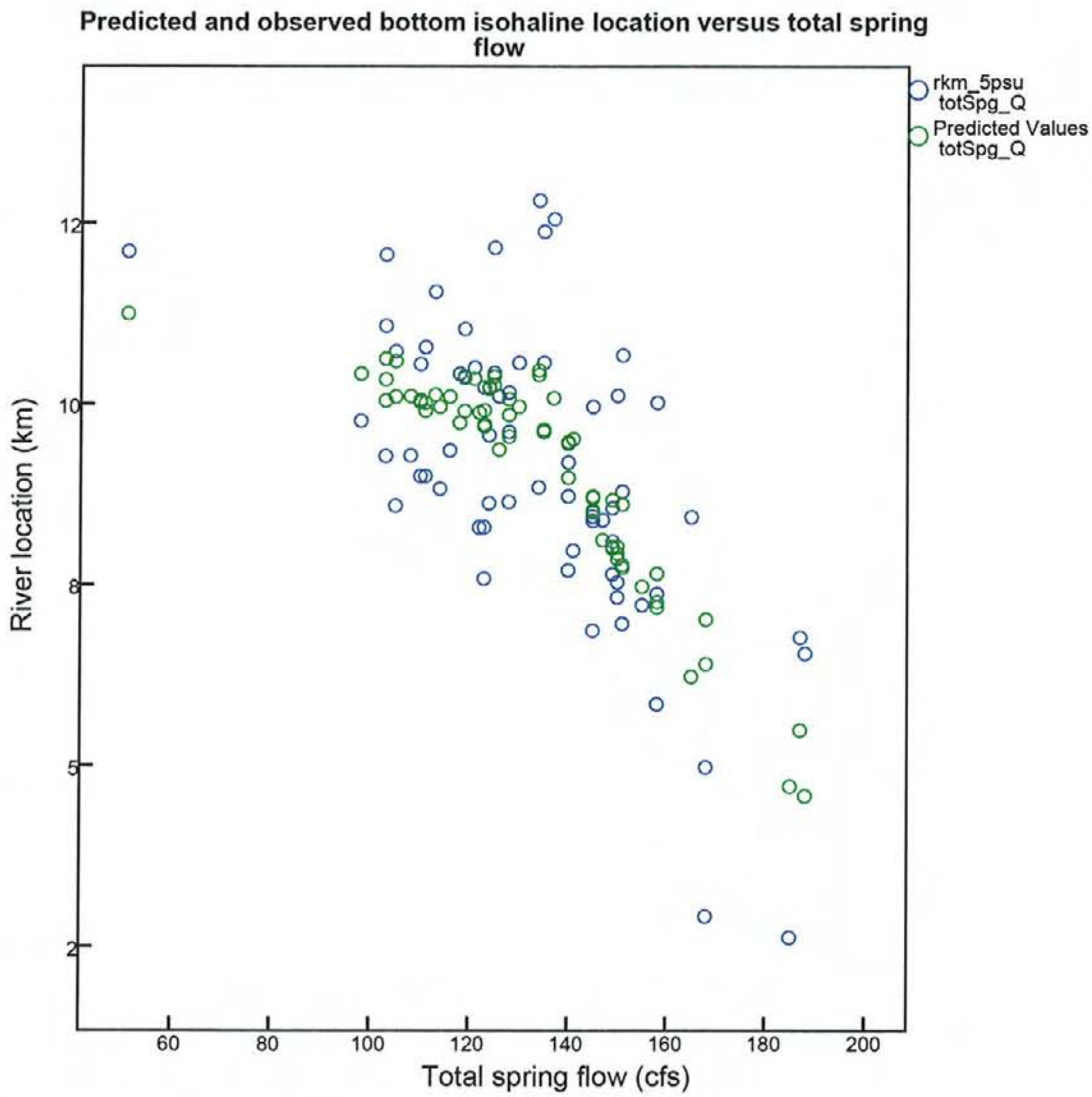
Notes

Output Created		2009-12-14T11:27:02.136
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_bot_isohaline_dataset.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	2008

Notes

Syntax		GRAPH /SCATTERPLOT(OVERLAY) =totSpg_Q totSpg_Q WITH rkm_5psu PRED_1 (PAIR) /MISSING=LISTWISE /TITLE='Predicted and observed isohaline location (km) versus total spring flow'.
Resources	Processor Time	0:00:00.406
	Elapsed Time	0:00:00.438

[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_bot_isohaline_dataset.sav




```
* NonLinear Regression.
MODEL PROGRAM  a0=15 a1=-.03 a2=-.03 a3=0 knot1=130.
COMPUTE  PRED_=a0 + a1*totSpg_Q  +a2*(totSpg_Q-knot1)*(totSpg_Q ge knot1)+ a3*homRiv_ght.
```

```
NLR rkm_12psu
  /OUTFILE='C:\DOCUME~1\kww\LOCALS~1\Temp\spss2116\SPSSFNLR.TMP'
  /PRED PRED_
  /SAVE PRED RESID
  /CRITERIA SSCONVERGENCE 1E-8 PCON 1E-8.
```

Nonlinear Regression Analysis

Notes

Output Created		2009-12-14T11:27:38.851
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_bot_isohaline_ dataset.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	2008
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used. Predicted values are calculated for cases with missing values on the dependent variable.
Syntax		MODEL PROGRAM a0=15 a1=-.03 a2=-.03 a3=0 knot1=130. COMPUTE PRED_=a0 + a1*totSpg_Q +a2*(totSpg_Q-knot1) *(totSpg_Q ge knot1)+ a3*homRiv_ght. NLR rkm_12psu /OUTFILE='C: \DOCUME~1\kww\LOCALS~1\Temp \spss2116\SPSSFNLR.TMP' /PRED PRED_ /SAVE PRED RESID /CRITERIA SSCONVERGENCE 1E-8 PCON 1E-8.
Resources	Processor Time	0:00:00.063
	Elapsed Time	0:00:00.094
Variables Created or Modified	PRED_2	Predicted Values
	RESID_2	Residuals
Files Saved	Parameter Estimates File	C: \DOCUME~1\kww\LOCALS~1\Temp \spss2116\SPSSFNLR.TMP

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model
 Dep\task_6b_bot_isohaline_dataset.sav
```

Iteration History[b]

Iteration Number[a]	Residual Sum of Squares	Parameter				
		a0	a1	a2	a3	knot1
1.0	1648.271	15.000	-.030	-.030	.000	130.000
1.1	164.501	9.630	-.029	-.060	1.070	132.502
2.0	164.501	9.630	-.029	-.060	1.070	132.502
2.1	164.346	9.630	-.029	-.060	1.070	131.245
3.0	164.346	9.630	-.029	-.060	1.070	131.245

Derivatives are calculated numerically.

a. Major iteration number is displayed to the left of the decimal, and minor iteration number is to the right of the decimal.

b. Run stopped after 5 model evaluations and 3 derivative evaluations because the relative reduction between successive parameter estimates is at most PCON = 1.00E-008.

Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
a0	9.630	3.051	3.481	15.779
a1	-.029	.026	-.081	.024
a2	-.060	.037	-.135	.015
a3	1.070	.484	.095	2.045
knot1	131.245	15.124	100.765	161.725

Correlations of Parameter Estimates

	a0	a1	a2	a3	knot1
a0	1.000	-.988	.650	-.223	.360
a1	-.988	1.000	-.670	.157	-.438
a2	.650	-.670	1.000	.063	-.137
a3	-.223	.157	.063	1.000	.105
knot1	.360	-.438	-.137	.105	1.000

ANOVA[a]

Source	Sum of Squares	df	Mean Squares
Regression	1485.165	5	297.033
Residual	164.346	44	3.735
Uncorrected Total	1649.511	49	
Corrected Total	358.299	48	

Dependent variable: rkm_12psu

a. R squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares) = .541.

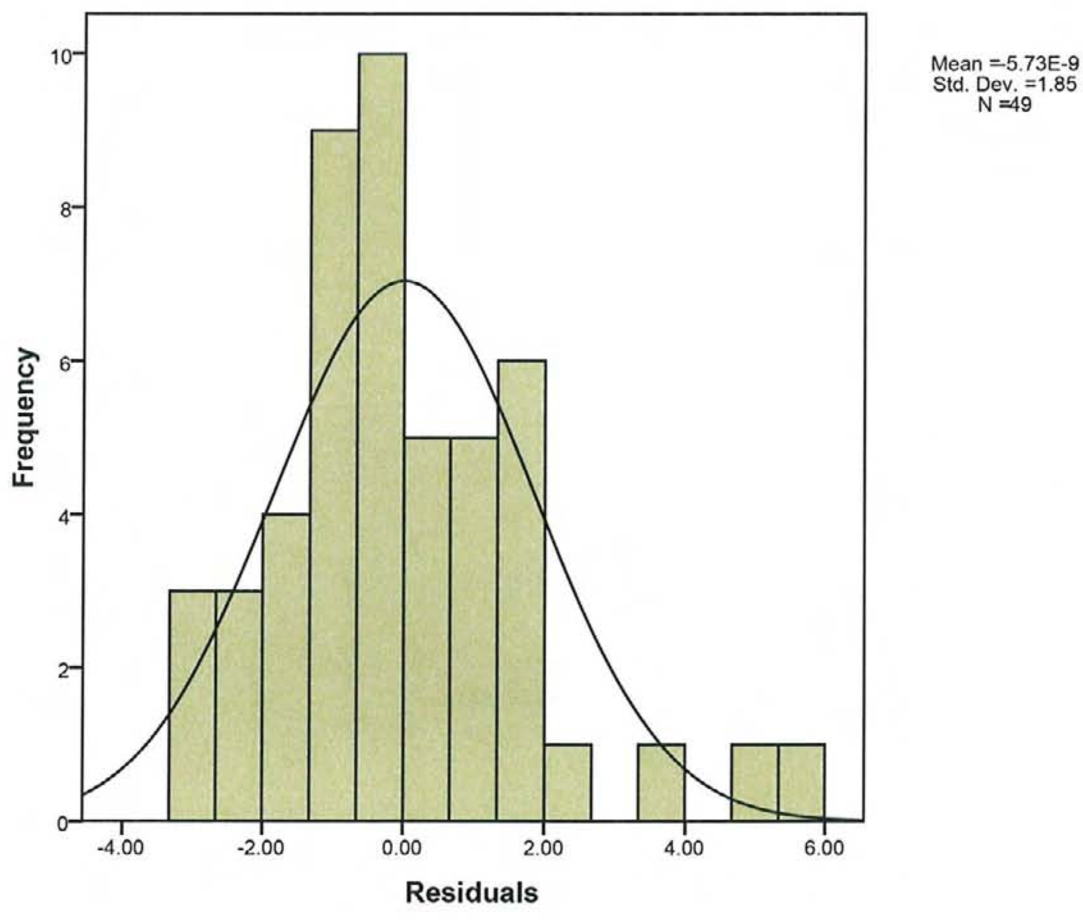
```
GRAPH
  /HISTOGRAM(NORMAL)=RESID_2.
```

Graph

Notes

Output Created		2009-12-14T11:27:51.537
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_bot_isohaline_dataset.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	2008
Syntax		GRAPH /HISTOGRAM(NORMAL)=RESID_2.
Resources	Processor Time	0:00:00.391
	Elapsed Time	0:00:00.390

[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_bot_isohaline_dataset.sav



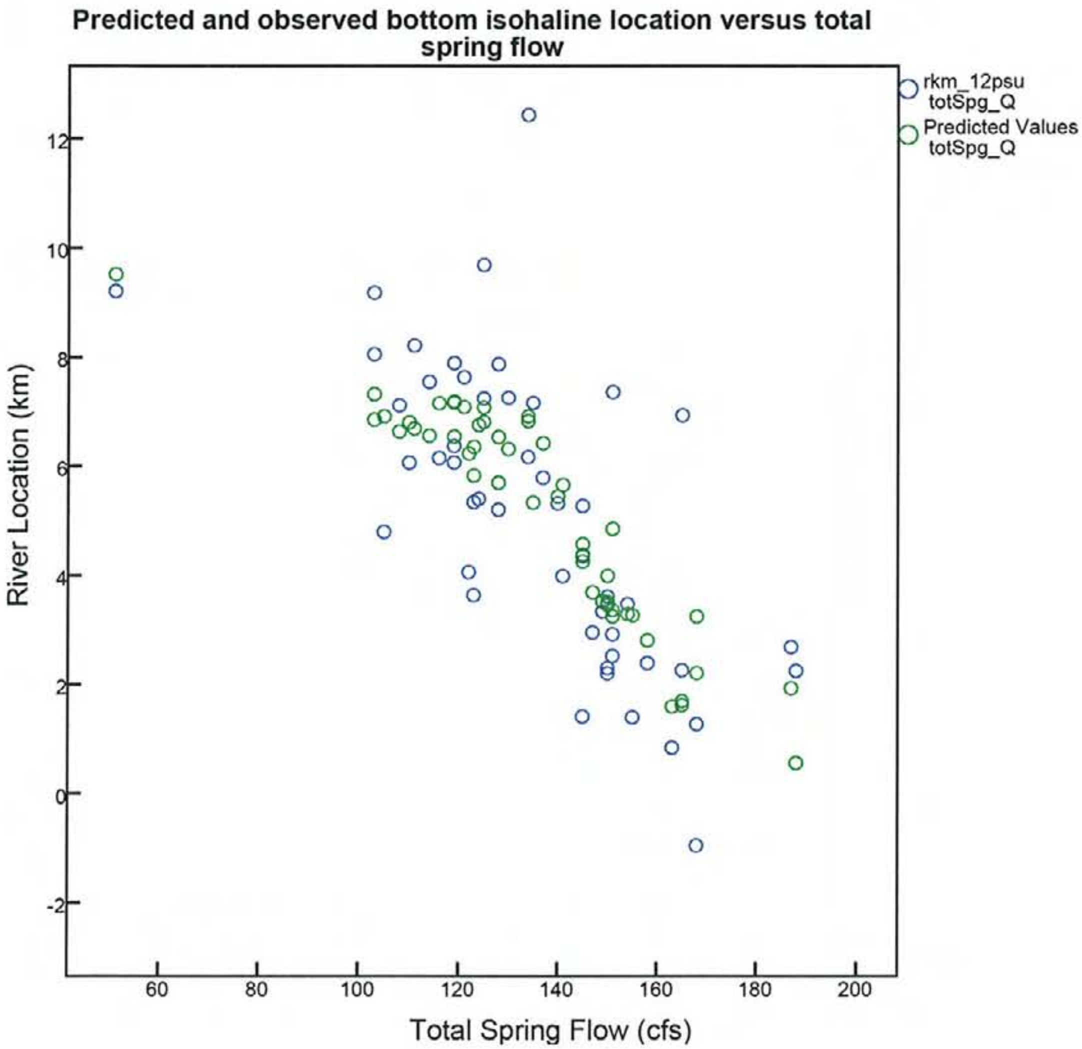
```
GRAPH
  /SCATTERPLOT(OVERLAY)=totSpg_Q totSpg_Q WITH rkm_12psu PRED_2 (PAIR)
  /MISSING=LISTWISE
  /TITLE='Predicted and observed isohaline location (km) versus total spring flow'.
```

Graph

Notes

Output Created		2009-12-14T11:28:39.424
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6b_bot_isohaline_dataset.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	2008
Syntax		GRAPH /SCATTERPLOT(OVERLAY) =totSpg_Q totSpg_Q WITH rkm_12psu PRED_2 (PAIR) /MISSING=LISTWISE /TITLE='Predicted and observed isohaline location (km) versus total spring flow'.
Resources	Processor Time	0:00:00.250
	Elapsed Time	0:00:00.313

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model
Dep\task_6b_bot_isohaline_dataset.sav
```



Predicted and observed bottom isohaline location versus total spring flow
rkm_12psu totSpg_Q
Predicted Values totSpg_Q
River Location (km)
Total Spring Flow (cfs)
12
10
8
6
4
2
0
-2
60
80
100
120
140
160
180
200

I-4
Fixed Location Models for Selected River Sections

0.1 Kilometer Salinity Regression Models

Notes

Output Created		2009-07-22T16:51:35.881
Comments		
Input	Active Dataset	DataSet1
	Filter	@200m_int = 0.1 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	200
Syntax		GRAPH /SCATTERPLOT(BIVAR)=shell_ght WITH topSal /MISSING=LISTWISE.
Resources	Processor Time	0:00:00.360
	Elapsed Time	0:00:00.359

Notes

Output Created		2009-07-22T16:52:04.129
Comments		
Input	Active Dataset	DataSet1
	Filter	@200m_int = 0.1 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	200
Syntax		GRAPH /SCATTERPLOT(BIVAR)=shell_ght WITH botSal /MISSING=LISTWISE.
Resources	Processor Time	0:00:00.343
	Elapsed Time	0:00:00.359

[DataSet1]

Regression

Notes

Output Created		2009-07-22T16:56:51.011
Comments		
Input	Active Dataset	DataSet1
	Filter	@200m_int = 0.1 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	200
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used.

Notes

Syntax		REGRESSION /MISSING LISTWISE /STATISTICS COEFF OUTS R ANOVA /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT topSal /METHOD=STEPWISE shell_ght Tot_Spring_Q /PARTIALPLOT ALL /RESIDUALS DURBIN HIST (ZRESID) NORM(ZRESID) /SAVE PRED.
Resources	Processor Time	0:00:00.797
	Elapsed Time	0:00:00.812
	Memory Required	2676 bytes
	Additional Memory Required for Residual Plots	1368 bytes
Variables Created or Modified	PRE_1	Unstandardized Predicted Value

[DataSet1]

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	shell_ght	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	Tot_Spring_Q	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: topSal

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.681[a]	.464	.456	2.72881185E0	
2	.718[b]	.515	.501	2.61292294E0	.927

a. Predictors: (Constant), shell_ght

b. Predictors: (Constant), shell_ght, Tot_Spring_Q

c. Dependent Variable: topSal

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	457.350	1	457.350	61.419	.000[a]
	Residual	528.695	71	7.446		
	Total	986.045	72			
2	Regression	508.129	2	254.065	37.213	.000[b]
	Residual	477.916	70	6.827		
	Total	986.045	72			

a. Predictors: (Constant), shell_ght

b. Predictors: (Constant), shell_ght, Tot_Spring_Q

c. Dependent Variable: topSal

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	20.931	.331		63.235	.000
	shell_ght	3.264	.417	.681	7.837	.000
2	(Constant)	26.683	2.133		12.510	.000
	shell_ght	2.692	.451	.562	5.972	.000
	Tot_Spring_Q	-.044	.016	-.256	-2.727	.008

a. Dependent Variable: topSal

Excluded Variables[b]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	Tot_Spring_Q	-.256[a]	-2.727	.008	-.310	.783

a. Predictors in the Model: (Constant), shell_ght

b. Dependent Variable: topSal

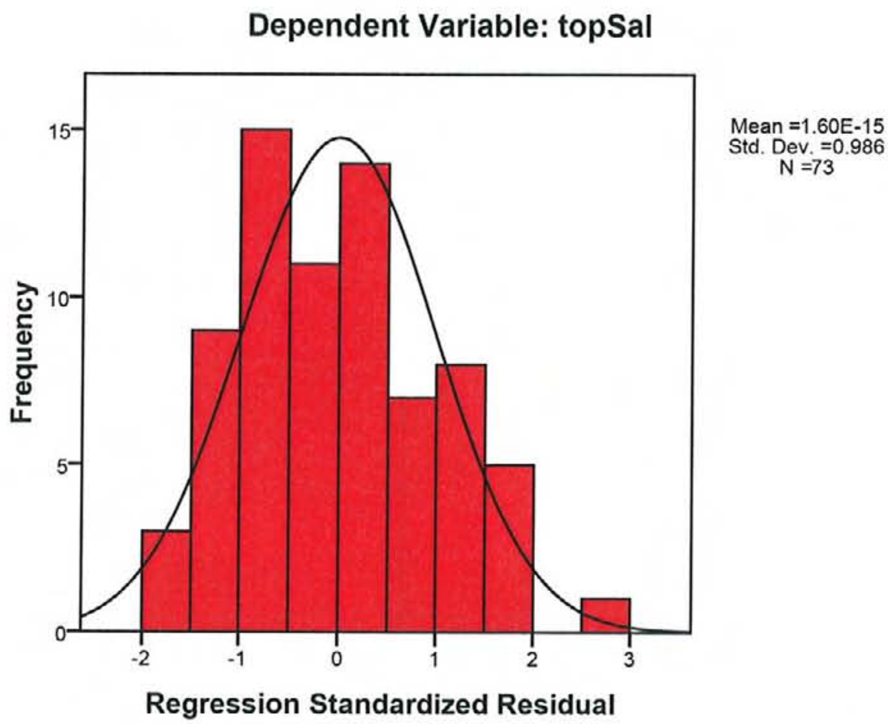
Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	1.4045E1	2.89215E1	2.0249E1	2.65656773E0	73
Residual	-4.8665E0	7.29171E0	...	2.57637676E0	73
Std. Predicted Value	-2.335	3.264	.000	1.000	73
Std. Residual	-1.862	2.791	.000	.986	73

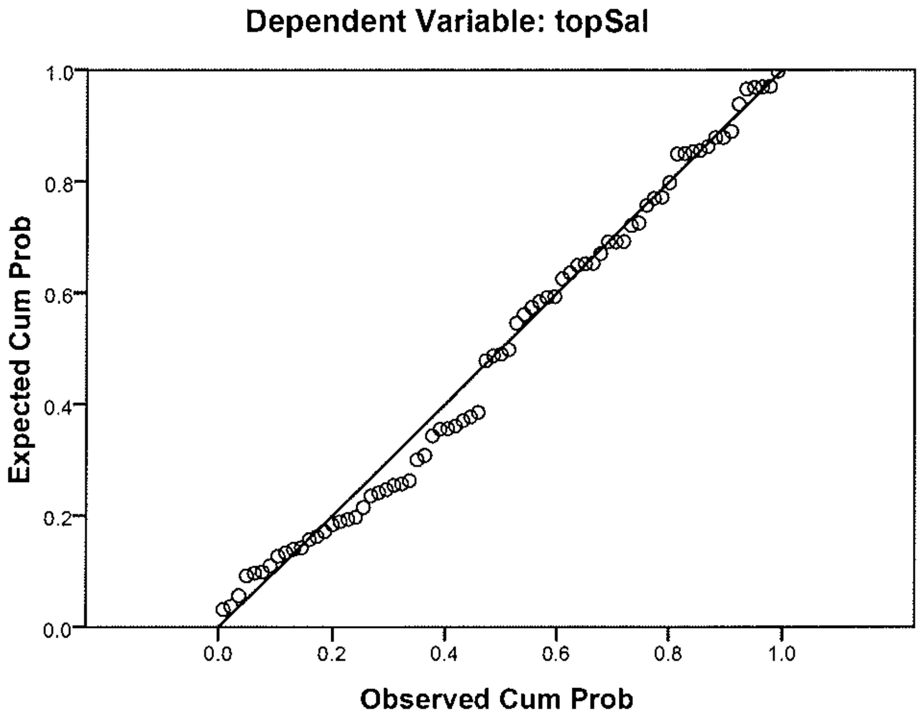
a. Dependent Variable: topSal

Charts

Histogram

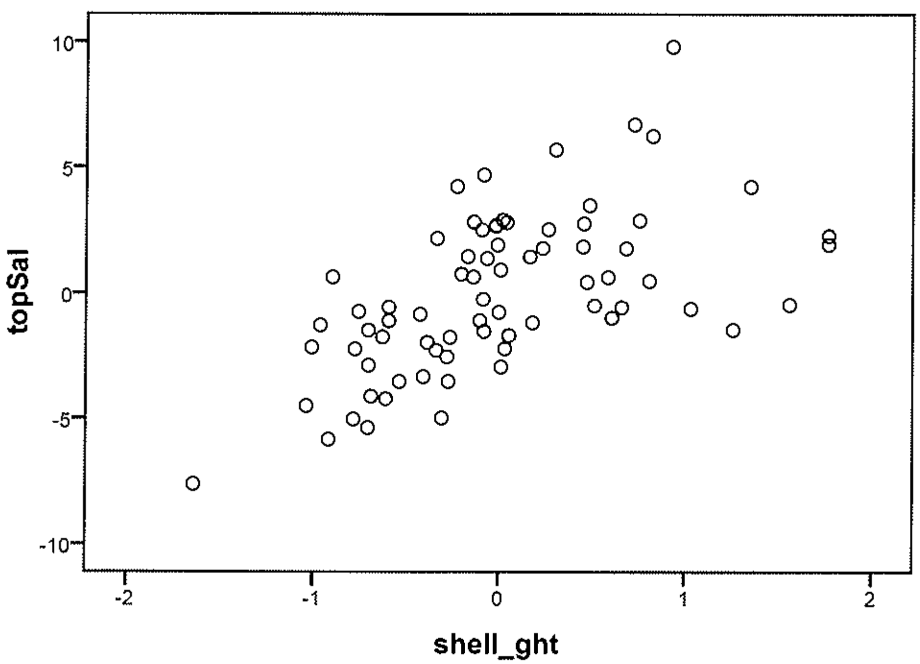

Dependent Variable: topSal
Mean =1.60E-15
Std. Dev. =0.986
N =73
Frequency
15
10
5
0
-2
-1
0
1
2
3
Regression Standardized Residual

Normal P-P Plot of Regression Standardized Residual

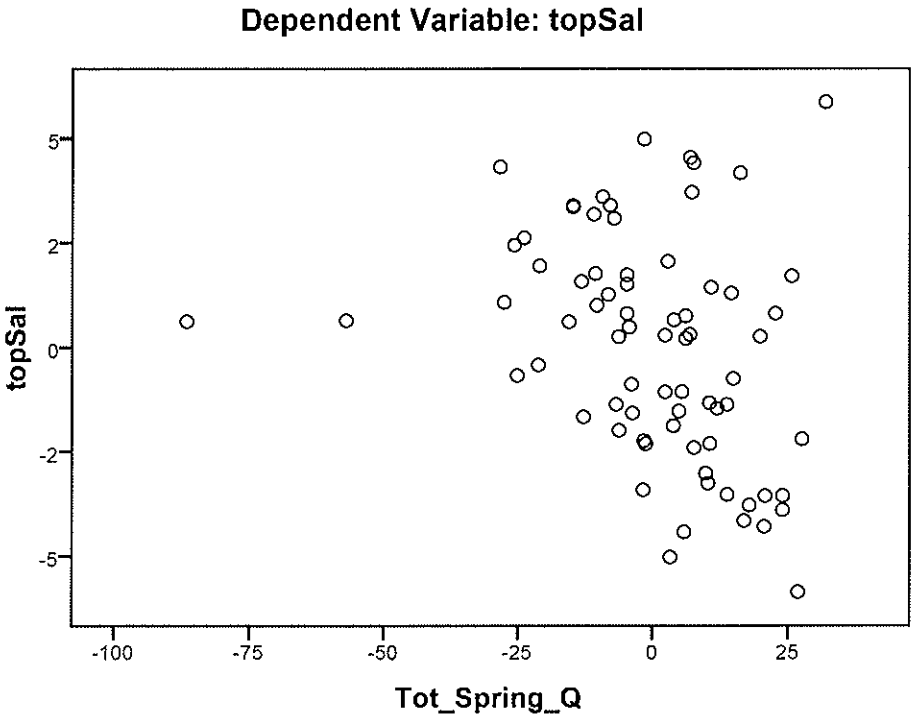


Partial Regression Plot

Dependent Variable: topSal



Partial Regression Plot



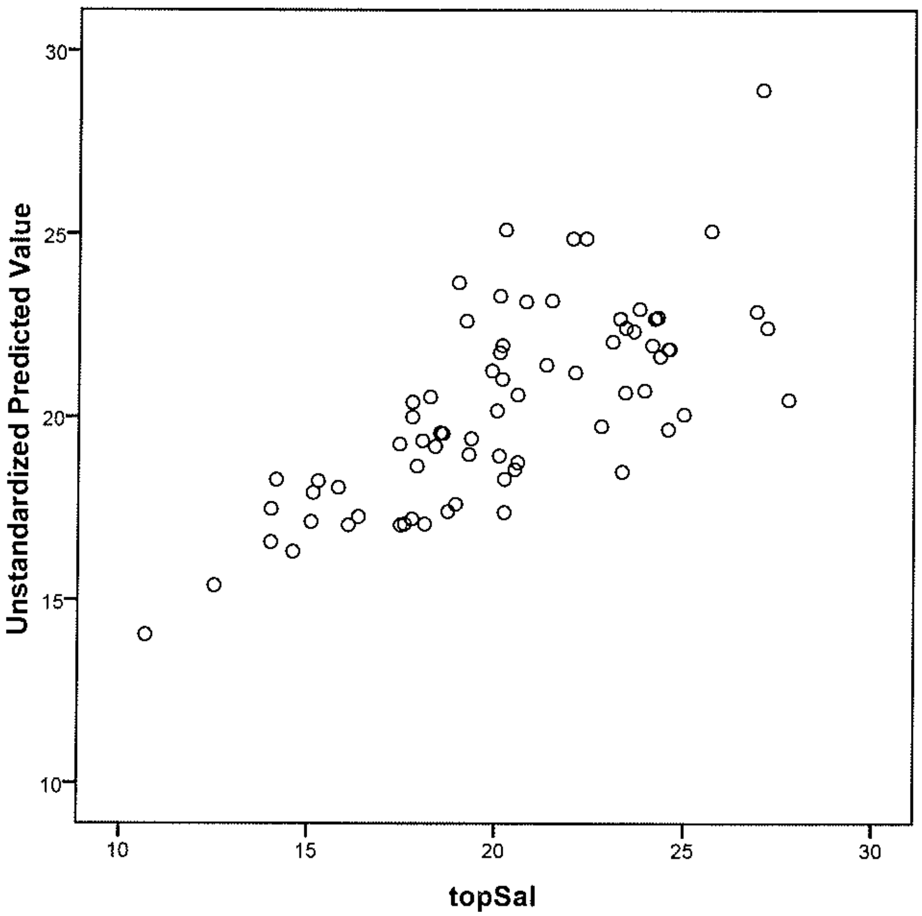

```
GRAPH
  /SCATTERPLOT(BIVAR)=topSal WITH PRE_1
  /MISSING=LISTWISE.
```

Graph

Notes

Output Created		2009-07-22T16:57:37.819
Comments		
Input	Active Dataset	DataSet1
	Filter	@200m_int = 0.1 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	200
Syntax		GRAPH /SCATTERPLOT(BIVAR)=topSal WITH PRE_1 /MISSING=LISTWISE.
Resources	Processor Time	0:00:00.422
	Elapsed Time	0:00:00.421

[DataSet1]




```
REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT botSal
  /METHOD=STEPWISE shell_ght Tot_Spring_Q
  /PARTIALPLOT ALL
  /RESIDUALS DURBIN HIST(ZRESID) NORM(ZRESID)
  /SAVE PRED.
```

Regression

Notes

Output Created		2009-07-22T17:01:03.157
Comments		
Input	Active Dataset	DataSet1
	Filter	@200m_int = 0.1 (FILTER)

Notes

Input	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	200
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used.
Syntax		REGRESSION /MISSING LISTWISE /STATISTICS COEFF OUTS R ANOVA /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT botSal /METHOD=STEPWISE shell_ght Tot_Spring_Q /PARTIALPLOT ALL /RESIDUALS DURBIN HIST (ZRESID) NORM(ZRESID) /SAVE PRED.
Resources	Processor Time	0:00:00.750
	Elapsed Time	0:00:00.750
	Memory Required	2716 bytes
	Additional Memory Required for Residual Plots	1368 bytes
Variables Created or Modified	PRE_2	Unstandardized Predicted Value

[DataSet1]

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	shell_ght	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	Tot_Spring_Q	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: botSal

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.683[a]	.466	.458	2.7836	
2	.713[b]	.508	.493	2.6919	.930

a. Predictors: (Constant), shell_ght

b. Predictors: (Constant), shell_ght, Tot_Spring_Q

c. Dependent Variable: botSal

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	466.500	1	466.500	60.207	.000[a]
	Residual	534.634	69	7.748		
	Total	1001.134	70			
2	Regression	508.394	2	254.197	35.080	.000[b]
	Residual	492.741	68	7.246		
	Total	1001.134	70			

a. Predictors: (Constant), shell_ght

b. Predictors: (Constant), shell_ght, Tot_Spring_Q

c. Dependent Variable: botSal

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	21.284	.343		62.057	.000
	shell_ght	3.334	.430	.683	7.759	.000
2	(Constant)	26.514	2.200		12.051	.000
	shell_ght	2.813	.469	.576	6.003	.000
	Tot_Spring_Q	-.040	.017	-.231	-2.404	.019

a. Dependent Variable: botSal

Excluded Variables[b]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	Tot_Spring_Q	-.231[a]	-2.404	.019	-.280	.786

a. Predictors in the Model: (Constant), shell_ght

b. Dependent Variable: botSal

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	14.360	29.163	20.569	2.6950	71
Residual	-5.2203	7.4305	.0000	2.6531	71

a. Dependent Variable: botSal

Residuals Statistics[a]

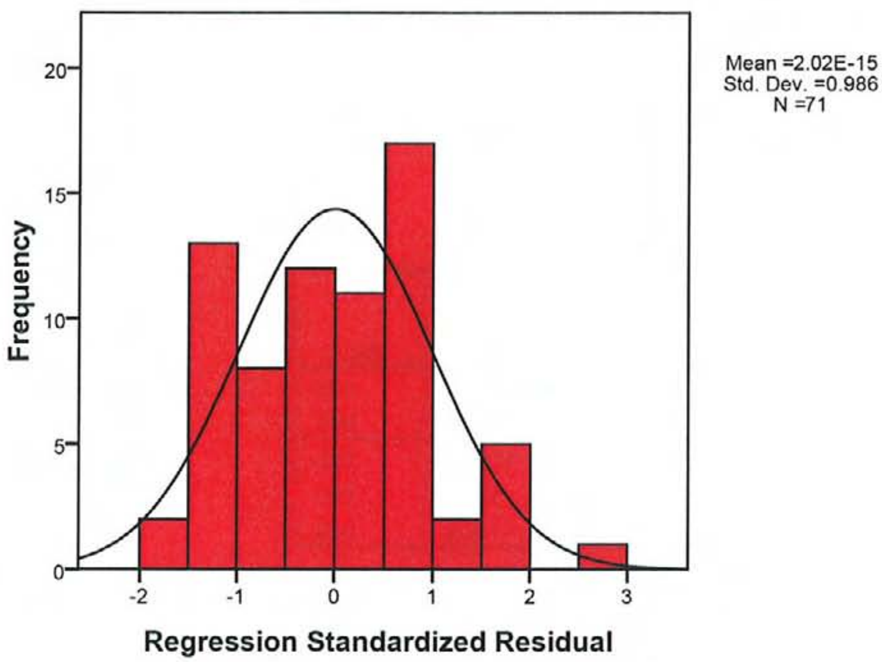
	Minimum	Maximum	Mean	Std. Deviation	N
Std. Predicted Value	-2.304	3.189	.000	1.000	71
Std. Residual	-1.939	2.760	.000	.986	71

a. Dependent Variable: botSal

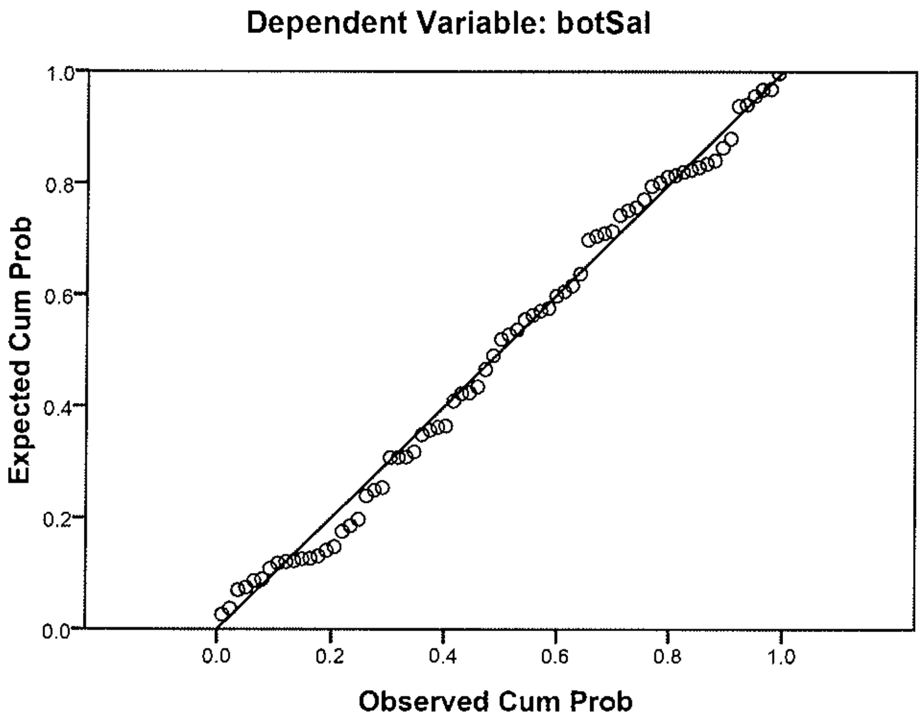
Charts

Histogram

Dependent Variable: botSal

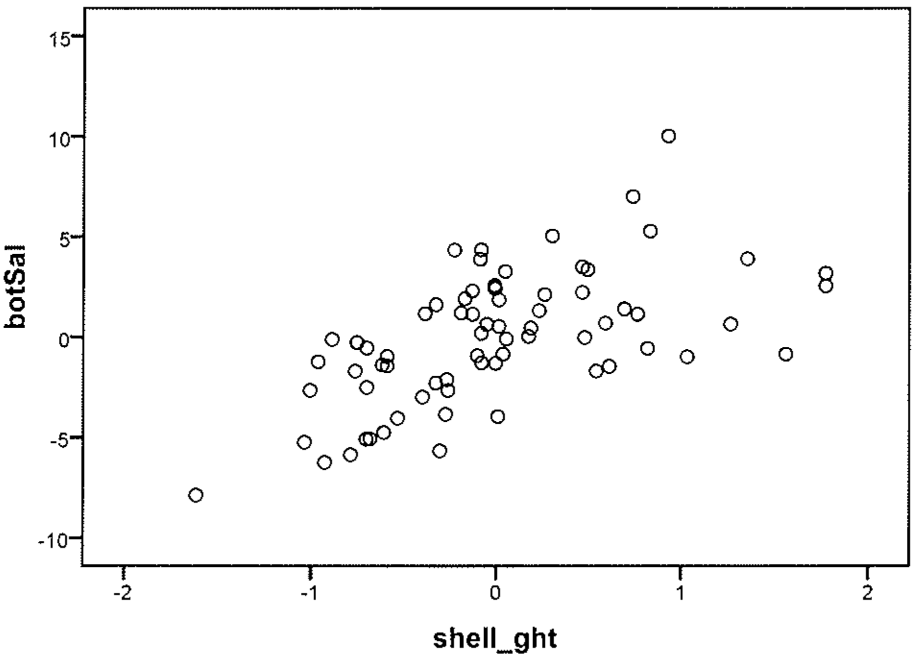


Normal P-P Plot of Regression Standardized Residual

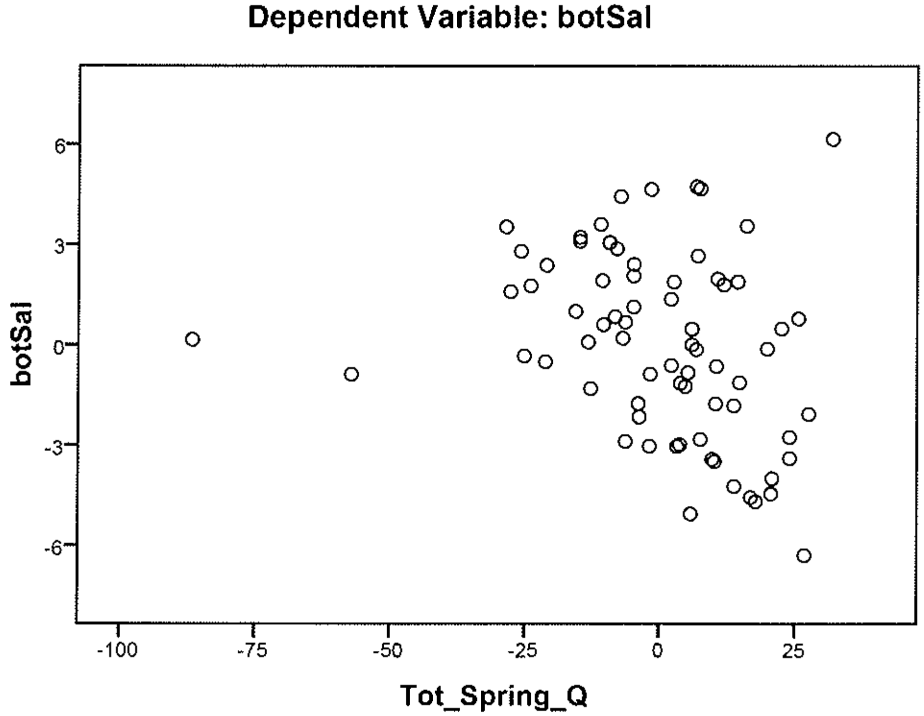


Partial Regression Plot

Dependent Variable: botSal



Partial Regression Plot



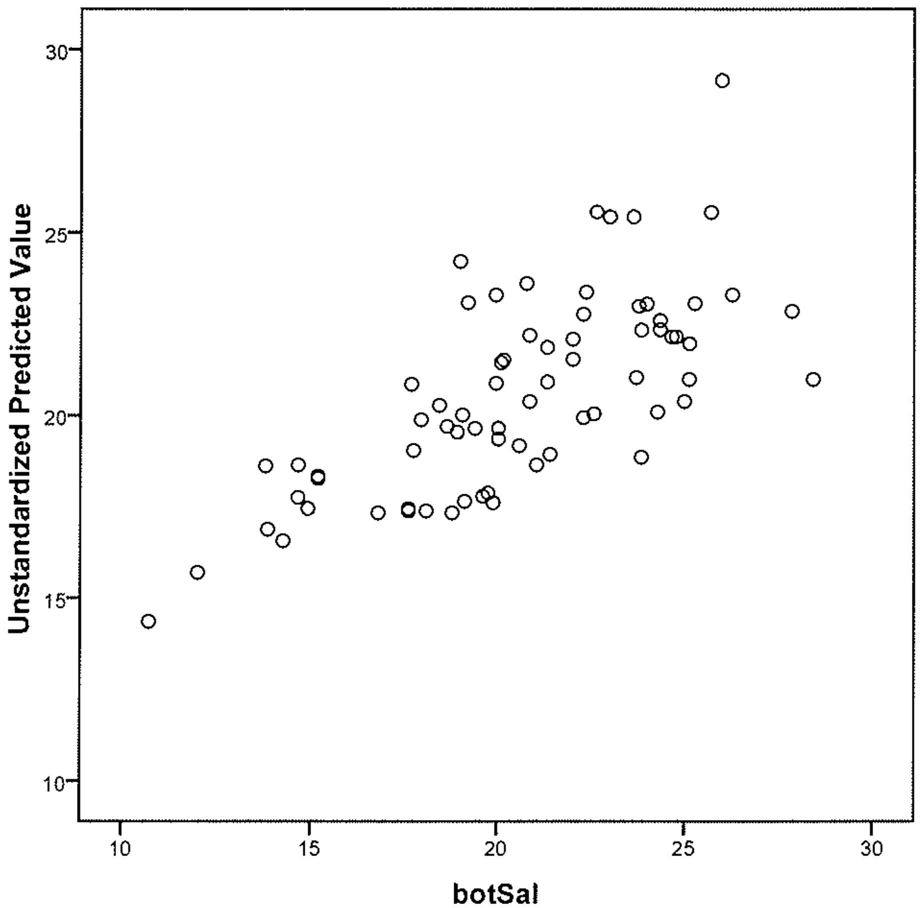

```
GRAPH
  /SCATTERPLOT(BIVAR)=botSal WITH PRE_2
  /MISSING=LISTWISE.
```

Graph

Notes

Output Created		2009-07-22T17:01:38.918
Comments		
Input	Active Dataset	DataSet1
	Filter	@200m_int = 0.1 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	200
Syntax		GRAPH /SCATTERPLOT(BIVAR)=botSal WITH PRE_2 /MISSING=LISTWISE.
Resources	Processor Time	0:00:00.422
	Elapsed Time	0:00:00.423

[DataSet1]




```
SORT CASES BY Date (A).
SAVE OUTFILE='P:\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\ta
sk_6c.sav'
  /COMPRESSED.
```

7.3 Kilometer Regression

Regression

Notes

Output Created		2009-10-22T15:51:48.908
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6c.sav
	Active Dataset	DataSet1
	Filter	@200m_int=7.3 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	53
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used.
Syntax		REGRESSION /SELECT=@200m_int EQ 7.3 /MISSING LISTWISE /STATISTICS COEFF OUTS R ANOVA CHANGE /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT topSal /METHOD=STEPWISE Tot_Spring_Q /RESIDUALS HIST(ZRESID) NORM (ZRESID) /SAVE PRED.
Resources	Processor Time	0:00:00.422
	Elapsed Time	0:00:00.453
	Memory Required	2324 bytes
	Additional Memory Required for Residual Plots	728 bytes
Variables Created or Modified	PRE_1	Unstandardized Predicted Value

[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6c.sav

Warnings

All cases were selected. There is no residuals output for unselected cases.

ANOVA[b,c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	79.199	1	79.199	19.203	.000[a]
	Residual	103.108	25	4.124		
	Total	182.307	26			

a. Predictors: (Constant), Tot_Spring_Q

b. Dependent Variable: topSal

c. Selecting only cases for which 200m_int = 7.3

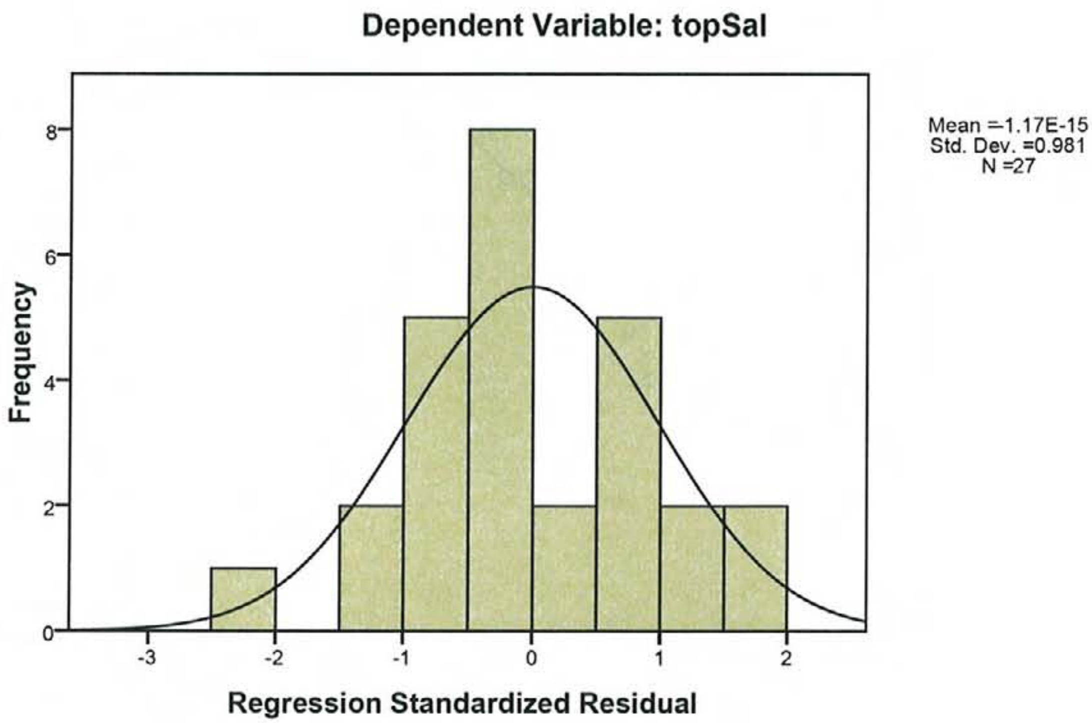
Residuals Statistics[a]

	200m_int = 7.3 (Selected)				
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	2.62677	9.62454	6.77000	1.745314	27
Residual	-4.623865	3.888944	.000000	1.991401	27
Std. Predicted Value	-2.374	1.636	.000	1.000	27
Std. Residual	-2.277	1.915	.000	.981	27

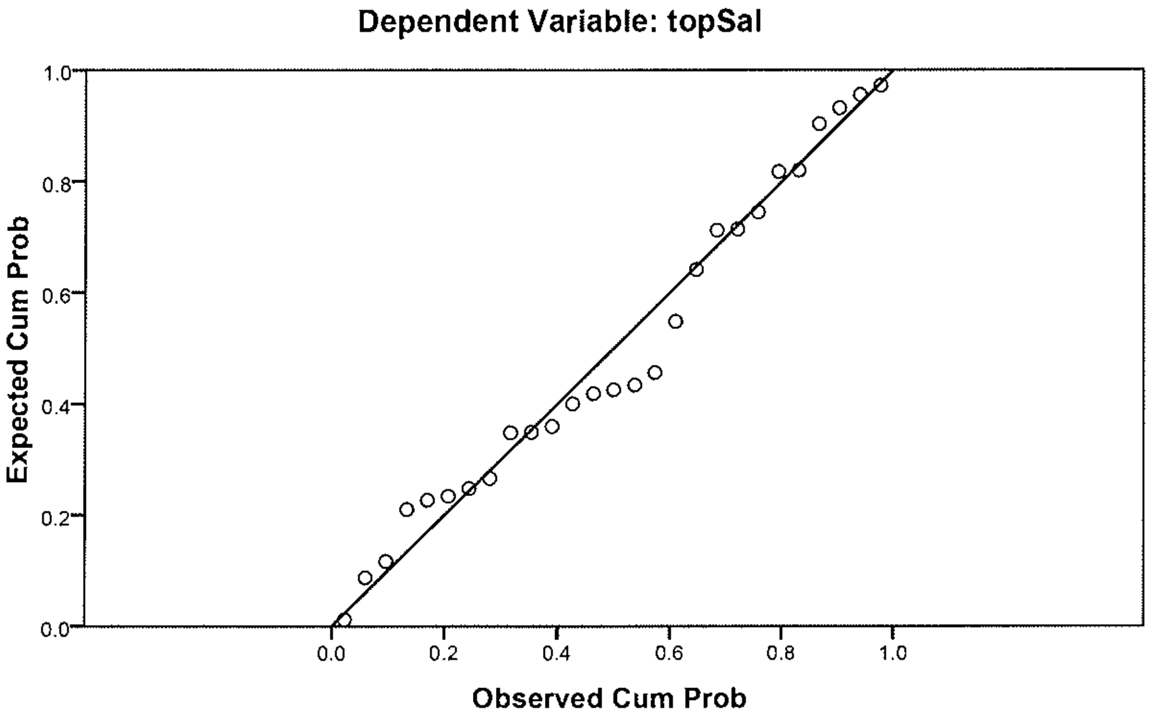
a. Dependent Variable: topSal

Charts

Histogram


Dependent Variable: topSal
Mean =-1.17E-15
Std. Dev. =0.981
N =27
Frequency
0
2
4
6
8
-3
-2
-1
0
1
2
Regression Standardized Residual

Normal P-P Plot of Regression Standardized Residual




```
GRAPH
  /SCATTERPLOT(OVERLAY)=topSal WITH PRE_1 (PAIR)
  /MISSING=LISTWISE.
```

Graph

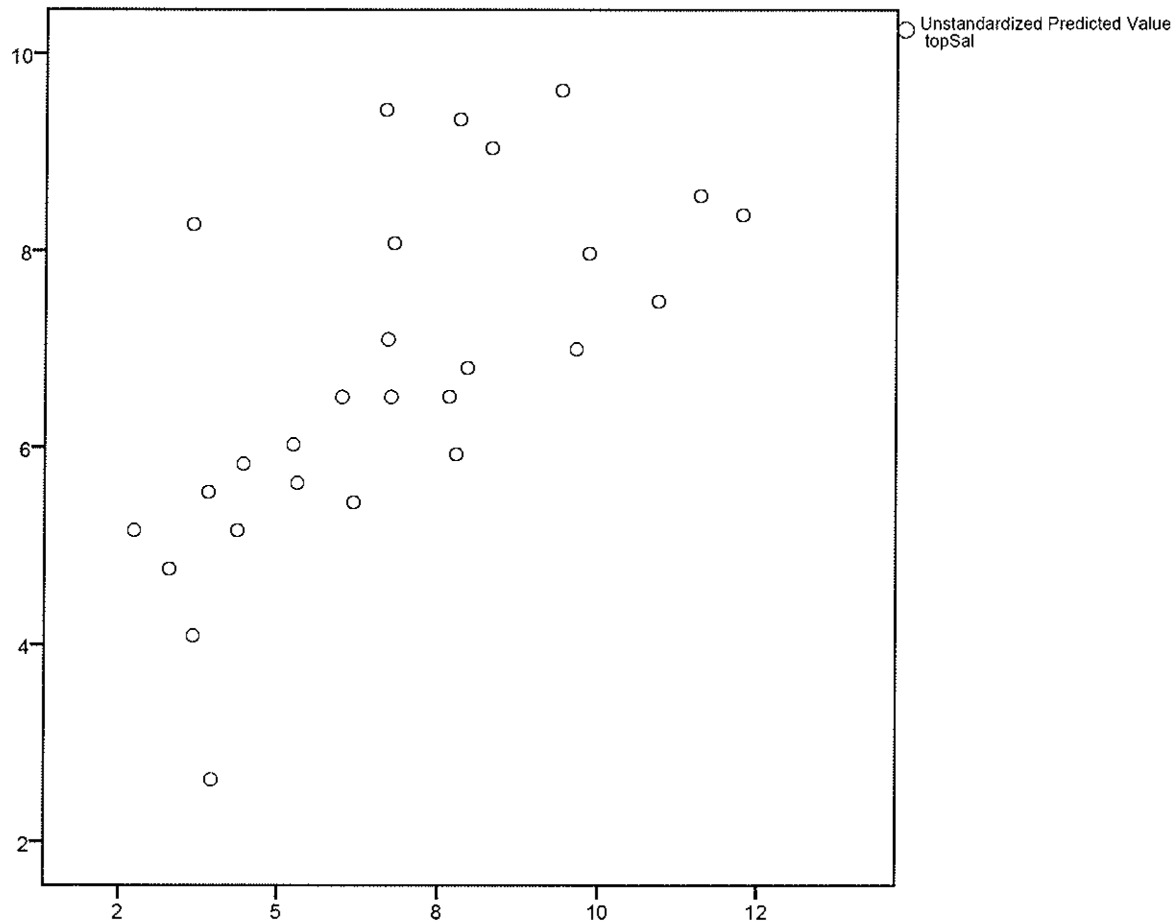
Notes

Output Created		2009-10-22T15:52:20.464
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6c.sav
	Active Dataset	DataSet1
	Filter	@200m_int=7.3 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	53

Notes

Syntax		GRAPH /SCATTERPLOT(OVERLAY) =topSal WITH PRE_1 (PAIR) /MISSING=LISTWISE.
Resources	Processor Time	0:00:00.422
	Elapsed Time	0:00:00.438

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model
 Dep\task_6c.sav
```



Regression

Notes

Output Created		2009-10-22T15:54:26.205
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6c.sav
	Active Dataset	DataSet1
	Filter	@200m_int=7.3 (FILTER)

Notes

Input	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	53
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used.
Syntax		REGRESSION /SELECT=@200m_int EQ 7.3 /MISSING LISTWISE /STATISTICS COEFF OUTS R ANOVA CHANGE /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT botSal /METHOD=STEPWISE Tot_Spring_Q homRiv_ght /RESIDUALS HIST(ZRESID) NORM (ZRESID) /SAVE PRED.
Resources	Processor Time	0:00:00.438
	Elapsed Time	0:00:00.438
	Memory Required	2676 bytes
	Additional Memory Required for Residual Plots	720 bytes
Variables Created or Modified	PRE_2	Unstandardized Predicted Value

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model
 Dep\task_6c.sav

REGRESSION
  /SELECT=@200m_int EQ 7.3
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA CHANGE
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT botSal
  /METHOD=STEPWISE Tot_Spring_Q
  /RESIDUALS HIST(ZRESID) NORM(ZRESID)
  /SAVE PRED.
```

Regression

Notes

Output Created		2009-10-22T15:55:57.405
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6c.sav
	Active Dataset	DataSet1

Notes

Input	Filter	@200m_int=7.3 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	53
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used.
Syntax		REGRESSION /SELECT=@200m_int EQ 7.3 /MISSING LISTWISE /STATISTICS COEFF OUTS R ANOVA CHANGE /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT botSal /METHOD=STEPWISE Tot_Spring_Q /RESIDUALS HIST(ZRESID) NORM (ZRESID) /SAVE PRED.
Resources	Processor Time	0:00:00.390
	Elapsed Time	0:00:00.436
	Memory Required	2364 bytes
	Additional Memory Required for Residual Plots	728 bytes
Variables Created or Modified	PRE_3	Unstandardized Predicted Value

[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6c.sav

Warnings

All cases were selected. There is no residuals output for unselected cases.

Variables Entered/Removed[a,b]

Model	Variables Entered	Variables Removed	Method
1	Tot_Spring_Q	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: botSal

b. Models are based only on cases for which 200m_int = 7.3

ANOVA[b,c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	367.611	1	367.611	51.696	.000[a]
	Residual	255.997	36	7.111		
	Total	623.609	37			

a. Predictors: (Constant), Tot_Spring_Q

b. Dependent Variable: botSal

c. Selecting only cases for which 200m_int = 7.3

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	25.442	2.495		10.198	.000
	Tot_Spring_Q	-.117	.016	-.768	-7.190	.000

a. Dependent Variable: botSal

b. Selecting only cases for which 200m_int = 7.3

Residuals Statistics[a]

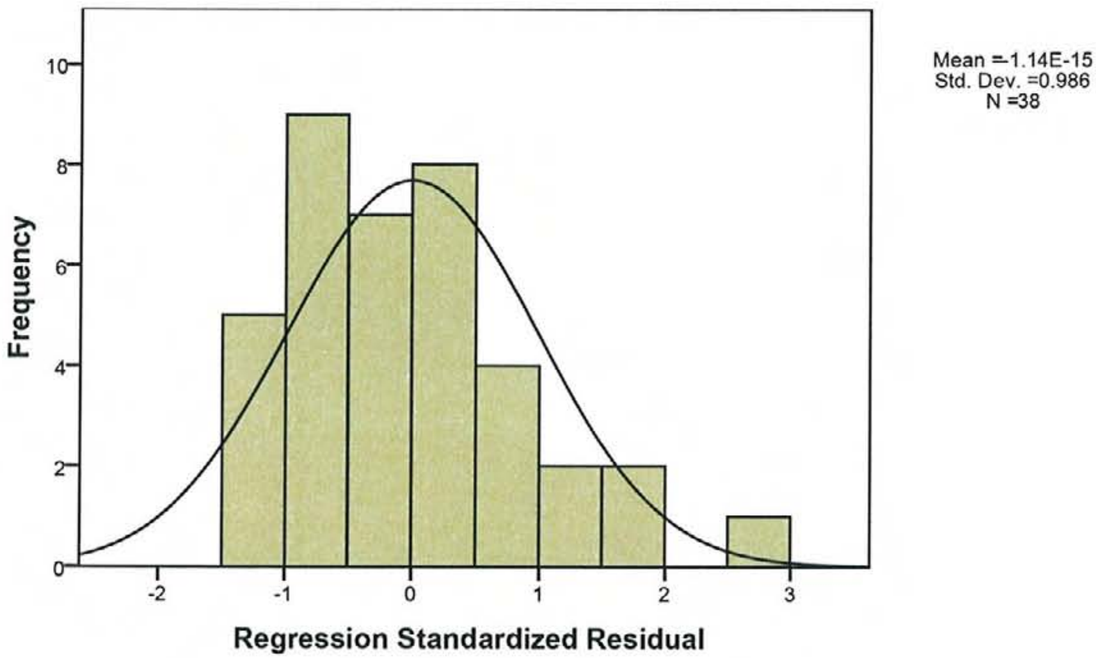
	200m_int = 7.3 (Selected)				
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	1.27628	12.83398	7.77711	3.152053	38
Residual	-3.939317	7.911616	.000000	2.630371	38
Std. Predicted Value	-2.062	1.604	.000	1.000	38
Std. Residual	-1.477	2.967	.000	.986	38

a. Dependent Variable: botSal

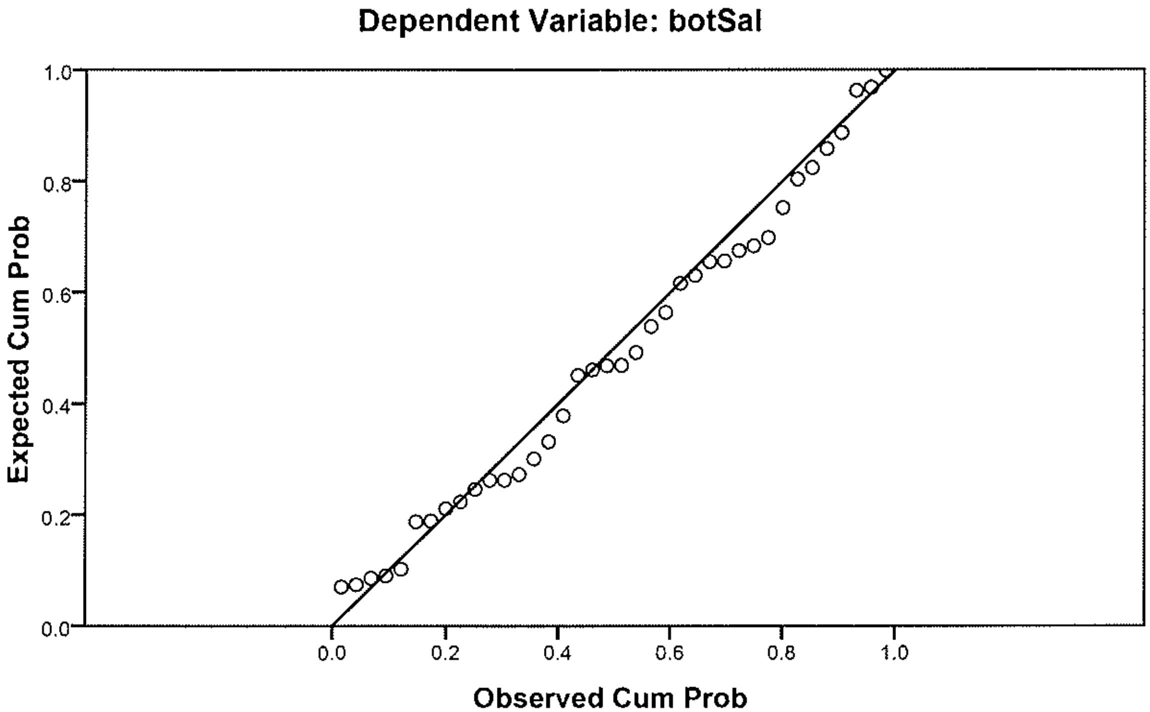
Charts

Histogram

Dependent Variable: botSal



Normal P-P Plot of Regression Standardized Residual




```
GRAPH
  /SCATTERPLOT(OVERLAY)=botSal WITH PRE_3 (PAIR)
  /MISSING=LISTWISE.
```

Graph

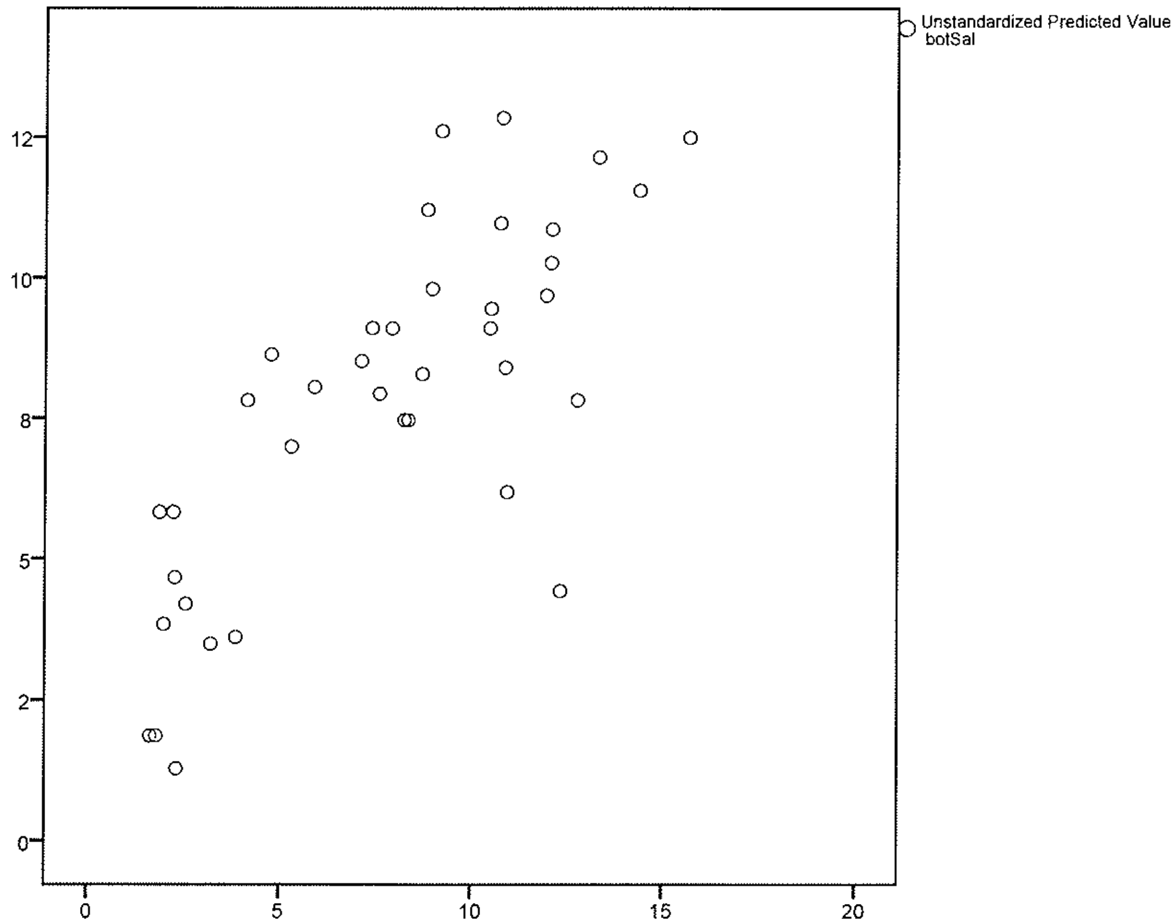
Notes

Output Created		2009-10-22T15:56:45.613
Comments		
Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6c.sav
	Active Dataset	DataSet1
	Filter	@200m_int=7.3 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	53

Notes

Syntax		GRAPH /SCATTERPLOT(OVERLAY) =botSal WITH PRE_3 (PAIR) /MISSING=LISTWISE.
Resources	Processor Time	0:00:00.438
	Elapsed Time	0:00:00.438

```
[DataSet1] \\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model
 Dep\task_6c.sav
```




```
GRAPH
  /SCATTERPLOT(OVERLAY)=Tot_Spring_Q WITH topSal (PAIR)
  /MISSING=LISTWISE.
```

Graph

Notes

Output Created	2009-10-22T15:58:38.449
Comments	

Notes

Input	Data	\\tsclient\P\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6c.sav
	Active Dataset	DataSet1
	Filter	@200m_int=7.3 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	53
Syntax		GRAPH /SCATTERPLOT(OVERLAY) =Tot_Spring_Q WITH topSal (PAIR) /MISSING=LISTWISE.
Resources	Processor Time	0:00:00.250
	Elapsed Time	0:00:00.250

9.1 kilometer Salinity Regressions Models >>

Regression

Notes

Output Created		2009-07-23T10:18:32.798
Comments		
Input	Data	P:\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6c.sav
	Active Dataset	DataSet1
	Filter	@200m_int = 9.1 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	375
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used.
Syntax		REGRESSION /MISSING LISTWISE /STATISTICS COEFF OUTS R ANOVA /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT topSal /METHOD=ENTER Tot_Spring_Q /PARTIALPLOT ALL /RESIDUALS DURBIN HIST (ZRESID) NORM(ZRESID) /SAVE PRED.
Resources	Processor Time	0:00:00.578
	Elapsed Time	0:00:00.577
	Memory Required	2452 bytes
	Additional Memory Required for Residual Plots	1000 bytes
Variables Created or Modified	PRE_9	Unstandardized Predicted Value

```
[DataSet1] P:\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_
6c.sav
```

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	Tot_Spring...	.	Enter

a. All requested variables entered.

b. Dependent Variable: topSal

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	266.564	1	266.564	84.532	.000[a]
	Residual	561.308	178	3.153		
	Total	827.872	179			

a. Predictors: (Constant), Tot_Spring_Q

b. Dependent Variable: topSal

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	10.763	.801		13.435	.000
	Tot_Spring_Q	-.051	.006	-.567	-9.194	.000

a. Dependent Variable: topSal

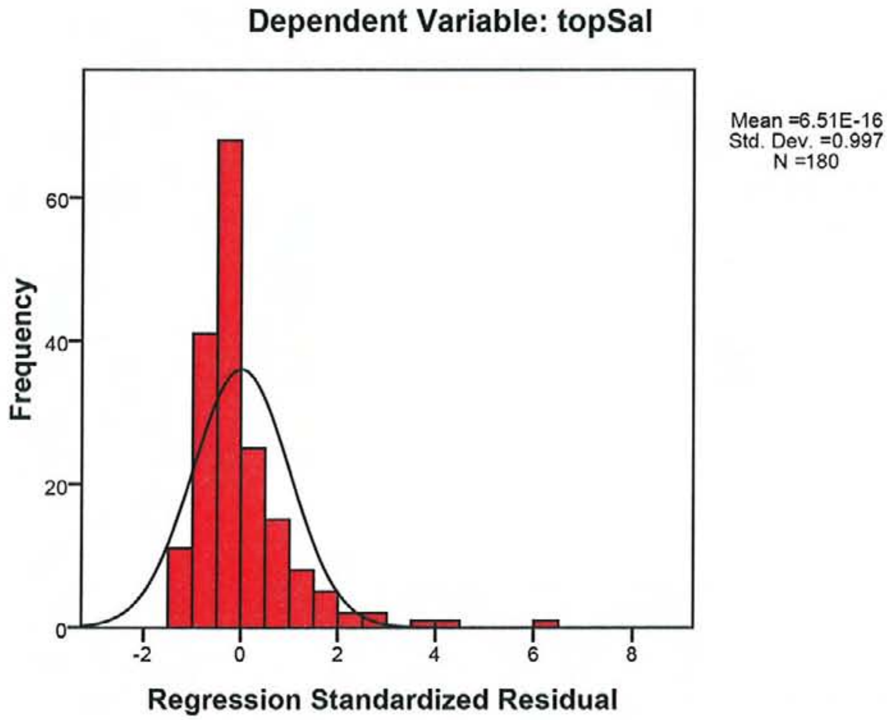
Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	.15767	8.27622	3.49840	1.220321	180
Residual	-2.606622	11.007501	.000000	1.770819	180
Std. Predicted Value	-2.738	3.915	.000	1.000	180
Std. Residual	-1.468	6.199	.000	.997	180

a. Dependent Variable: topSal

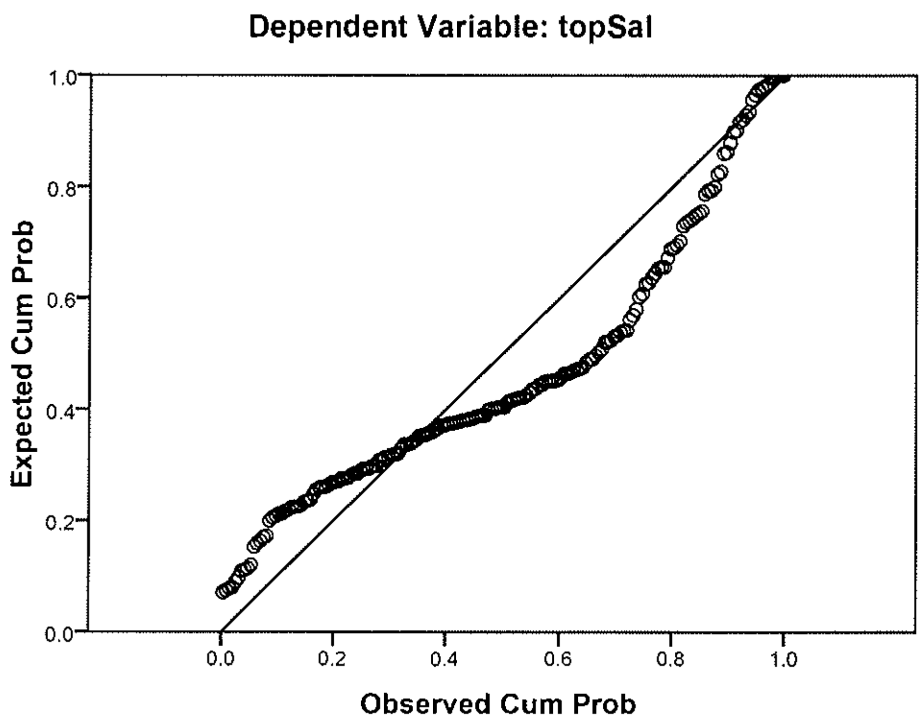
Charts

Histogram



Dependent Variable: topSal
Mean =6.51E-16
Std. Dev. =0.997
N =180
Frequency
60
40
20
0
-2
0
2
4
6
8
Regression Standardized Residual

Normal P-P Plot of Regression Standardized Residual




```
GRAPH
  /SCATTERPLOT(BIVAR)=topSal WITH PRE_9
  /MISSING=LISTWISE.
```

Graph

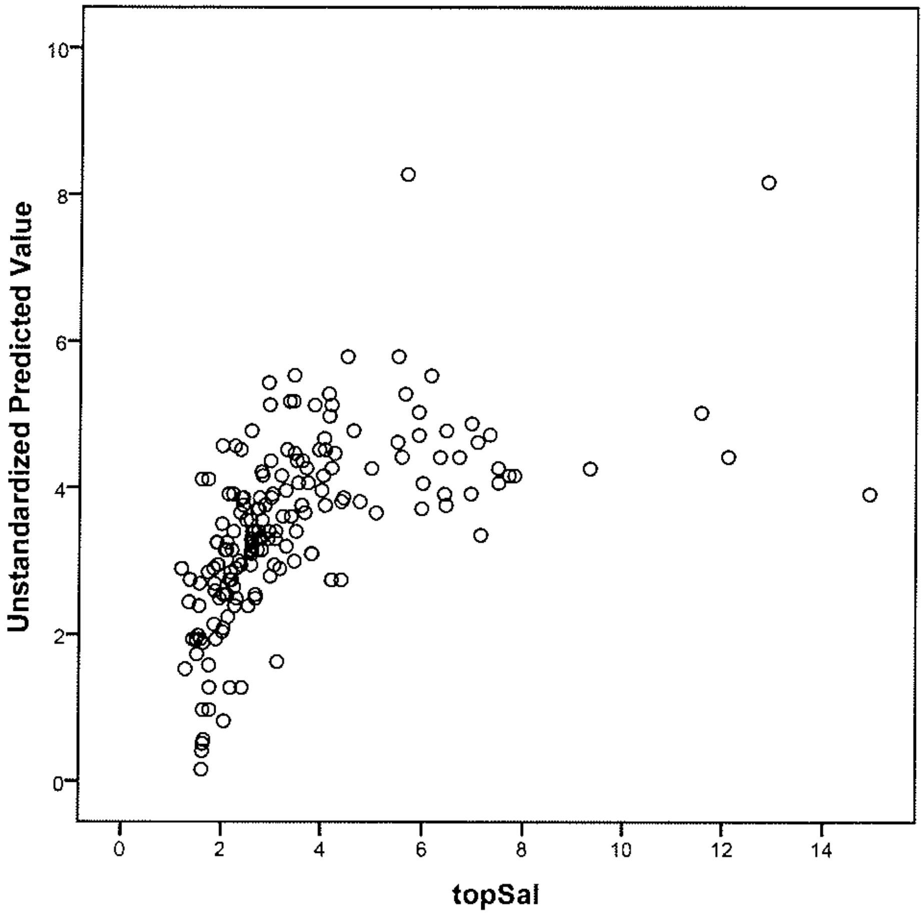
Notes

Output Created		2009-07-23T10:19:38.108
Comments		
Input	Data	P:\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6c.sav
	Active Dataset	DataSet1
	Filter	@200m_int = 9.1 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	375
Syntax		GRAPH /SCATTERPLOT(BIVAR)=topSal WITH PRE_9 /MISSING=LISTWISE.

Notes

Resources	Processor Time	0:00:00.235
	Elapsed Time	0:00:00.234

[DataSet1] P:\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6c.sav




```
GRAPH
  /SCATTERPLOT(BIVAR)=topSal WITH Tot_Spring_Q
  /MISSING=LISTWISE.
```

Graph

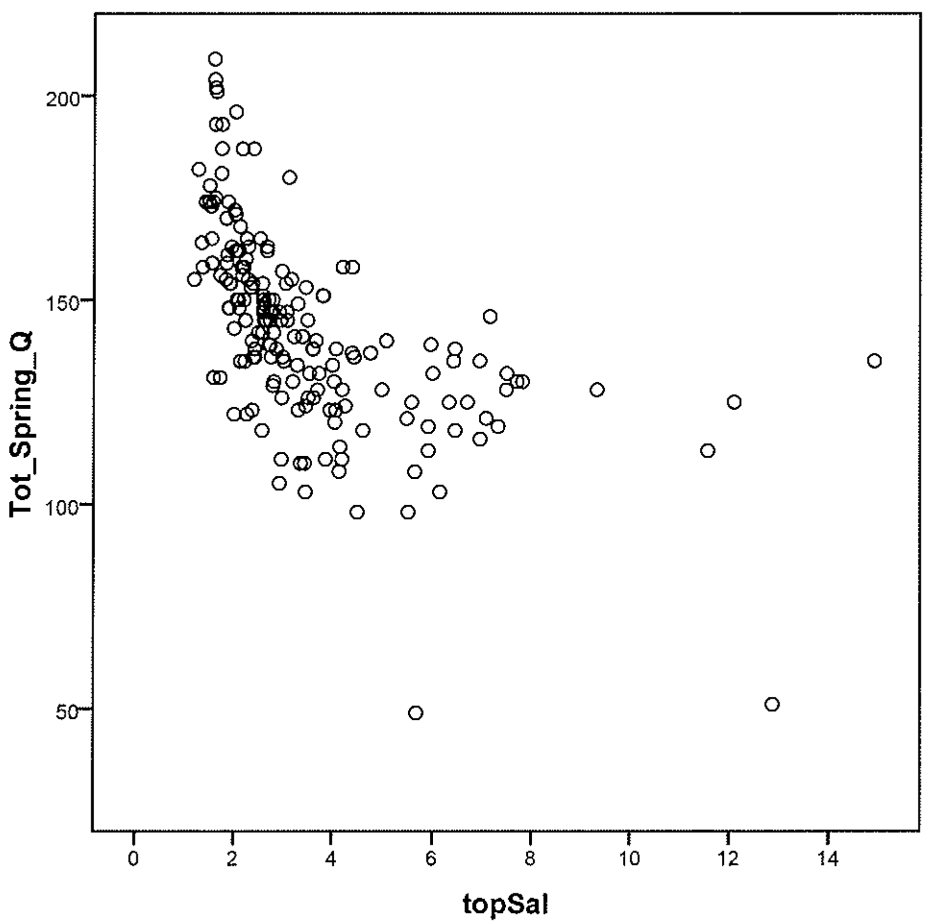
Notes

Output Created		2009-07-23T10:20:29.840
Comments		
Input	Data	P:\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6c.sav
	Active Dataset	DataSet1
	Filter	@200m_int = 9.1 (FILTER)

Notes

Input	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	375
Syntax		GRAPH /SCATTERPLOT(BIVAR)=topSal WITH Tot_Spring_Q /MISSING=LISTWISE.
Resources	Processor Time	0:00:00.359
	Elapsed Time	0:00:00.375

```
[DataSet1] P:\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_
6c.sav
```




```
* Curve Estimation.
TSET NEWVAR=NONE.
CURVEFIT
  /VARIABLES=topSal WITH Tot_Spring_Q
  /CONSTANT
  /MODEL=LINEAR LOGARITHMIC INVERSE QUADRATIC CUBIC COMPOUND POWER S GROWTH EXPONENTIAL L
GSTIC
```

```
  /PLOT FIT.
REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT botSal
  /METHOD=STEPWISE Tot_Spring_Q shell_ght
  /PARTIALPLOT ALL
  /RESIDUALS DURBIN HIST(ZRESID) NORM(ZRESID)
  /SAVE PRED.
```

Regression

Notes

Output Created		2009-07-23T10:24:07.926
Comments		
Input	Data	P:\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_6c.sav
	Active Dataset	DataSet1
	Filter	@200m_int = 9.1 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	375
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used.
Syntax		REGRESSION /MISSING LISTWISE /STATISTICS COEFF OUTS R ANOVA /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT botSal /METHOD=STEPWISE Tot_Spring_Q shell_ght /PARTIALPLOT ALL /RESIDUALS DURBIN HIST (ZRESID) NORM(ZRESID) /SAVE PRED.
Resources	Processor Time	0:00:00.719
	Elapsed Time	0:00:00.749
	Memory Required	2852 bytes
	Additional Memory Required for Residual Plots	1368 bytes
Variables Created or Modified	PRE_10	Unstandardized Predicted Value

```
[DataSet1] P:\1AG801201 Homosassa\Scope of Work\Task 6 Empirical Salinity Model Dep\task_
6c.sav
```

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Tot_Spring_Q	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	shell_ght	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: botSal

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.612[a]	.375	.366	2.234843	
2	.689[b]	.474	.459	2.064190	1.651

a. Predictors: (Constant), Tot_Spring_Q

b. Predictors: (Constant), Tot_Spring_Q, shell_ght

c. Dependent Variable: botSal

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	212.899	1	212.899	42.627	.000[a]
	Residual	354.611	71	4.995		
	Total	567.510	72			
2	Regression	269.249	2	134.624	31.595	.000[b]
	Residual	298.261	70	4.261		
	Total	567.510	72			

a. Predictors: (Constant), Tot_Spring_Q

b. Predictors: (Constant), Tot_Spring_Q, shell_ght

c. Dependent Variable: botSal

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	15.581	1.644		9.479	.000
	Tot_Spring_Q	-.081	.012	-.612	-6.529	.000
2	(Constant)	13.683	1.605		8.523	.000

a. Dependent Variable: botSal

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
2	Tot_Spring_Q	-.065	.012	-.495	-5.360	.000
	shell_ght	1.303	.358	.336	3.637	.001

a. Dependent Variable: botSal

Excluded Variables[b]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	shell_ght	.336[a]	3.637	.001	.399	.879

a. Predictors in the Model: (Constant), Tot_Spring_Q

b. Dependent Variable: botSal

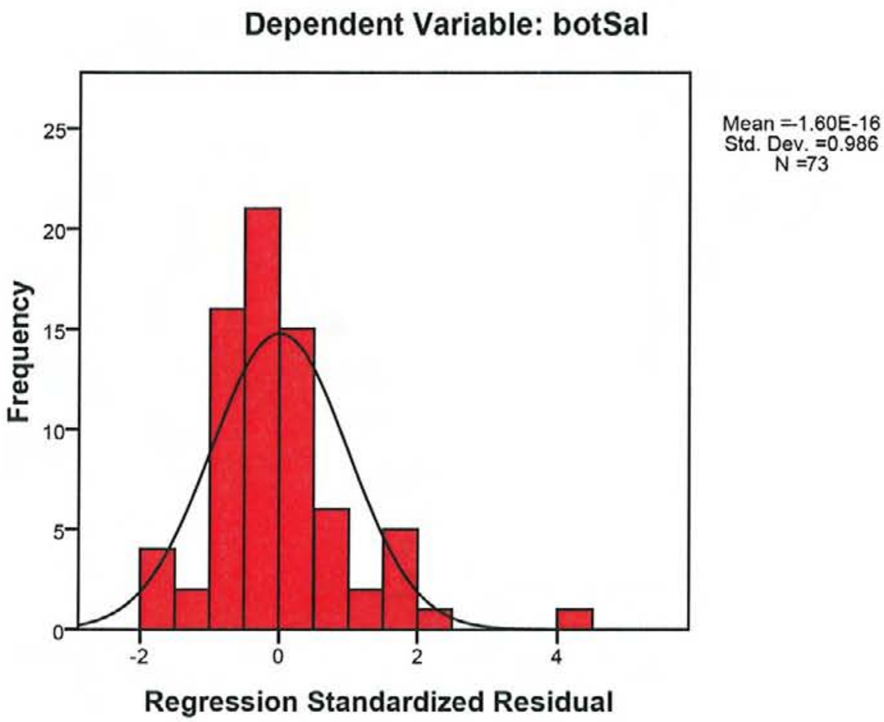
Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	.80273	11.93733	4.98535	1.933796	73
Residual	-3.996879	8.638739	.000000	2.035318	73
Std. Predicted Value	-2.163	3.595	.000	1.000	73
Std. Residual	-1.936	4.185	.000	.986	73

a. Dependent Variable: botSal

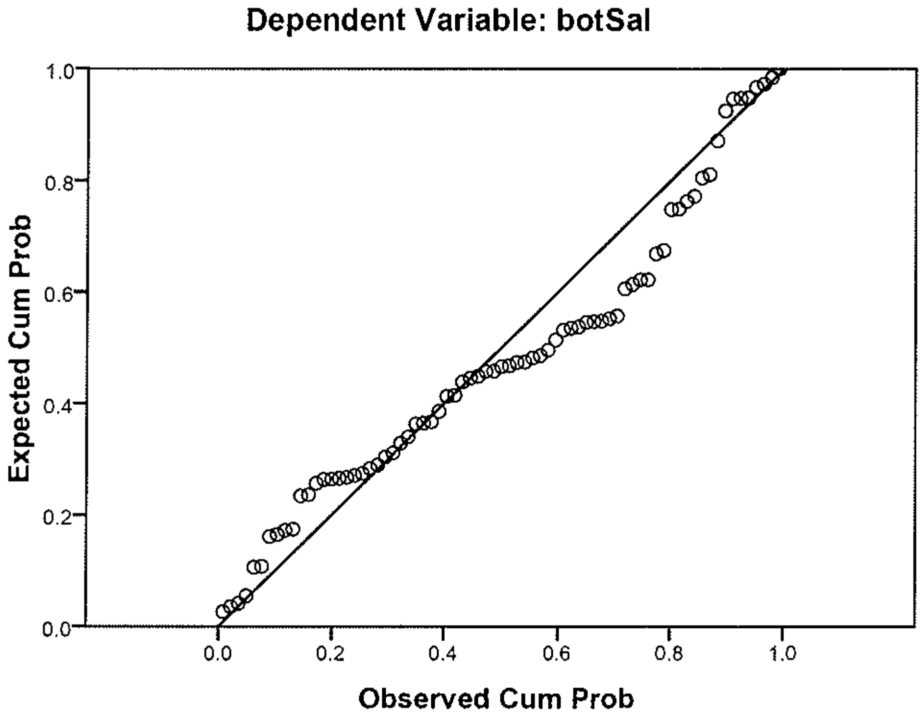
Charts

Histogram



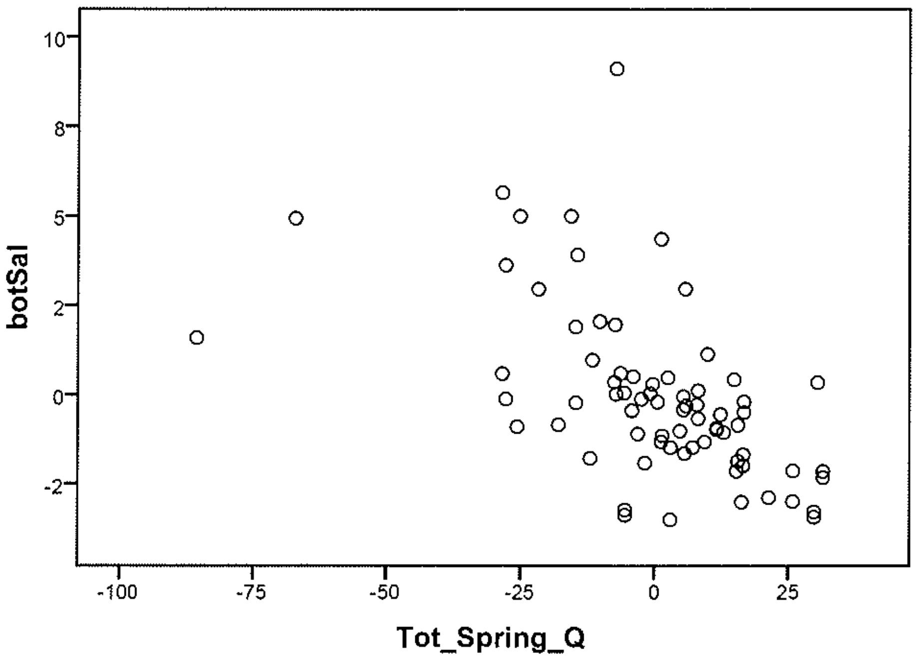
Dependent Variable: botSal
Mean =-1.60E-16
Std. Dev. =0.986
N =73
Frequency
0
5
10
15
20
25
-2
0
2
4
Regression Standardized Residual

Normal P-P Plot of Regression Standardized Residual



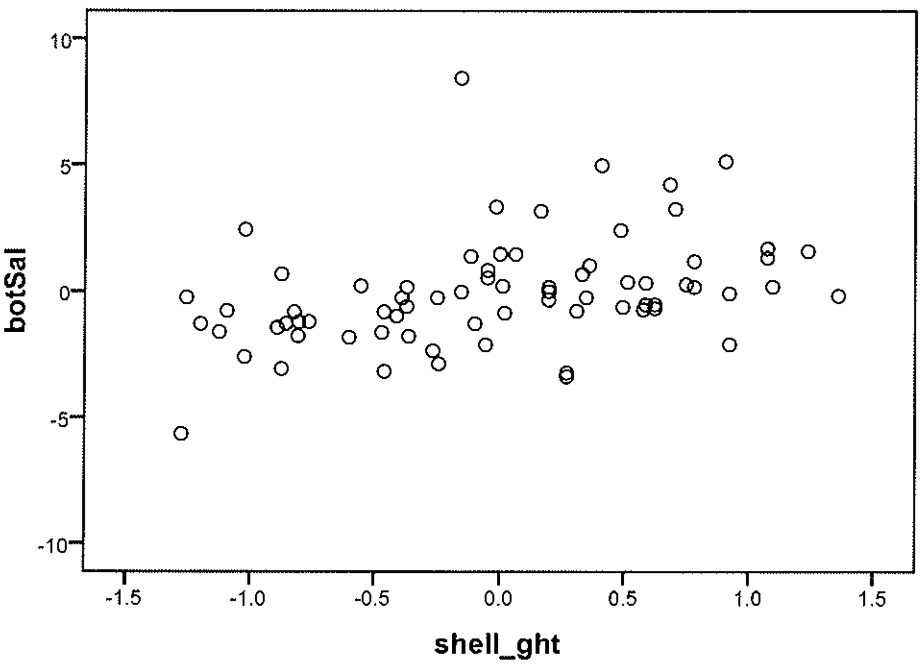
Partial Regression Plot

Dependent Variable: botSal



Partial Regression Plot

Dependent Variable: botSal



I-5
Whole River Models

Whole River Regression Models

```
REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA CHANGE
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT topSal
  /METHOD=STEPWISE KM Tot_Spring_Q
  /PARTIALPLOT ALL
  /RESIDUALS HIST(ZRESID) NORM(ZRESID)
  /SAVE PRED RESID.
```

Regression

Notes

Output Created		2009-06-16T10:07:37.861
Comments		
Input	Active Dataset	DataSet3
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	2258
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used.
Syntax		REGRESSION /MISSING LISTWISE /STATISTICS COEFF OUTS R ANOVA CHANGE /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT topSal /METHOD=STEPWISE KM Tot_Spring_Q /PARTIALPLOT ALL /RESIDUALS HIST(ZRESID) NORM (ZRESID) /SAVE PRED RESID.
Resources	Processor Time	0:00:00.969
	Elapsed Time	0:00:01.048
	Memory Required	2316 bytes
	Additional Memory Required for Residual Plots	1368 bytes
Variables Created or Modified	PRE_1	Unstandardized Predicted Value
	RES_1	Unstandardized Residual

```
[DataSet3]
```

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	KM	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	Tot_Spring_Q	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: topSal

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		
					R Square Change	F Change	df1
1	.908[a]	.825	.825	3.04420	.825	3788.602	1
2	.941[b]	.885	.884	2.47086	.060	417.930	1

a. Predictors: (Constant), KM

b. Predictors: (Constant), KM, Tot_Spring_Q

c. Dependent Variable: topSal

Model Summary[c]

Model	Change Statistics	
	df2	Sig. F Change
1	805	.000
2	804	.000

a. Predictors: (Constant), KM

b. Predictors: (Constant), KM, Tot_Spring_Q

c. Dependent Variable: topSal

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	35109.458	1	35109.458	3788.602	.000[a]
	Residual	7460.039	805	9.267		
	Total	42569.497	806			
2	Regression	37660.974	2	18830.487	3084.372	.000[b]
	Residual	4908.523	804	6.105		
	Total	42569.497	806			

a. Predictors: (Constant), KM

b. Predictors: (Constant), KM, Tot_Spring_Q

c. Dependent Variable: topSal

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	19.679	.216		90.989	.000
	KM	-1.648	.027	-.908	-61.552	.000
2	(Constant)	29.696	.520		57.056	.000
	KM	-1.611	.022	-.888	-73.915	.000
	Tot_Spring_Q	-.075	.004	-.246	-20.443	.000

a. Dependent Variable: topSal

Excluded Variables[b]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	Tot_Spring_Q	-.246[a]	-20.443	.000	-.585	.993

a. Predictors in the Model: (Constant), KM

b. Dependent Variable: topSal

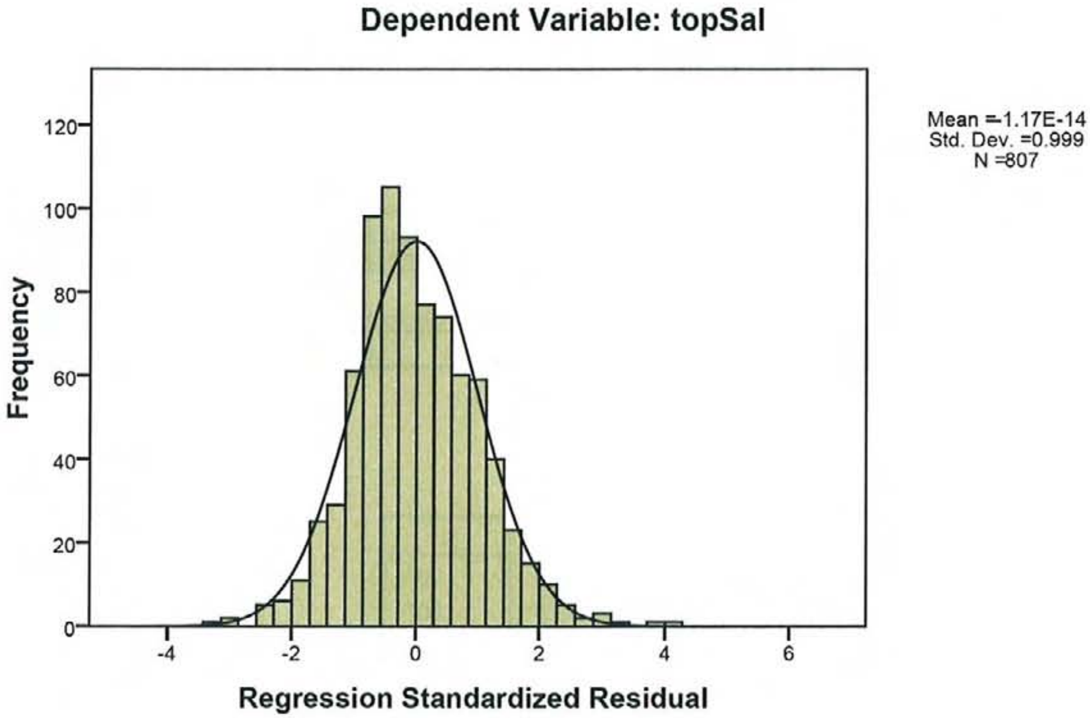
Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-3.6931	26.0103	8.1156	6.83563	807
Residual	-7.98335	9.94079	.00000	2.46779	807
Std. Predicted Value	-1.728	2.618	.000	1.000	807
Std. Residual	-3.231	4.023	.000	.999	807

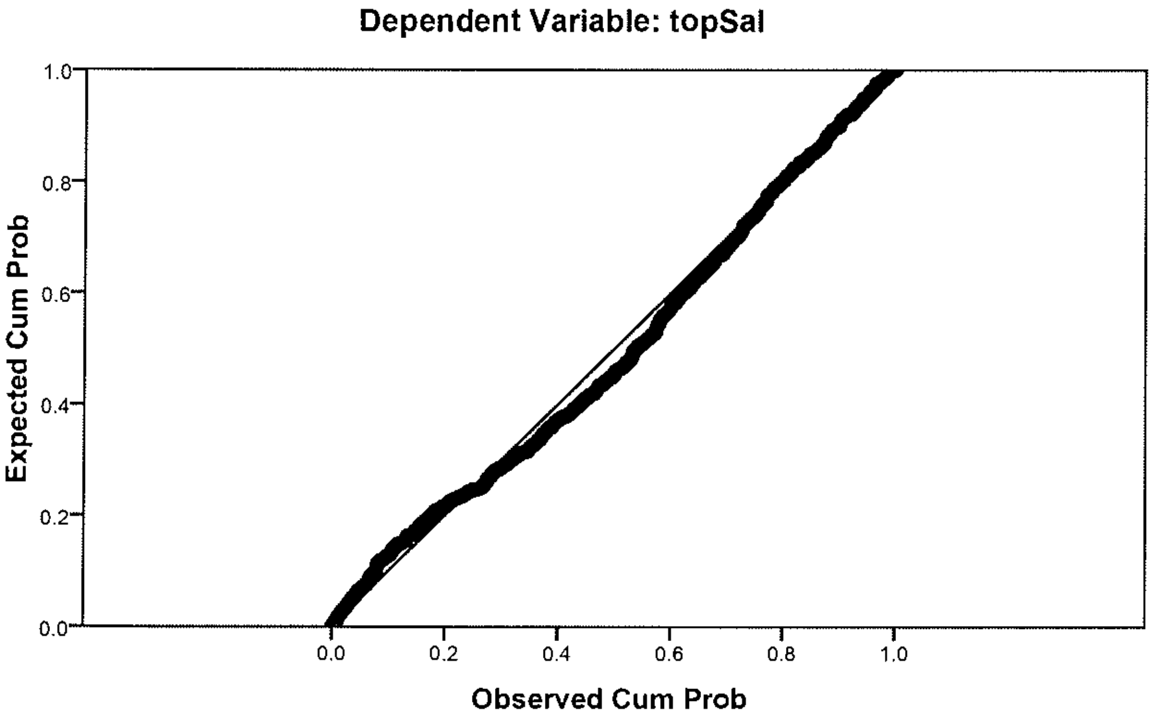
a. Dependent Variable: topSal

Charts

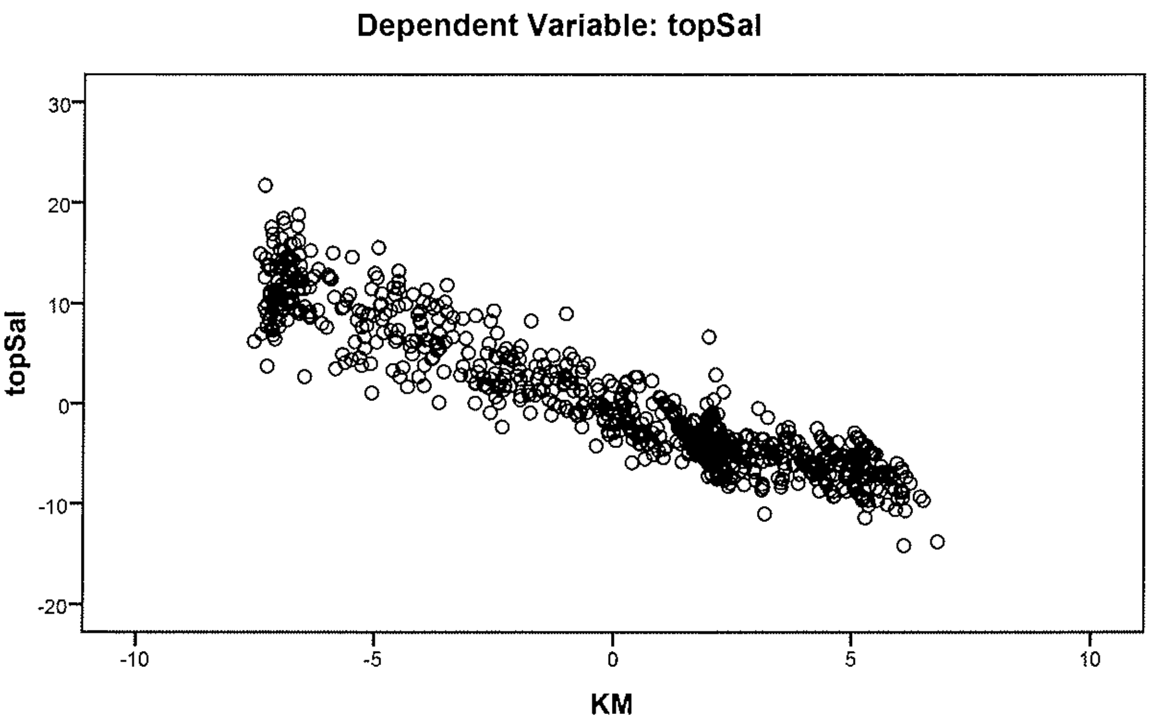
Histogram


Dependent Variable: topSal
Mean =-1.17E-14
Std. Dev. =0.999
N =807
120
100
80
60
40
20
0
Frequency
-4
-2
0
2
4
6
Regression Standardized Residual

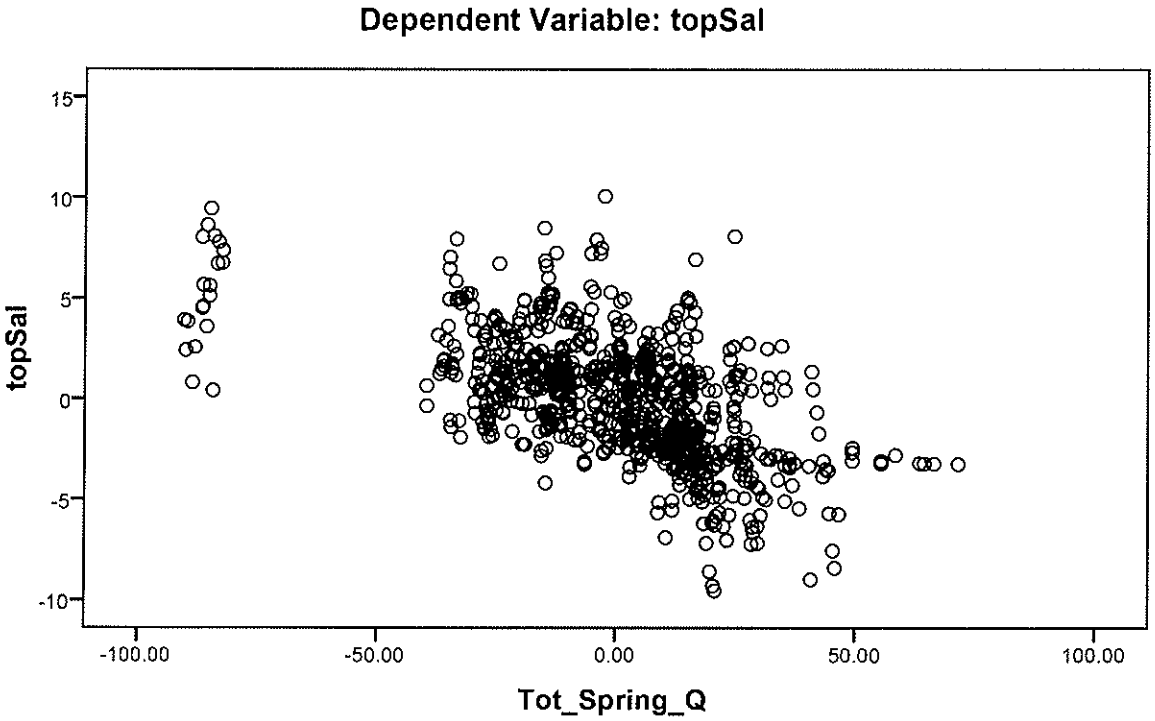
Normal P-P Plot of Regression Standardized Residual



Partial Regression Plot



Partial Regression Plot




```
GRAPH
  /SCATTERPLOT(OVERLAY)=Tot_Spring_Q Tot_Spring_Q WITH topSal PRE_1 (PAIR)
  /MISSING=LISTWISE.
```

Graph

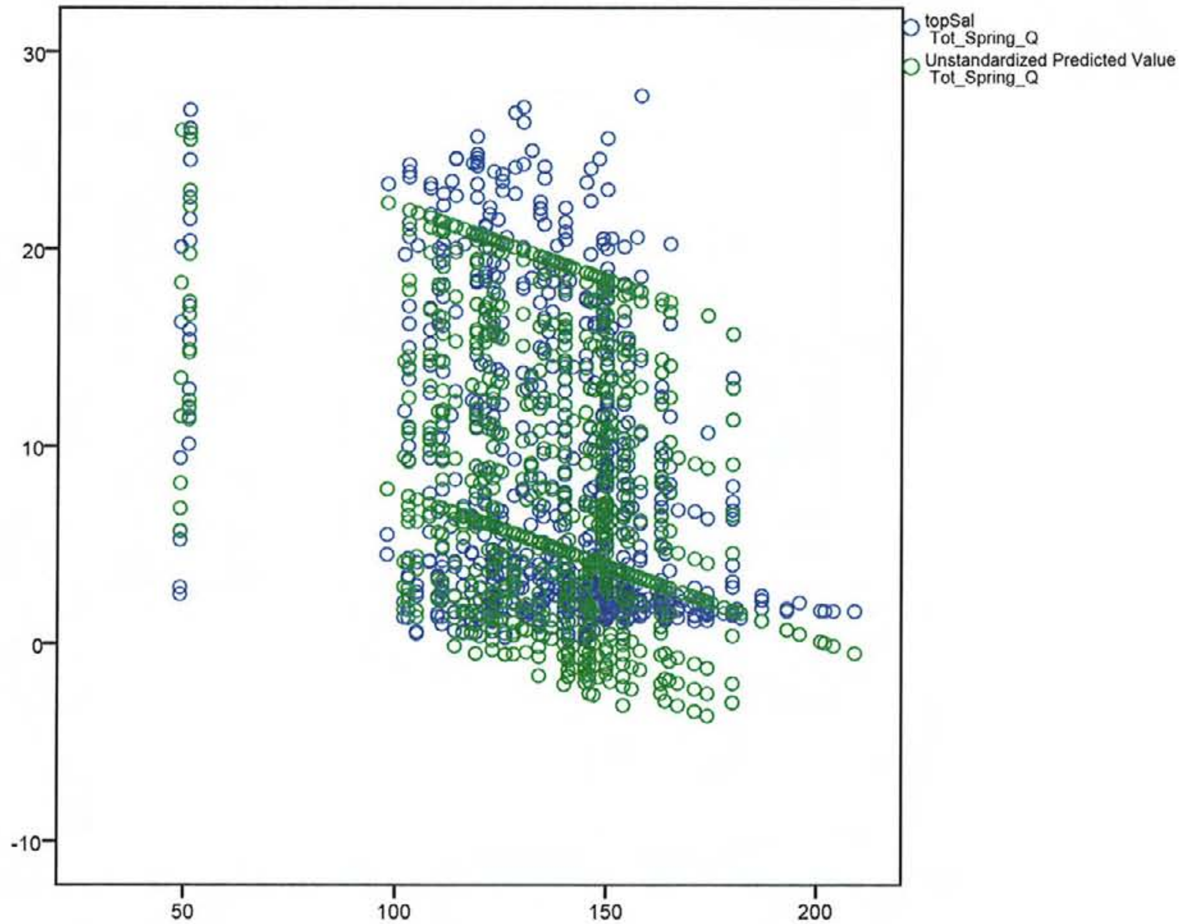
Notes

Output Created		2009-06-16T10:08:29.874
Comments		
Input	Active Dataset	DataSet3
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	2258
Syntax		GRAPH /SCATTERPLOT(OVERLAY) =Tot_Spring_Q Tot_Spring_Q WITH topSal PRE_1 (PAIR) /MISSING=LISTWISE.

Notes

Resources	Processor Time	0:00:00.485
	Elapsed Time	0:00:00.485

```
[DataSet3]
```




```
GRAPH
  /SCATTERPLOT(BIVAR)=PRE_1 WITH topSal
  /MISSING=LISTWISE.
```

Graph

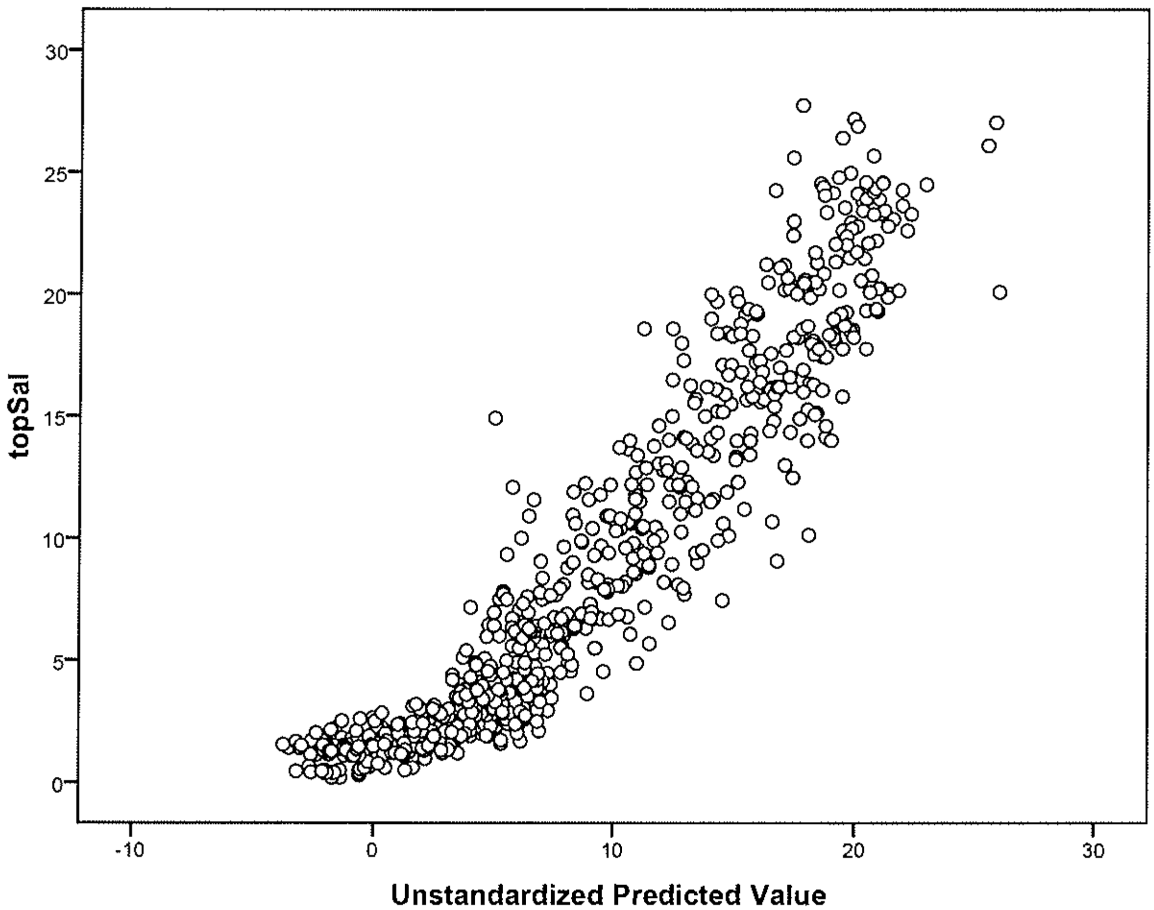
Notes

Output Created		2009-06-16T10:09:39.418
Comments		
Input	Active Dataset	DataSet3
	Filter	<none>
	Weight	<none>
	Split File	<none>

Notes

Input	N of Rows in Working Data File	2258
Syntax		GRAPH /SCATTERPLOT(BIVAR)=PRE_1 WITH topSal /MISSING=LISTWISE.
Resources	Processor Time	0:00:00.282
	Elapsed Time	0:00:00.281

[DataSet3]




```
USE ALL.
COMPUTE filter_$=(topSal > 3).
VARIABLE LABEL filter_$ 'topSal > 3 (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE.
REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA CHANGE
```

```
/CRITERIA=PIN(.05) POUT(.10)
/NOORIGIN
/DEPENDENT topSal
/METHOD=STEPWISE KM Tot_Spring_Q
/PARTIALPLOT ALL
/RESIDUALS HIST(ZRESID) NORM(ZRESID)
/SAVE PRED RESID.
```

Regression

Notes

Output Created		2009-06-16T10:14:14.483
Comments		
Input	Active Dataset	DataSet3
	Filter	topSal > 3 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	573
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used.
Syntax		REGRESSION /MISSING LISTWISE /STATISTICS COEFF OUTS R ANOVA CHANGE /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT topSal /METHOD=STEPWISE KM Tot_Spring_Q /PARTIALPLOT ALL /RESIDUALS HIST(ZRESID) NORM (ZRESID) /SAVE PRED RESID.
Resources	Processor Time	0:00:00.891
	Elapsed Time	0:00:00.922
	Memory Required	2372 bytes
	Additional Memory Required for Residual Plots	1368 bytes
Variables Created or Modified	PRE_2	Unstandardized Predicted Value
	RES_2	Unstandardized Residual

[DataSet3]

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	KM	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	Tot_Spring_Q	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: topSal

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		
					R Square Change	F Change	df1
1	.858[a]	.736	.735	3.46850	.736	1368.215	1
2	.922[b]	.850	.849	2.61993	.114	370.571	1

a. Predictors: (Constant), KM

b. Predictors: (Constant), KM, Tot_Spring_Q

c. Dependent Variable: topSal

Model Summary[c]

Model	Change Statistics	
	df2	Sig. F Change
1	491	.000
2	490	.000

a. Predictors: (Constant), KM

b. Predictors: (Constant), KM, Tot_Spring_Q

c. Dependent Variable: topSal

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16460.346	1	16460.346	1368.215	.000[a]
	Residual	5906.987	491	12.031		
	Total	22367.333	492			
2	Regression	19003.957	2	9501.978	1384.314	.000[b]
	Residual	3363.377	490	6.864		
	Total	22367.333	492			

a. Predictors: (Constant), KM

b. Predictors: (Constant), KM, Tot_Spring_Q

c. Dependent Variable: topSal

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	20.146	.268		75.195	.000
	KM	-1.690	.046	-.858	-36.989	.000
2	(Constant)	33.232	.709		46.855	.000
	KM	-1.767	.035	-.897	-50.864	.000
	Tot_Spring_Q	-.097	.005	-.339	-19.250	.000

a. Dependent Variable: topSal

Excluded Variables[b]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	Tot_Spring_Q	-.339[a]	-19.250	.000	-.656	.987

a. Predictors in the Model: (Constant), KM

b. Dependent Variable: topSal

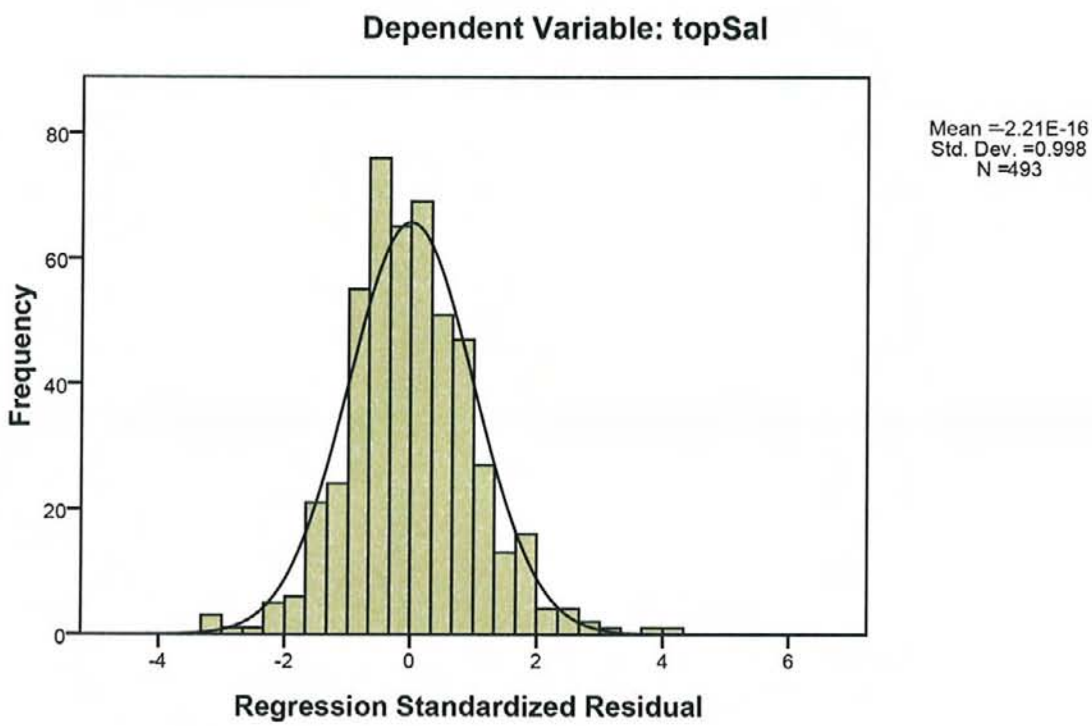
Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-.0810	28.4927	12.0949	6.21498	493
Residual	-8.40046	10.64863	.00000	2.61460	493
Std. Predicted Value	-1.959	2.638	.000	1.000	493
Std. Residual	-3.206	4.064	.000	.998	493

a. Dependent Variable: topSal

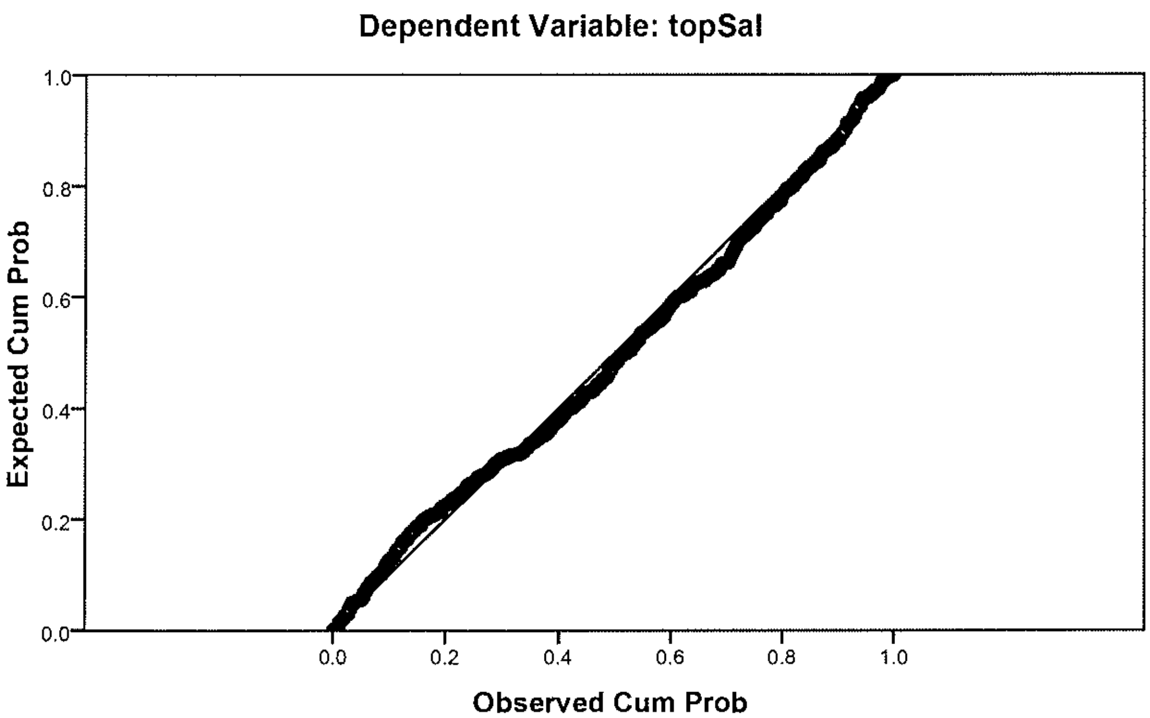
Charts

Histogram

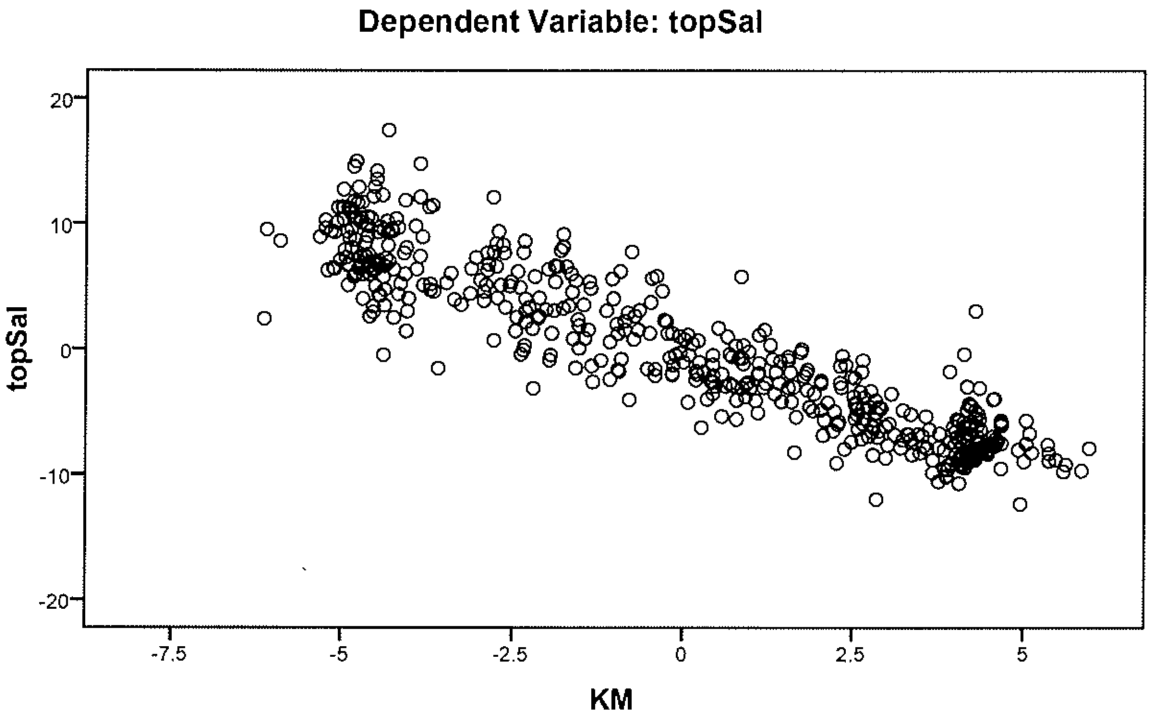


Dependent Variable: topSal
Mean =-2.21E-16
Std. Dev. =0.998
N =493
Frequency
80
60
40
20
0
-4
-2
0
2
4
6
Regression Standardized Residual

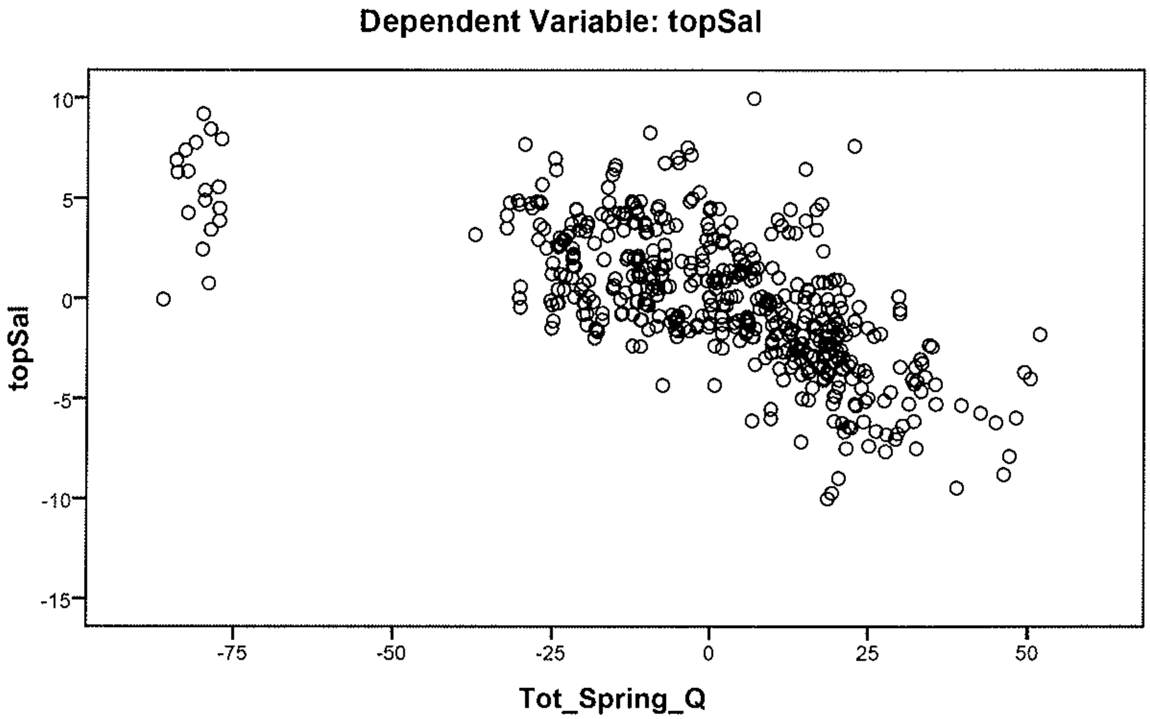
Normal P-P Plot of Regression Standardized Residual



Partial Regression Plot



Partial Regression Plot



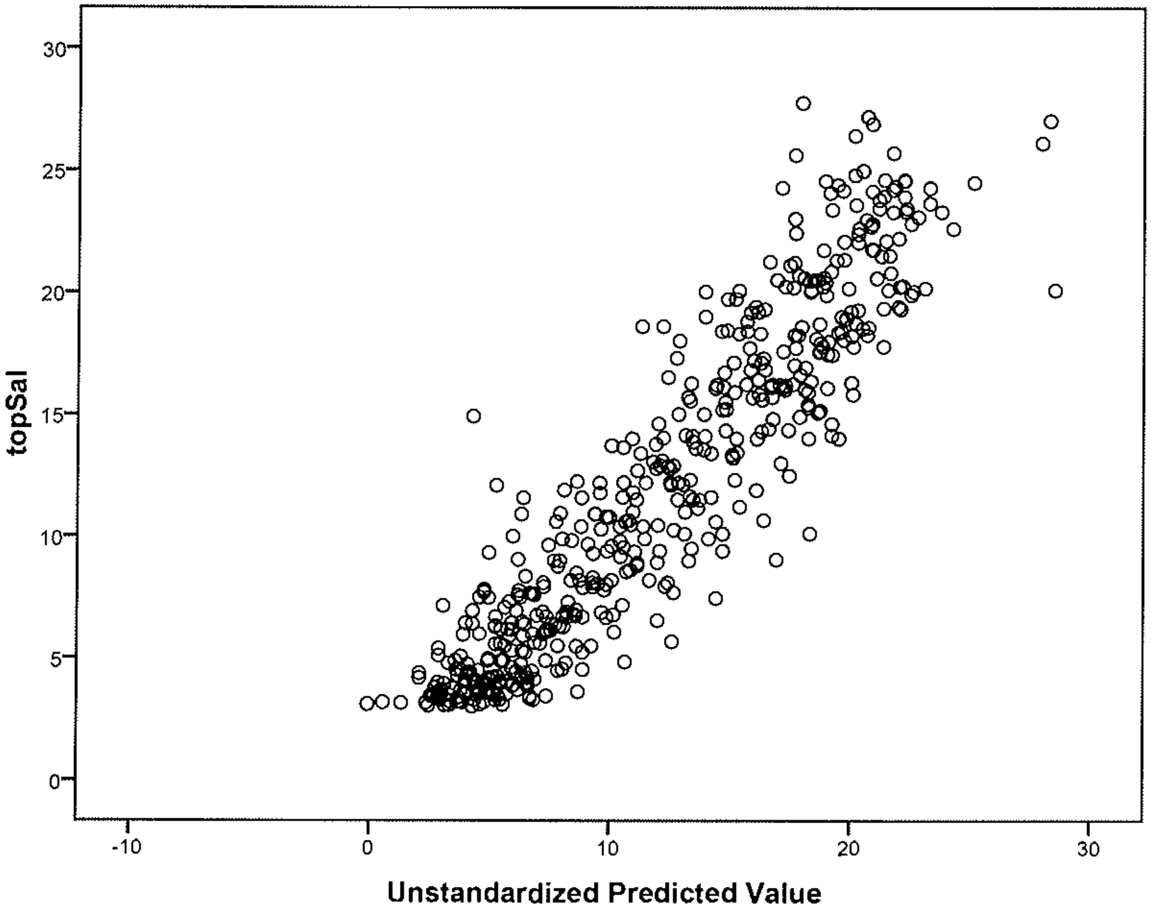

```
GRAPH
  /SCATTERPLOT(BIVAR)=PRE_2 WITH topSal
  /MISSING=LISTWISE.
```

Graph

Notes

Output Created		2009-06-16T10:15:12.308
Comments		
Input	Active Dataset	DataSet3
	Filter	topSal > 3 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	573
Syntax		GRAPH /SCATTERPLOT(BIVAR)=PRE_2 WITH topSal /MISSING=LISTWISE.
Resources	Processor Time	0:00:00.266
	Elapsed Time	0:00:00.266

[DataSet3]




```
COMPUTE Tot_Spring_Q=HomSpg_daily_Q + SEFork_daily_Q.
EXECUTE.
REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA CHANGE
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT topSal
  /METHOD=STEPWISE KM Tot_Spring_Q
  /PARTIALPLOT ALL
  /RESIDUALS HIST(ZRESID) NORM(ZRESID)
  /SAVE PRED RESID.
```

Regression

Notes

Output Created	2009-06-16T10:20:06.544
Comments	

Notes

Input	Active Dataset	DataSet3
	Filter	topSal > 3 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	573
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used.
Syntax		REGRESSION /MISSING LISTWISE /STATISTICS COEFF OUTS R ANOVA CHANGE /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT topSal /METHOD=STEPWISE KM Tot_Spring_Q /PARTIALPLOT ALL /RESIDUALS HIST(ZRESID) NORM (ZRESID) /SAVE PRED RESID.
Resources	Processor Time	0:00:00.968
	Elapsed Time	0:00:00.985
	Memory Required	2332 bytes
	Additional Memory Required for Residual Plots	1368 bytes
Variables Created or Modified	PRE_1	Unstandardized Predicted Value
	RES_1	Unstandardized Residual

[DataSet3]

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	KM	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	Tot_Spring_Q	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: topSal

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16010.576	1	16010.576	1436.731	.000[a]
	Residual	5270.997	473	11.144		
	Total	21281.573	474			
2	Regression	18246.975	2	9123.487	1419.063	.000[b]
	Residual	3034.598	472	6.429		
	Total	21281.573	474			

a. Predictors: (Constant), KM

b. Predictors: (Constant), KM, Tot_Spring_Q

c. Dependent Variable: topSal

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	19.981	.262		76.333	.000
	KM	-1.697	.045	-.867	-37.904	.000
2	(Constant)	36.763	.921		39.895	.000
	KM	-1.777	.034	-.908	-51.835	.000
	Tot_Spring_Q	-.122	.007	-.327	-18.651	.000

a. Dependent Variable: topSal

Excluded Variables[b]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	Tot_Spring_Q	-.327[a]	-18.651	.000	-.651	.985

a. Predictors in the Model: (Constant), KM

b. Dependent Variable: topSal

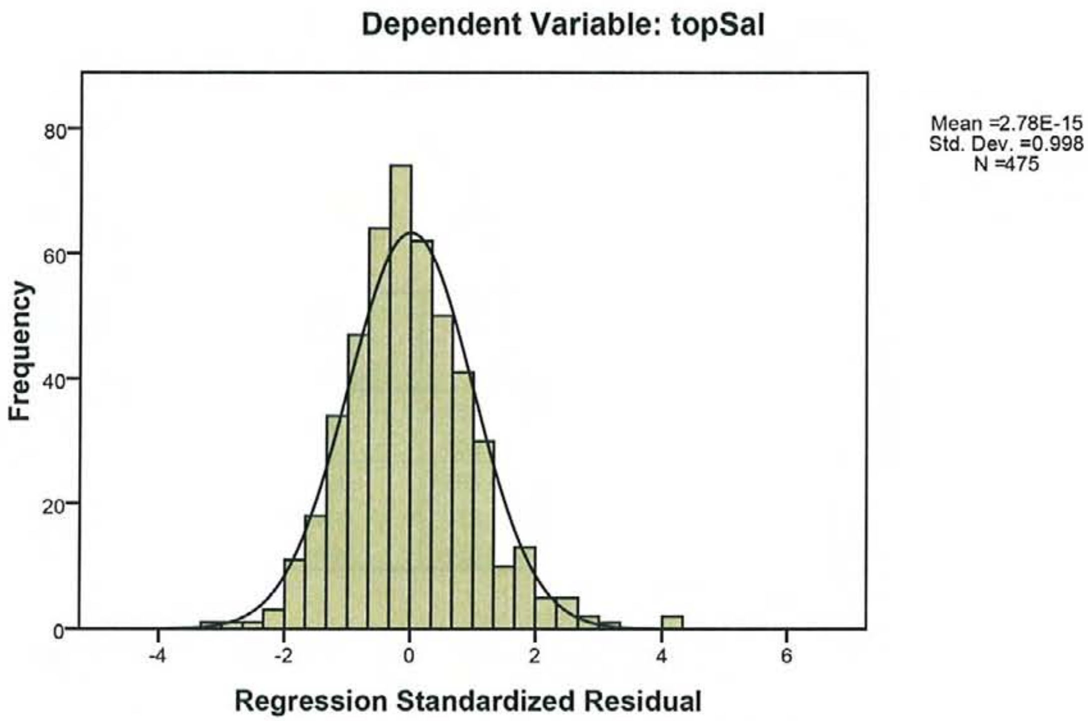
Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-1.1723	24.8154	11.9351	6.20449	475
Residual	-7.85843	10.60639	.00000	2.53024	475
Std. Predicted Value	-2.113	2.076	.000	1.000	475
Std. Residual	-3.099	4.183	.000	.998	475

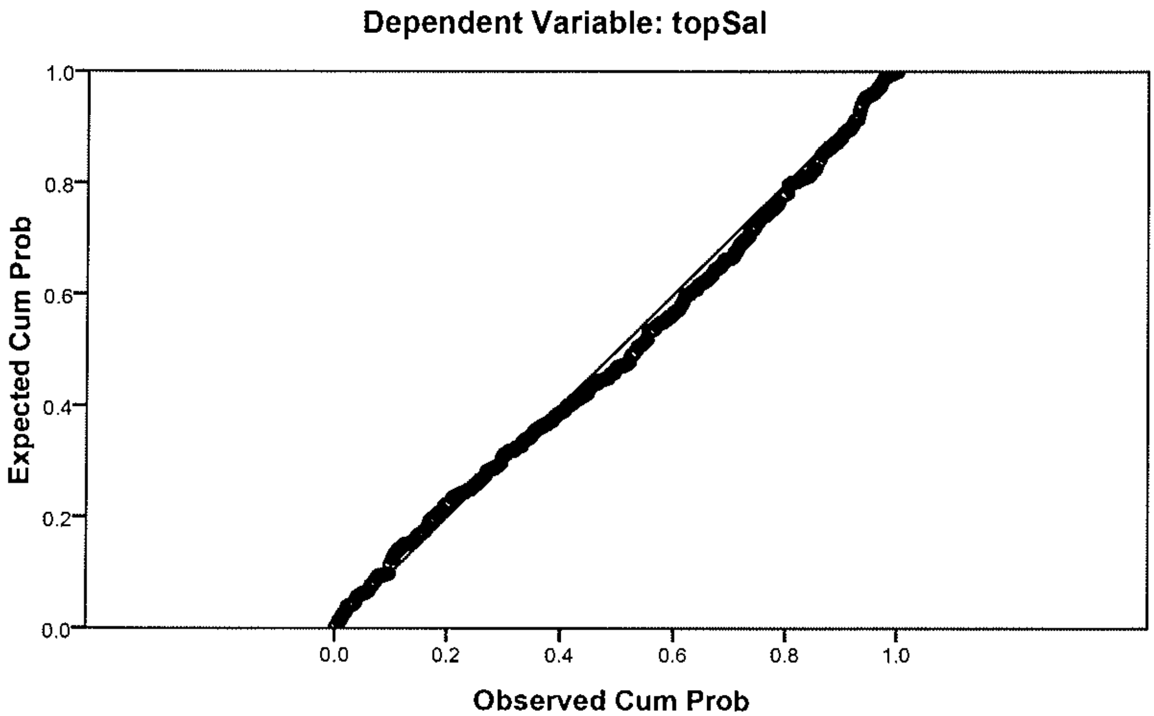
a. Dependent Variable: topSal

Charts

Histogram

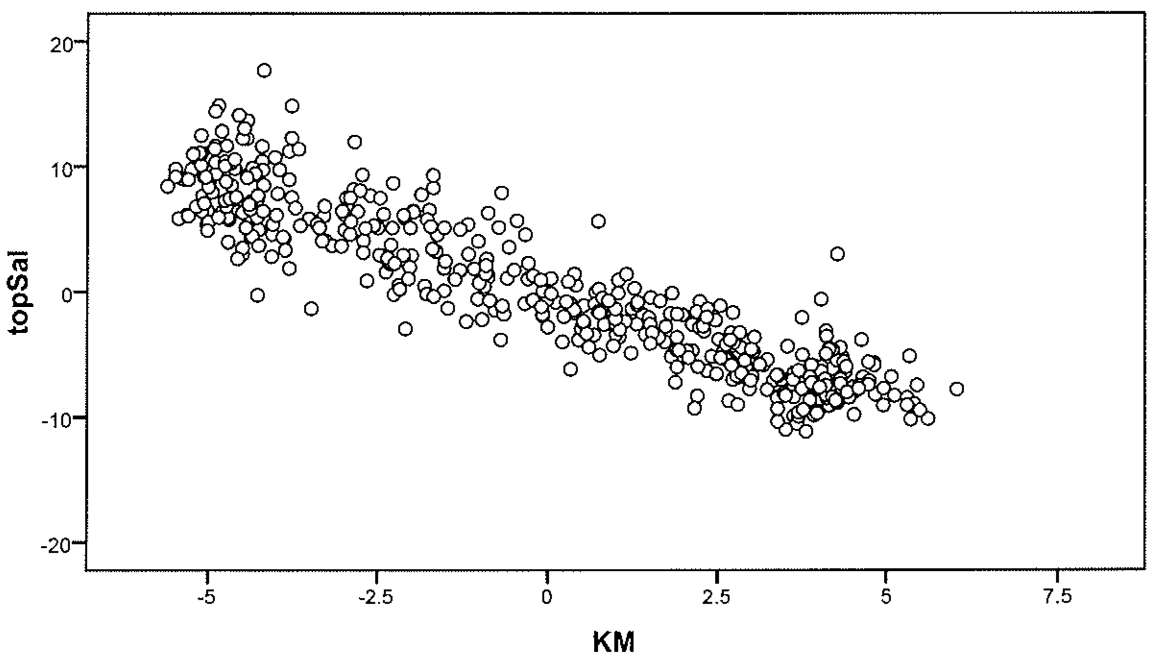

Dependent Variable: topSal
Mean =2.78E-15
Std. Dev. =0.998
N =475
Frequency
80
60
40
20
0
-4
-2
0
2
4
6
Regression Standardized Residual

Normal P-P Plot of Regression Standardized Residual

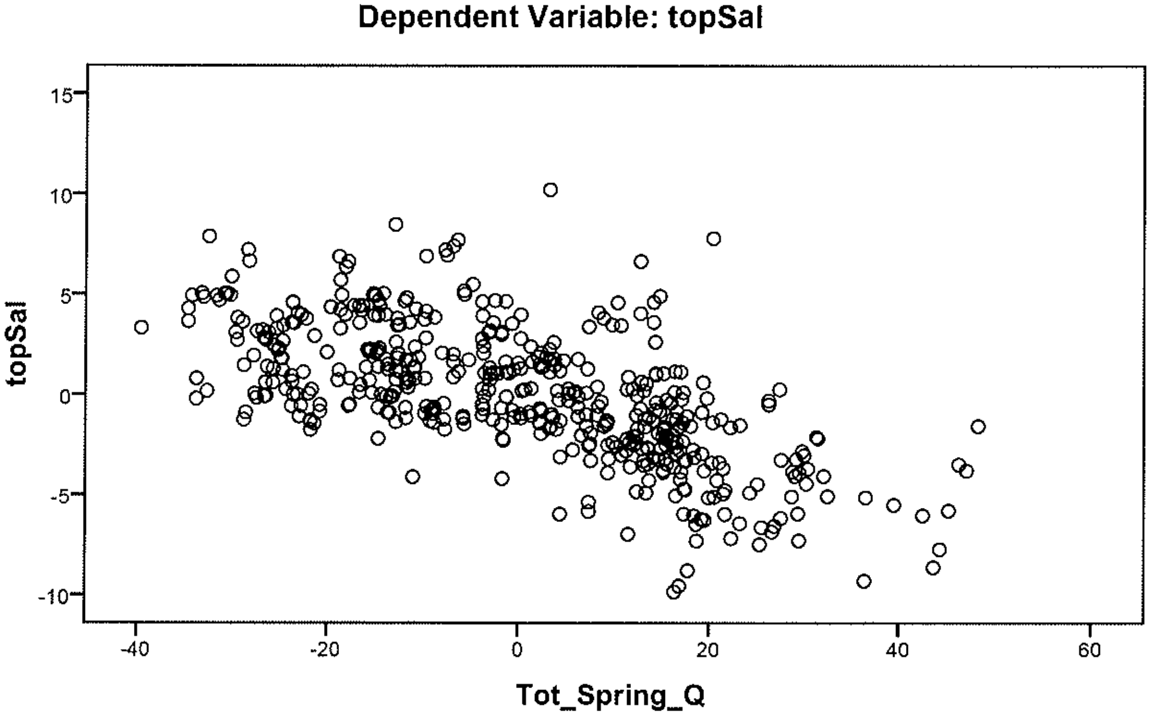


Partial Regression Plot

Dependent Variable: topSal



Partial Regression Plot



Explore

Notes

Output Created		2009-06-16T12:50:52.590
Comments		
Input	Active Dataset	DataSet3
	Filter	topSal > 3 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	573
Missing Value Handling	Definition of Missing	User-defined missing values for dependent variables are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any dependent variable or factor used.
Syntax		EXAMINE VARIABLES=Stratification BY KM /PLOT=BOXPLOT /STATISTICS=NONE /NOTOTAL.

Notes

Resources	Processor Time	0:00:00.265
	Elapsed Time	0:00:00.267

[DataSet3]

Notes

Output Created		2009-06-16T12:53:12.474
Comments		
Input	Active Dataset	DataSet3
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	2258
Missing Value Handling	Definition of Missing	User-defined missing values for dependent variables are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any dependent variable or factor used.
Syntax		EXAMINE VARIABLES=Stratification BY KM /PLOT=BOXPLOT /STATISTICS=NONE /NOTOTAL.
Resources	Processor Time	0:00:00.313
	Elapsed Time	0:00:00.327

[DataSet3]

Notes

Output Created		2009-06-16T12:54:23.096
Comments		
Input	Active Dataset	DataSet3
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	2258
Missing Value Handling	Definition of Missing	User-defined missing values for dependent variables are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any dependent variable or factor used.
Syntax		EXAMINE VARIABLES=Stratification BY KM /PLOT=BOXPLOT /STATISTICS=NONE /NOTOTAL.
Resources	Processor Time	0:00:00.312
	Elapsed Time	0:00:00.328

```
[DataSet3]

REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA CHANGE
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT botSal
  /METHOD=STEPWISE KM Tot_Spring_Q
  /PARTIALPLOT ALL
  /RESIDUALS HIST(ZRESID) NORM(ZRESID)
  /SAVE PRED RESID.
```

Regression

Notes

Output Created		2009-06-18T14:12:20.673
Comments		
Input	Active Dataset	DataSet3
	Filter	<none>
	Weight	<none>
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	N of Rows in Working Data File	2258
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used.
Syntax		REGRESSION /MISSING LISTWISE /STATISTICS COEFF OUTS R ANOVA CHANGE /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT botSal /METHOD=STEPWISE KM Tot_Spring_Q /PARTIALPLOT ALL /RESIDUALS HIST(ZRESID) NORM (ZRESID) /SAVE PRED RESID.
Resources	Processor Time	0:00:01.000
	Elapsed Time	0:00:01.016
	Memory Required	2396 bytes
	Additional Memory Required for Residual Plots	1368 bytes
Variables Created or Modified	PRE_2	Unstandardized Predicted Value
	RES_2	Unstandardized Residual

```
[DataSet3]
```

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	KM	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	Tot_Spring_Q	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: botSal

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		
					R Square Change	F Change	df1
1	.862[a]	.744	.743	3.61892	.744	2899.556	1
2	.920[b]	.847	.847	2.79815	.103	673.689	1

a. Predictors: (Constant), KM

b. Predictors: (Constant), KM, Tot_Spring_Q

c. Dependent Variable: botSal

Model Summary[c]

Model	Change Statistics	
	df2	Sig. F Change
1	1000	.000
2	999	.000

a. Predictors: (Constant), KM

b. Predictors: (Constant), KM, Tot_Spring_Q

c. Dependent Variable: botSal

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	37974.190	1	37974.190	2899.556	.000[a]
	Residual	13096.553	1000	13.097		
	Total	51070.743	1001			
2	Regression	43248.934	2	21624.467	2761.873	.000[b]
	Residual	7821.810	999	7.830		
	Total	51070.743	1001			

a. Predictors: (Constant), KM

b. Predictors: (Constant), KM, Tot_Spring_Q

c. Dependent Variable: botSal

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	17.603	.225		78.258	.000
	KM	-1.360	.025	-.862	-53.848	.000
2	(Constant)	30.766	.536		57.385	.000
	KM	-1.400	.020	-.887	-71.442	.000
	Tot_Spring_Q	-.087	.003	-.322	-25.956	.000

a. Dependent Variable: botSal

Excluded Variables[b]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	Tot_Spring_Q	-.322[a]	-25.956	.000	-.635	.994

a. Predictors in the Model: (Constant), KM

b. Dependent Variable: botSal

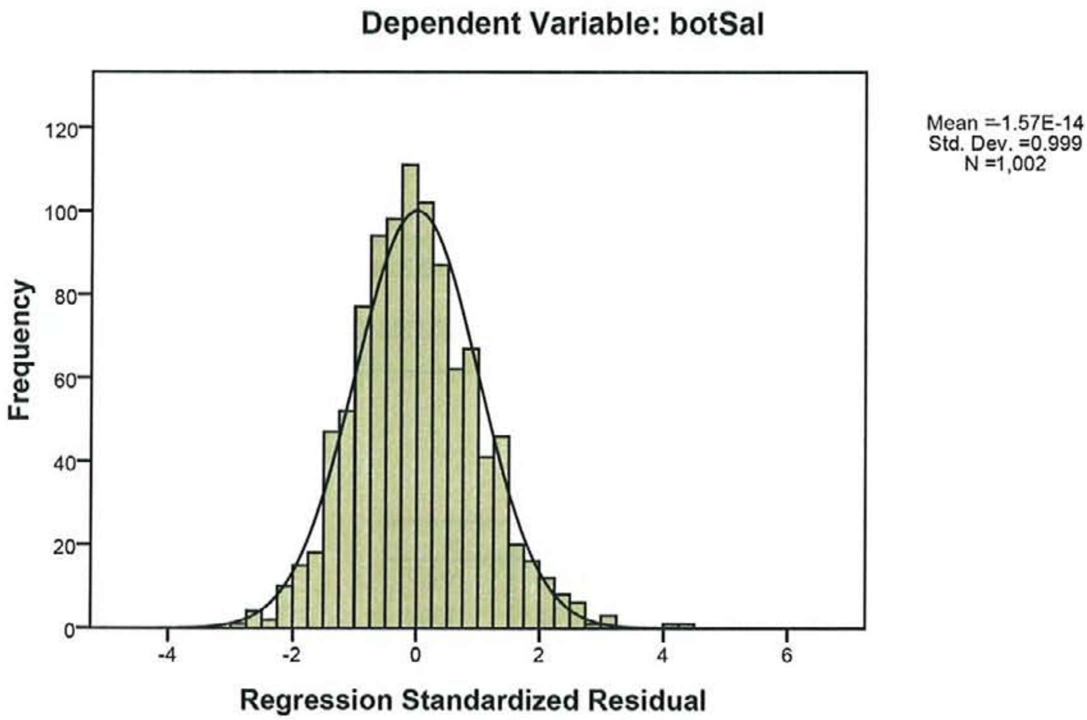
Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-5.1442	22.2554	7.1719	6.57311	1002
Residual	-7.76655	12.49582	.00000	2.79535	1002
Std. Predicted Value	-1.874	2.295	.000	1.000	1002
Std. Residual	-2.776	4.466	.000	.999	1002

a. Dependent Variable: botSal

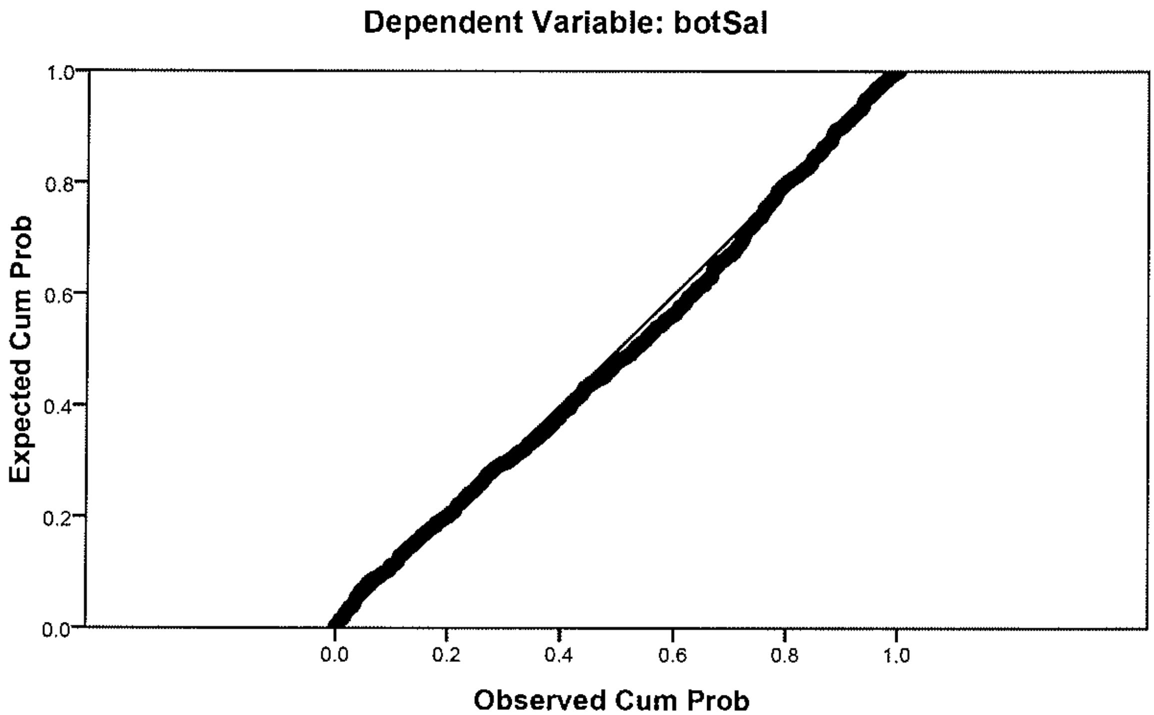
Charts

Histogram

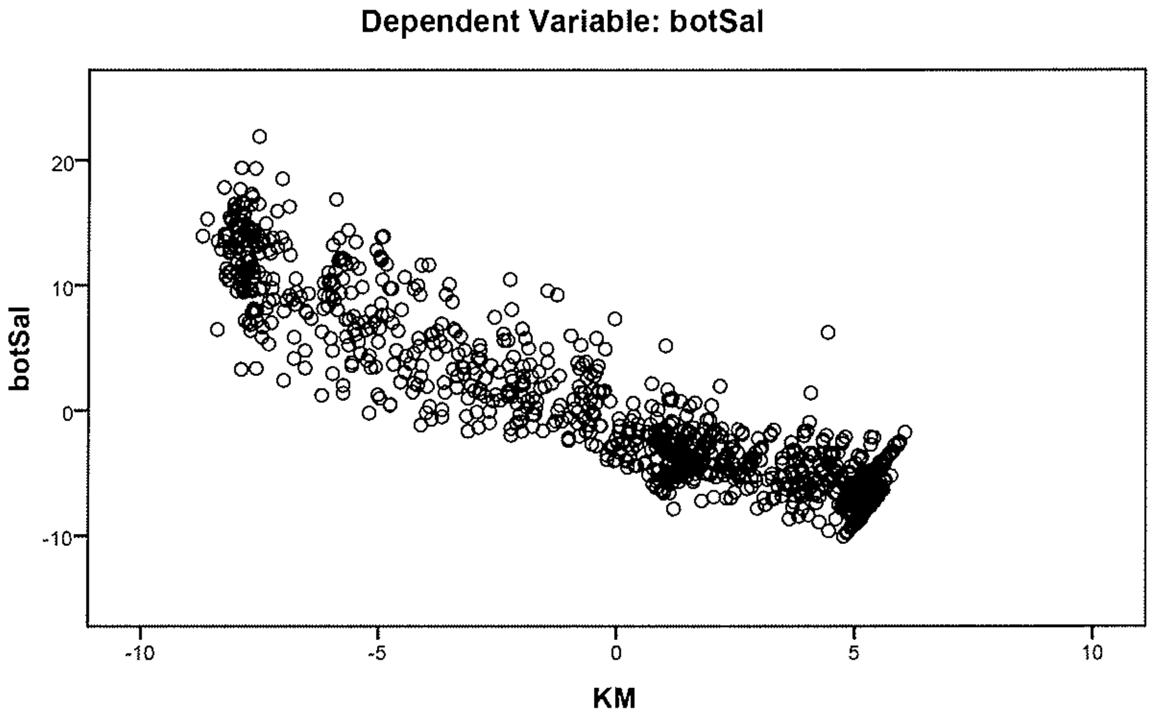


Dependent Variable: botSal
Mean =-1.57E-14
Std. Dev. =0.999
N =1,002
Frequency
120
100
80
60
40
20
0
-4
-2
0
2
4
6
Regression Standardized Residual

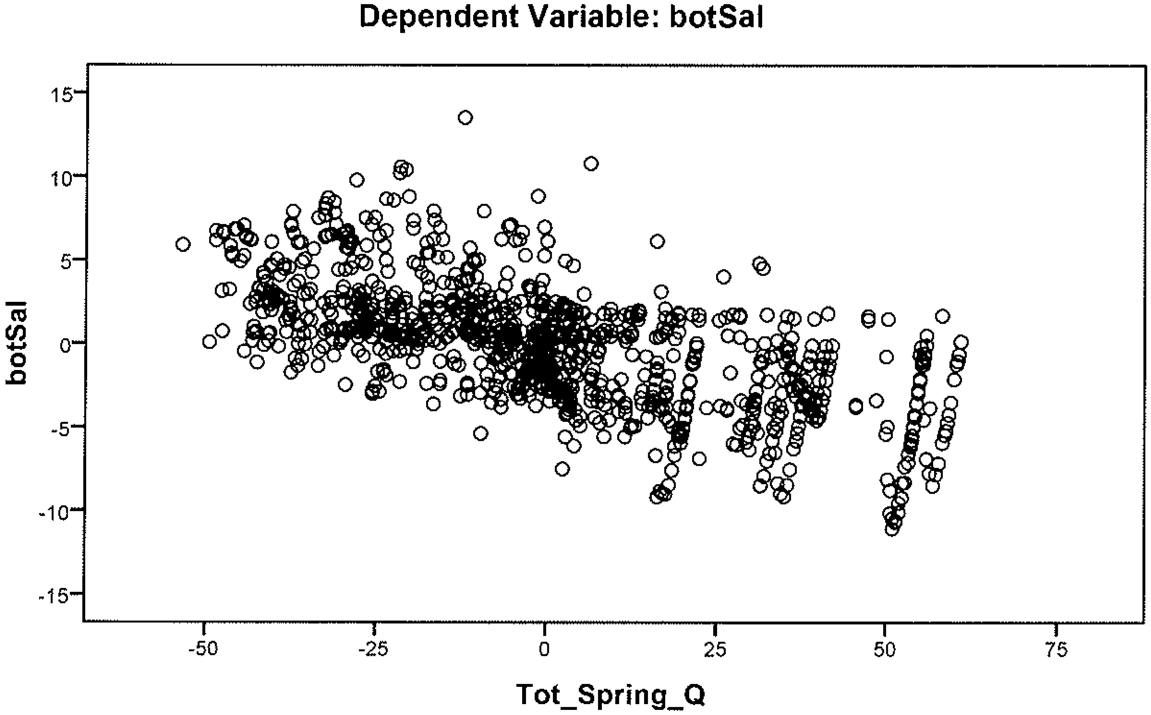
Normal P-P Plot of Regression Standardized Residual



Partial Regression Plot



Partial Regression Plot




```
GRAPH
  /SCATTERPLOT(BIVAR)=botSal WITH PRE_2
  /MISSING=LISTWISE.
```

Graph

Notes

Output Created		2009-06-18T14:13:26.907
Comments		
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	N of Rows in Working Data File	2258
Syntax		GRAPH /SCATTERPLOT(BIVAR)=botSal WITH PRE_2 /MISSING=LISTWISE.
Resources	Processor Time	0:00:00.391
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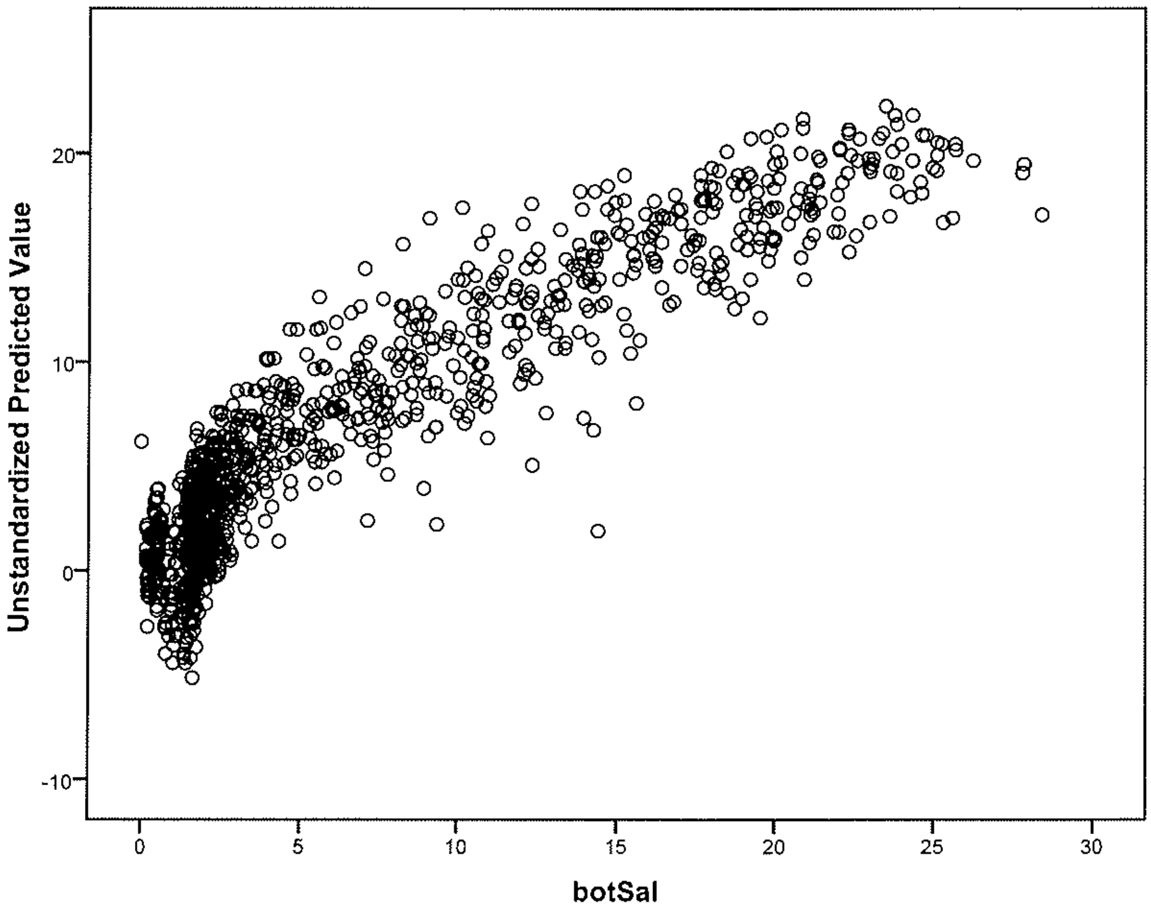
[DataSet3]




```
USE ALL.
COMPUTE filter_$=(botSal > 3).
VARIABLE LABEL filter_$ 'botSal > 3 (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE.
REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA CHANGE
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT botSal
  /METHOD=STEPWISE KM Tot_Spring_Q
  /PARTIALPLOT ALL
  /RESIDUALS HIST(ZRESID) NORM(ZRESID)
  /SAVE PRED RESID.
```

Regression

Notes

Output Created		2009-06-18T14:14:36.940
Comments		
Input	Active Dataset	DataSet3
	Filter	botSal > 3 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	716
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used.
Syntax		REGRESSION /MISSING LISTWISE /STATISTICS COEFF OUTS R ANOVA CHANGE /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT botSal /METHOD=STEPWISE KM Tot_Spring_Q /PARTIALPLOT ALL /RESIDUALS HIST(ZRESID) NORM (ZRESID) /SAVE PRED RESID.
Resources	Processor Time	0:00:00.922
	Elapsed Time	0:00:00.938
	Memory Required	2436 bytes
	Additional Memory Required for Residual Plots	1368 bytes
Variables Created or Modified	PRE_3	Unstandardized Predicted Value
	RES_3	Unstandardized Residual

[DataSet3]

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	KM	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: botSal

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
2	Tot_Spring_Q	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: botSal

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		
					R Square Change	F Change	df1
1	.747[a]	.559	.558	4.36663	.559	661.702	1
2	.889[b]	.791	.790	3.01025	.232	578.499	1

a. Predictors: (Constant), KM

b. Predictors: (Constant), KM, Tot_Spring_Q

c. Dependent Variable: botSal

Model Summary[c]

Model	Change Statistics	
	df2	Sig. F Change
1	523	.000
2	522	.000

a. Predictors: (Constant), KM

b. Predictors: (Constant), KM, Tot_Spring_Q

c. Dependent Variable: botSal

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12616.946	1	12616.946	661.702	.000[a]
	Residual	9972.265	523	19.067		
	Total	22589.211	524			
2	Regression	17859.062	2	8929.531	985.427	.000[b]
	Residual	4730.149	522	9.062		
	Total	22589.211	524			

a. Predictors: (Constant), KM

b. Predictors: (Constant), KM, Tot_Spring_Q

c. Dependent Variable: botSal

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	18.131	.298		60.795	.000
	KM	-1.338	.052	-.747	-25.724	.000
2	(Constant)	37.811	.844		44.817	.000
	KM	-1.595	.037	-.891	-42.630	.000
	Tot_Spring_Q	-.129	.005	-.503	-24.052	.000

a. Dependent Variable: botSal

Excluded Variables[b]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	Tot_Spring_Q	-.503[a]	-24.052	.000	-.725	.918

a. Predictors in the Model: (Constant), KM

b. Dependent Variable: botSal

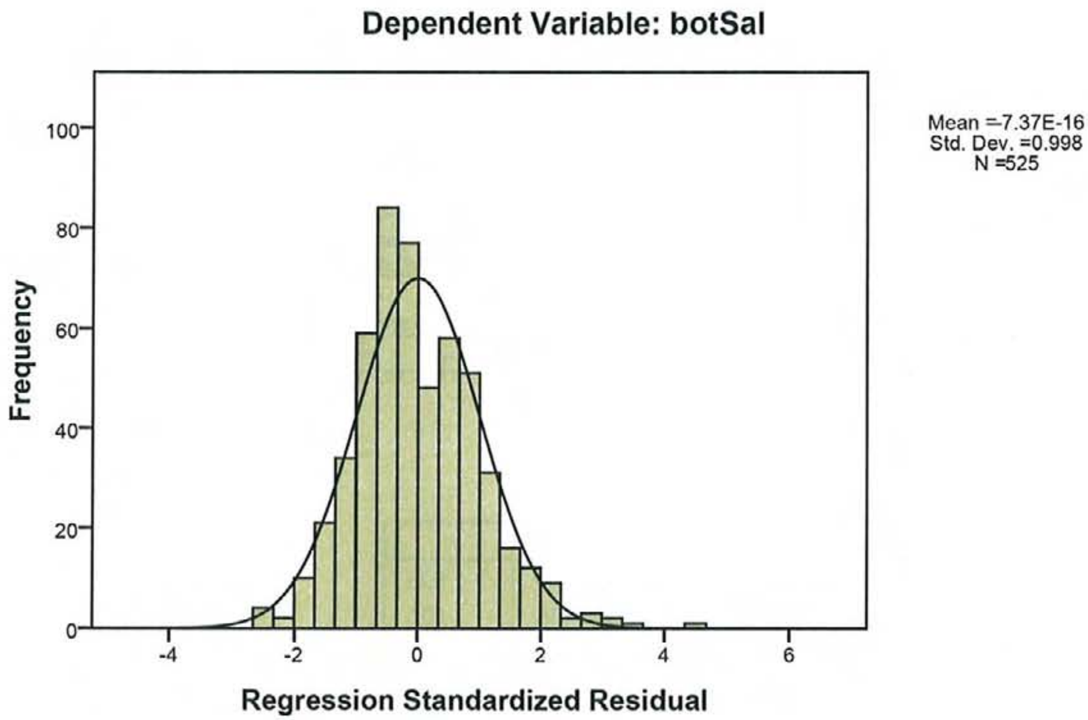
Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-1.1100	25.1309	12.2299	5.83799	525
Residual	-7.76145	13.55580	.00000	3.00450	525
Std. Predicted Value	-2.285	2.210	.000	1.000	525
Std. Residual	-2.578	4.503	.000	.998	525

a. Dependent Variable: botSal

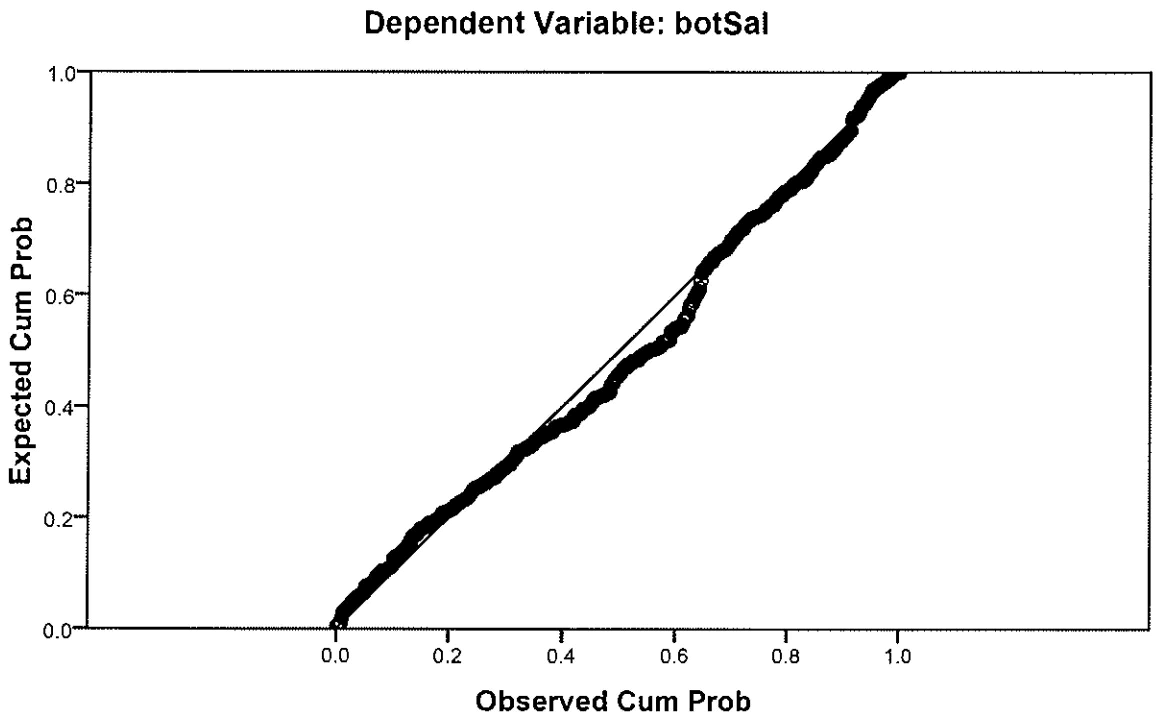
Charts

Histogram

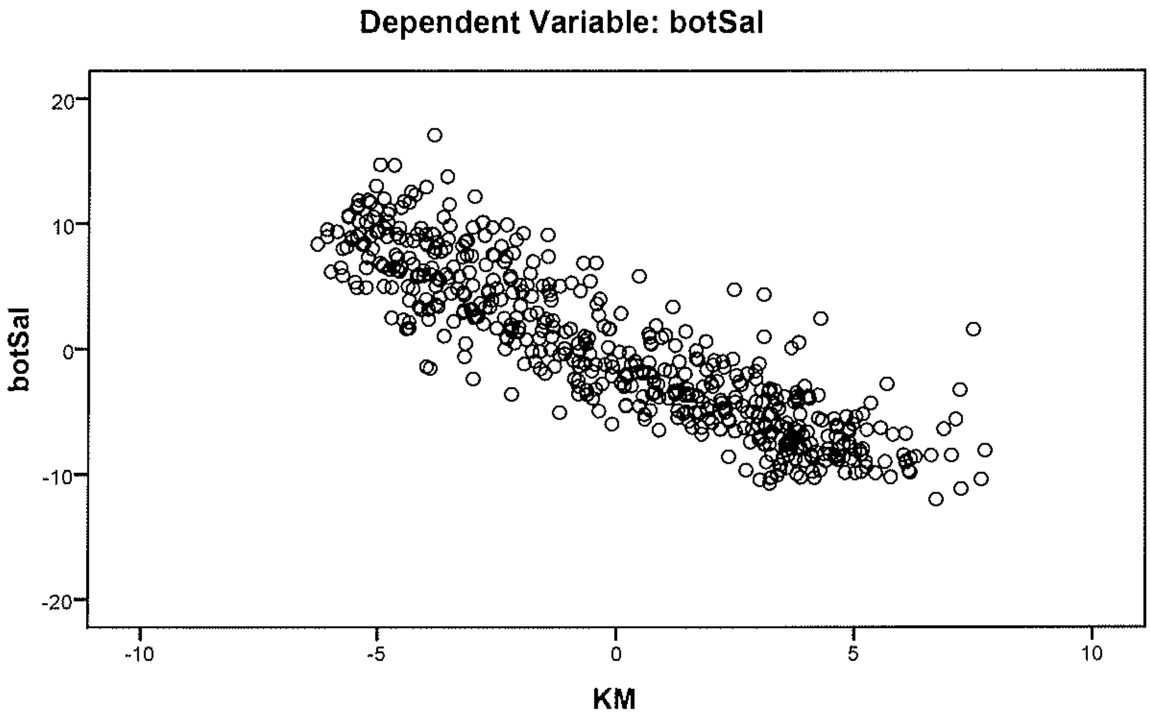


Dependent Variable: botSal
Mean =-7.37E-16
Std. Dev. =0.998
N =525
100
80
60
40
20
0
Frequency
-4
-2
0
2
4
6
Regression Standardized Residual

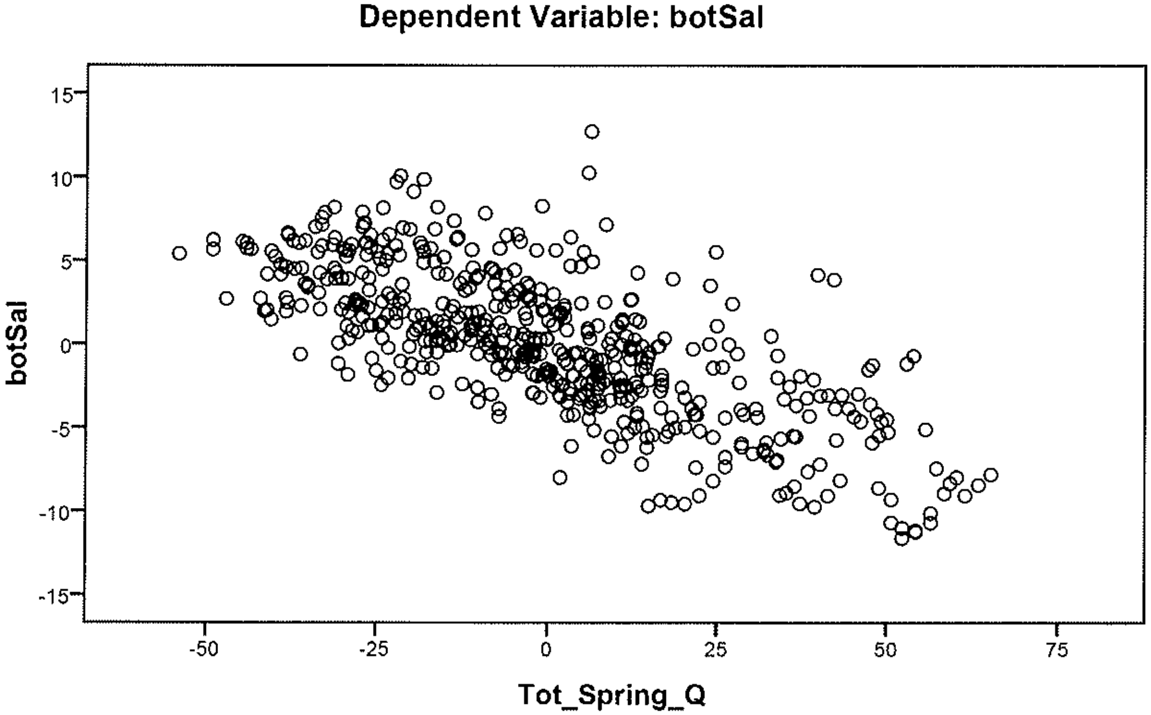
Normal P-P Plot of Regression Standardized Residual



Partial Regression Plot



Partial Regression Plot




```
GRAPH
  /SCATTERPLOT(BIVAR)=botSal WITH PRE_3
  /MISSING=LISTWISE.
```

Graph

Notes

Output Created		2009-06-18T14:15:00.247
Comments		
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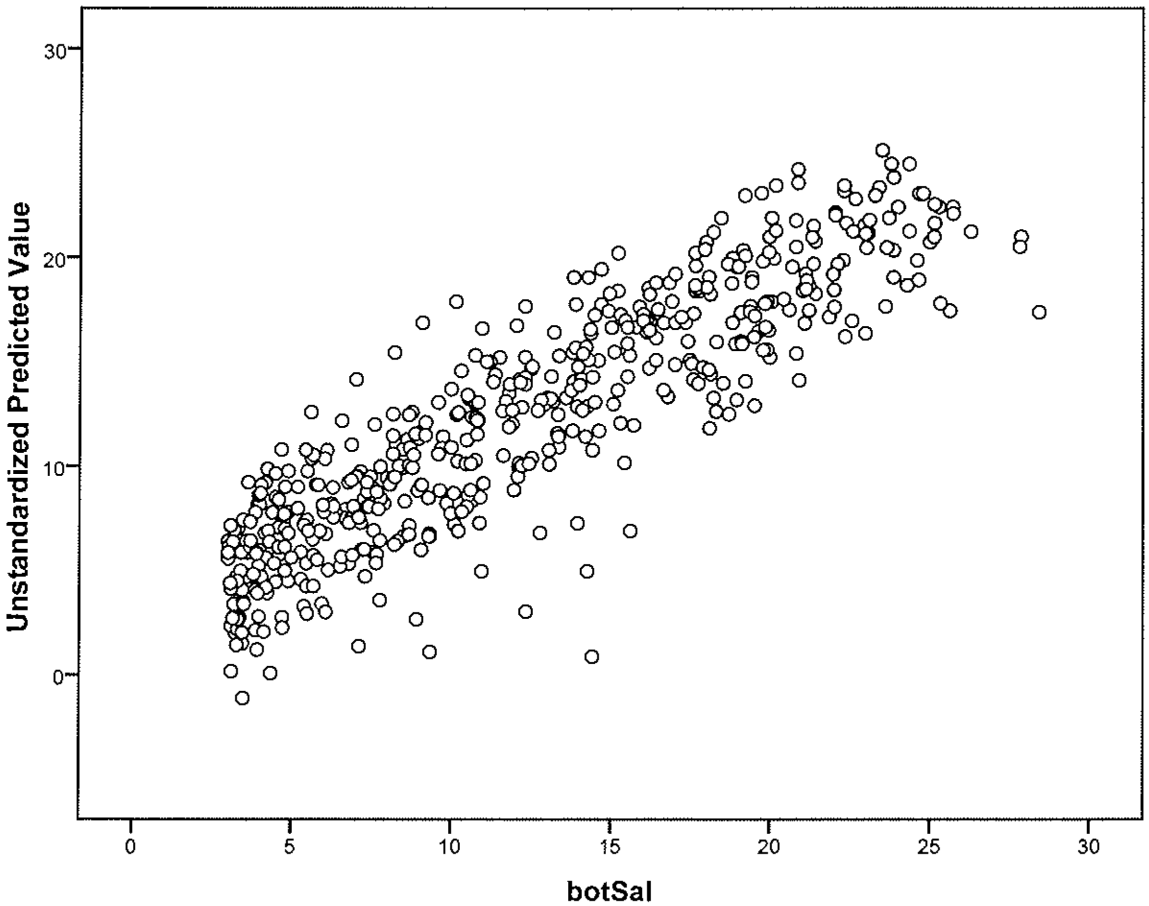
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	716
Syntax		GRAPH /SCATTERPLOT(BIVAR)=botSal WITH PRE_3 /MISSING=LISTWISE.
Resources	Processor Time	0:00:00.406
	Elapsed Time	0:00:00.422

[DataSet3]



Unstandardized Predicted Value
botSal
0
5
10
15
20
25
30
0
10
20
30

Appendix J

Tech Memo – Homosassa River Salinity and Thermal Analyses

MEMORANDUM

TO: Mr. Sid Flannery, Senior Environmental Scientist
Southwest Florida Water Management District

From: Ken W. Watson, Ph.D., President
HSW Engineering, Inc.

Date: January 26, 2010 (modified in February 2011)

Re: Technical Memo
Homosassa River Salinity and Thermal Analyses
Modification to P.O. 08POSOW1270

HSW Engineering, Inc. (HSW) developed regression models for the Homosassa River to estimate the location (in river kilometers) of specific isohalines as a function of spring flow and tide stage. One objective of developing these regression models is to associate specific isohaline river kilometer locations with river bottom areas and river volumes upstream of those locations. Habitat may then be associated with areas and volumes that maintain a salinity level at or less than the isohaline value.

Spring flow is defined as the sum of the mean daily spring flow, as reported for Homosassa Springs and Southeast (SE) Fork Spring, and tide stage is the stage as reported at the Homosassa River gauge at the time of sampling. The period of record for available input data (i.e., 15 minute data) generally dates back to 2004. The development of these and other statistical associations are presented in – "A Modeling Study of the Relationships of Freshwater Flow with the Salinity and the Thermal Characteristics of the Homosassa River, February 2011" (HSW 2011). Isohaline models were developed for surface and bottom salinities of 3, 5 and 12 psu.

The isohaline regression models were used to predict daily isohaline locations for year 2007 and for a period from October 1995 to May 2009 (Period of Record [POR]). The year 2007 corresponds to the hydrodynamic model period (HSW 2011) and the POR is a time frame for which some spring flow data are available. To compute daily isohaline positions using the regression models, daily total spring flow and daily mean tide data are used as model input.

The input data for daily mean tide includes the 2007 mean tide data (to compare with the hydrodynamic model results) and the average monthly mean tide for the remainder of the time period (i.e., 1995 – 2009). Regression models also were developed to extend the data record for spring flow from Homosassa and SE Fork Springs. No total spring flow value was estimated when spring flow data were unavailable for both springs. Means monthly daily mean tide data were used in the models because daily mean tide at Homosassa gauge is unavailable for much of the POR.

The regression model output is a data set that includes the input data and the location, in river kilometers, of the surface and bottom isohalines. The average water column location of a specific isohaline is defined as the average location of the surface and bottom isohaline. Baseline bottom areas, associated with bottom salinity isohalines, and volumes, associated with water column isohalines, were then calculated using the area/volume relationships reported in Section 2.3 Figure 2-5 of HSW (2011). The data files and associated computational files are provided with this memo on a CD in MS Excel format (file "Master Homosassa River Area and Volume Tables.xls" and file "Master Homosassa River Area and Volume Tables_POR.xls"). Some graphical output is presented in this technical memo.

To identify an appropriate time frame for the thermal analysis, an analysis was completed for the 2007-2008 season to determine the joint-probability for the critical cold event used for modeling changes in the thermal refuge availability for manatees in the Homosassa River system. To characterize the severity of the cold event that was modeled, the analysis was repeated for the 1997-1998 manatee season through the 2007-2008 manatee season. The results of this analysis also are presented in this memo.

Comparison of Hydrodynamic (EFDC) and Empirical (Regression) Models

HSW (2011) presented a detailed discussion of the development of the hydrodynamic model for the Homosassa River using input data for year 2007. As part of this technical memo, an output dataset was developed that includes the centerline position of selected isohalines to compare with similar output data from the empirical models. To produce this dataset, salinity values generated every three hours throughout the model domain were extracted from model cells, associated with the river centerline. The centerline location of a specific isohaline was found by using the salinity value and river kilometer associated with the centerline model cells, and linear interpolation. The post processed dataset includes centerline positions of the 3, 5, and 12 psu isohalines for surface, bottom and depth average salinity.

In general, the hydrodynamic and empirical model results compare favorably, particularly for the bottom salinities (Figures J-1). The hydrodynamic model results for particular isohalines occur further upstream during the summer months when compared to the empirical model results. This is most apparent for the 3 psu and for the surface salinity isohalines.

Bottom river area and river volume are the area and volume upstream of a particular isohaline, and both decrease as the RKM increases (i.e., the graphs (J-2) are mirror images of the RKM graphs (J-1)). Bottom area is determined using the bottom salinity isohaline locations hence the estimates from the two modeling approaches are quite similar for each of the three isohalines. River volume is estimated using the depth average salinities so the comparison (J-2) is not quite as good as for bottom area.

The comparison between the two modeling approaches probably is best represented by the RKM versus flow graphs (J-3) and bottom area and volume versus flow graphs (J-4). The surface isohalines are further upstream using the hydrodynamic model results particularly for the 3 psu isohaline and for low flows. However, in general the two model results are supportive. Similarly, river bottom areas computed using the two model types are quite comparable (J-4). The hydrodynamic model simulates less river volume associated with the 3 psu isohaline, particularly at low flows, when compared to the empirical model.

Scatter plots of the isohaline RKM positions estimated by the two modeling approaches also are helpful in visualizing how the models compare (Attachment J-5). The red line in each graph is the 1:1 line. When data (and the fitted line) are above the 1:1 line, the hydrodynamic model is predicting that the isohaline is further upstream then the empirical model is predicting. The bottom isohalines compare most favorably followed by the average and then the surface isohalines. The 3 psu isohalines are most comparable across depths.

The hydrodynamic model was calibrated primarily using the data for the USGS gauge at Homosassa, which is located near RKM 9, so values near this gauge should be most accurately estimated using the hydrodynamic model. In addition, the hydrodynamic model was developed using data for 2007, which was a year of relatively low spring flow (about 130 cfs median flow versus long term 150 cfs median flow). The empirical models were developed using data collected throughout the river and over a period of about 5 years when Homosassa gauge stage and vertical profile salinity data were available.

Joint Probability Analysis

To support the thermal analysis presented in HSW (2011), two factor (flow and air temperature) and three factor (flow, air temperature and tide) factor joint probabilities for the 1996-1997 through 2006-2007 manatee seasons were estimated using Homosassa Springs flow records, the Brooksville FAWN-IFAS meteorological station, and the Homosassa River tide/stage records. This type of analysis previously was completed for the 2007-2008 season to determine the joint-probability for the critical cold event used for modeling changes in the thermal refuge available for manatees in the Homosassa River system. A three day event window was calculated using a joint probability of air temperature (from Brooksville FAWN-IFAS Station), spring discharge (Homosassa Springs), and tide (Homosassa River). From this analysis, there were two possible windows identified; the first was 12/16/07 – 12/18/07 based on the joint probability of all three variables and the second is 1/2/08 – 1/4/08 based on only air temperature and discharge. By analyzing three day moving averages of measured air temperature and tide, the 1/2/08 – 1/4/08 window was determined to be the more critical time period for withdrawal considerations.

To characterize the severity of the cold event that was modeled (HSW 2011), the analysis was repeated for the 1997-1998 manatee season through the 2007-2008 manatee season. Mean daily air temperature, spring discharge, and high tide for each day in the six-month manatee season were ranked from lowest to highest and assigned a Cunnane probability of nonexceedence. The joint probability of nonexceedence was the multiplication of the individual probabilities. Since the timeframe of interest is three days, a three day moving average of joint probability was used to identify the combination of the lowest two factor (flow and air temperature) and three factor (flow, air temperature and tide) factor joint probabilities. Three-day average joint probabilities were then ranked from lowest (representing the most severe combination of factors) to highest.

The datasets used in this analysis included the Brooksville FAWN-IFAS meteorological station and the Homosassa Springs USGS Gauge Station. The Homosassa River tide/stage records were not utilized because continuous data does not exist prior to 2004. However, given how highly correlated the Homosassa River and Homosassa Springs stage values are, using Homosassa Springs stage values is justified. The Brooksville station is also missing periods of record over the timeframe requested by the District [missing periods are 1996 – 1997 manatee season, 10/1/97 – 12/31/97, 10/1/98 – 11/18/98, 2/21/99 – 3/31/99, 1/1/00 – 3/26/00] which makes joint probability for the 1997 to 2000 timeframe more difficult to analyze. Therefore, the two factor and three factor joint probability analysis was conducted for two periods 1997 – 2008 (excluding data gaps) and from 2000 – 2008. From 2000 – 2008 there is a continuous record of air temperature and relatively good records of flow and stage at Homosassa Springs (there are intermitted time periods where either flow or stage data is missing).

The nine lowest two factor and three factor joint probabilities for each period analyzed are listed in Table 1. For the three factor analysis, the 1/2/08 – 1/4/08 window was the second (2) most severe for both periods considered with the remaining nine events occurring during December and January of the 2000 – 2001 manatee season. For the two factor analysis, the 1/2/08 – 1/4/08 window was the 74 (out of 1458) and 85 (out of 1708) for the 2000 – 2008 period and the 1997 – 2008 period respectively. Therefore, the event modeled for thermal analysis represents a severe cold event based on joint probability.

Table 1: Two Factor and three factor joint probability for 2000 – 2008 and 1997 – 2008.

2000 - 2008 Day	3 Day Avg. JP (3 factor)	2000 - 2008 Day	3 Day Avg. JP (2 factor)	1997 - 2008 Day	3 Day Avg. JP (3 factor)	1997 -2008 Day	3 Day Avg. (2 factor)
1/2/2001	0.000122	1/1/2001	0.002104	1/2/2001	9.78E-05	1/1/2001	0.001931
1/4/2008	0.000126	12/31/2000	0.002915	1/4/2008	9.89E-05	12/31/2000	0.002521
1/3/2001	0.000136	3/6/2001	0.003398	1/3/2001	0.000109	3/6/2001	0.003046
1/4/2001	0.000136	12/21/2000	0.004115	1/4/2001	0.000109	12/21/2000	0.003856
1/1/2001	0.000234	1/2/2001	0.004998	1/1/2001	0.000195	1/2/2001	0.005153
1/5/2001	0.00051	3/5/2001	0.005409	1/5/2001	0.000414	3/5/2001	0.005634
1/23/2001	0.000656	1/5/2002	0.006969	1/23/2001	0.000511	12/30/2000	0.006388
12/21/2000	0.000786	2/14/2006	0.00708	12/21/2000	0.000672	2/14/2006	0.006732
1/24/2001	0.000992	12/30/2000	0.007083	1/24/2001	0.000764	1/5/2002	0.006745

Data Files

Two data files are included with this delivery - MS Excel format (file "Master Homosassa River Area and Volume Tables_2007.xls" and file "Master Homosassa River Area and Volume Tables_POR.xls").

1. The data set for 2007 is in the Excel file "Master Homosassa River Area and Volume Tables_2007.xls".

2. The regression models were updated (from the Draft 1 EFDC Model Report) and presented in the report – "A Modeling Study of the Relationships of Freshwater Flow with the Salinity and the Thermal Characteristics of the Homosassa River, February 2011" (HSW 2011).

    a. The regression models were developed using tide stage recorded at the USGS gauge at Homosassa and at the time of sampling.

    b. Daily surface and bottom kilometer values are calculated for each isohaline using daily spring flow and mean stage. A water column value is calculated by averaging the surface and bottom kilometer values.

    c. Bottom areas are assigned to the kilometer values by associating the area/volume versus river kilometer values presented in Appendix C. The association is done using an Excel linear interpolation function. The results are presented in file "Master Homosassa River Area and Volume Tables_2007.xls".

    d. Bottom areas are calculated using the bottom salinity isohaline relationship and the river volume is calculated using the water column average isohaline location. No areas or volumes were calculated for the surface isohaline location.

3. Comparison of the hydrodynamic and the empirical model isohaline locations for 2007 (the hydrodynamic model period) is presented in Figures J-1 to J-4. The figures also are included in file "Master Homosassa River Area and Volume Tables_POR.xls".

4. Records of spring flow date back to October 1995 for Homosassa Springs and to October 2000 for SE Fork Spring. The data records for both springs are intermittent at times but frequently data are available for at least one of the springs. To develop an extended flow record, flows from each spring were regressed against the other spring and the regression equations were used to fill in the data record when at least one flow value was available. Because there are extended periods of time when data are not available for either spring, no attempt was made to fill in any data gaps for which flow data were not available for either

spring. The regression equations and graphs are provided in file "Master Homosassa River Area and Volume Tables_2007.xls".

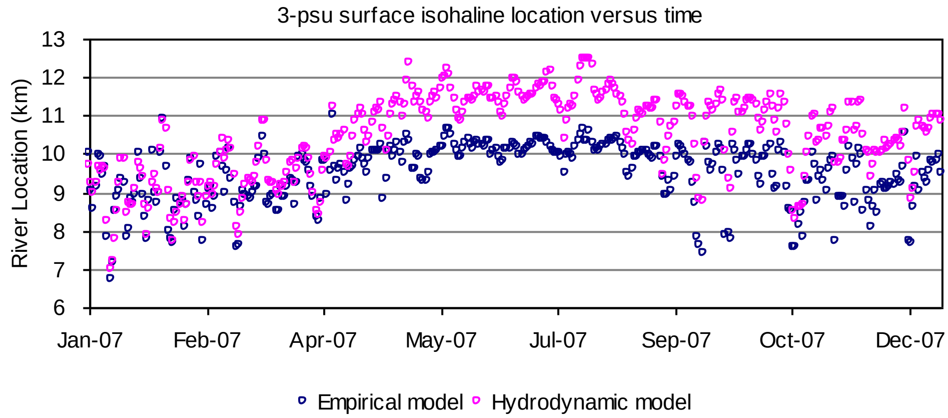
5. The empirical isohaline models presented in HSW (2011) were used to predict isohaline locations for the period of record (beginning in 1995 and ending in 2009). Mean tide at the Homosassa gauge is an independent variable used in the predictive regression models and data are not available for much of the period of record (1995-2009). Mean monthly values for daily mean tide were generated from the available data record and were used in the predictive models for days other than for year 2007. The tide data are provided in file "Master Homosassa River Area and Volume Tables_2007.xls".

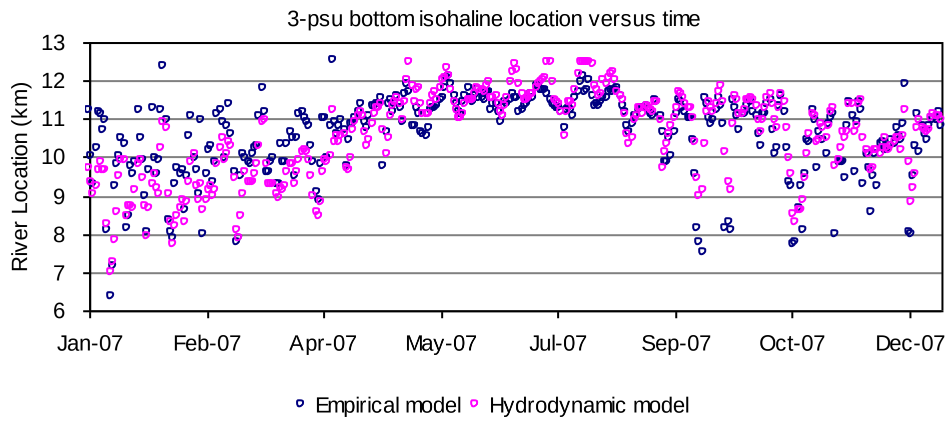
6. Daily river bottom areas (associated with the average daily position of the bottom isohaline) and daily river volumes (associated with the average of the surface and bottom average daily isohaline positions) were calculated using the area/volume relationships reported in Section 2.3 Figure 2-5 (HSW 2011). The regression equations, POR output and graphs are provided in file "Master Homosassa River Area and Volume Tables_POR.xls".

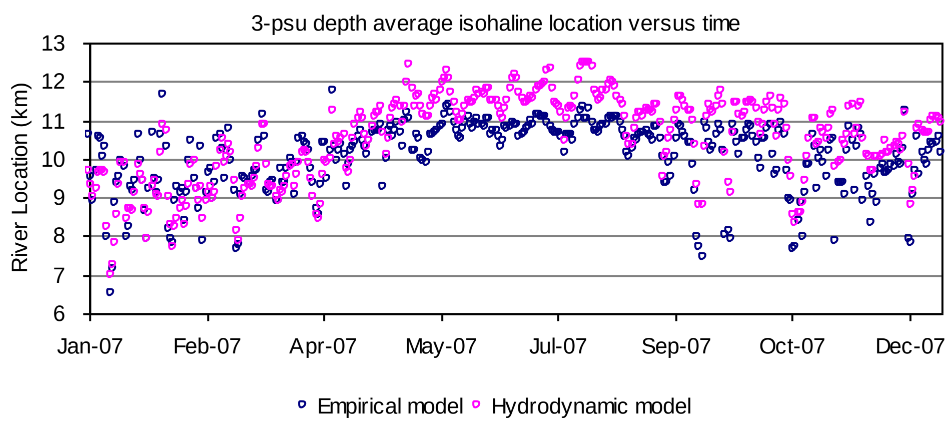
7. Using the regression models and flow reductions from baseline of 5, 10, 15, 20, 25, and 30%, river kilometer values and associated area and volumes were generated. The regression equations, POR output, and graphs are provided in file "Master Homosassa River Area and Volume Tables_POR.xls". Similar information is included in "Master Homosassa River Area and Volume Tables_2007.xls" for year 2007.

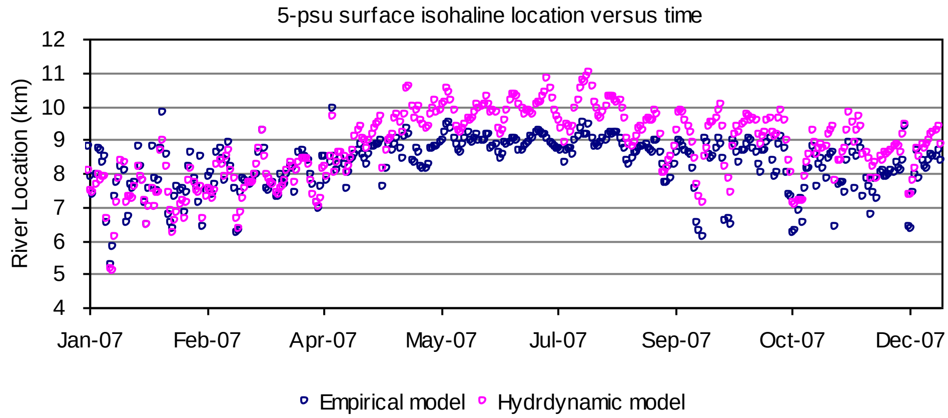
ATTACHMENT J-1

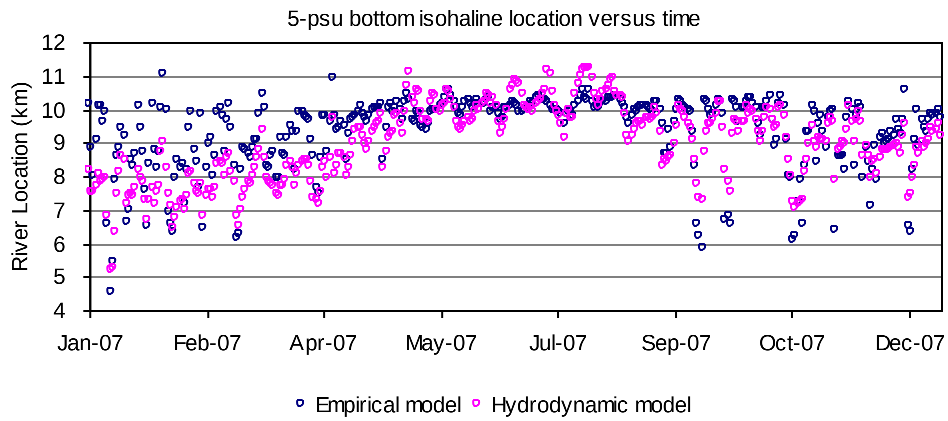
ISOHALINE LOCATIONS VERSUS TIME

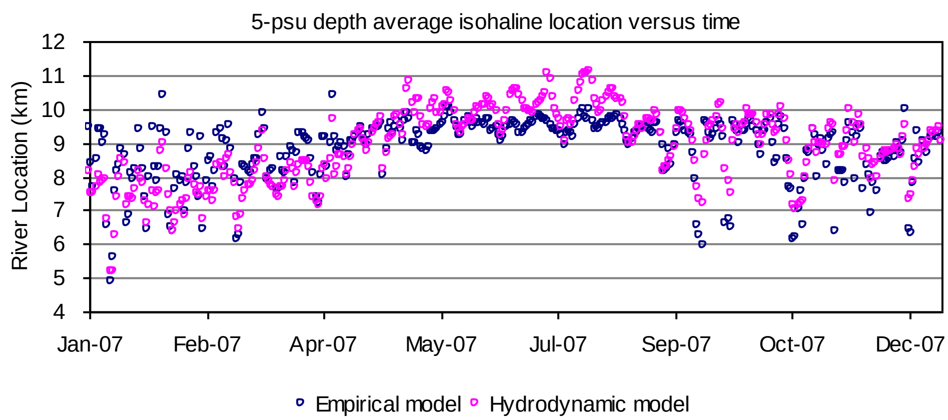

3-psu surface isohaline location versus time
River Location (km)
13
12
11
10
9
8
7
6
Jan-07
Feb-07
Apr-07
May-07
Jul-07
Sep-07
Oct-07
Dec-07
Empirical model
Hydrodynamic model


3-psu bottom isohaline location versus time
River Location (km)
13
12
11
10
9
8
7
6
Jan-07
Feb-07
Apr-07
May-07
Jul-07
Sep-07
Oct-07
Dec-07
Empirical model
Hydrodynamic model

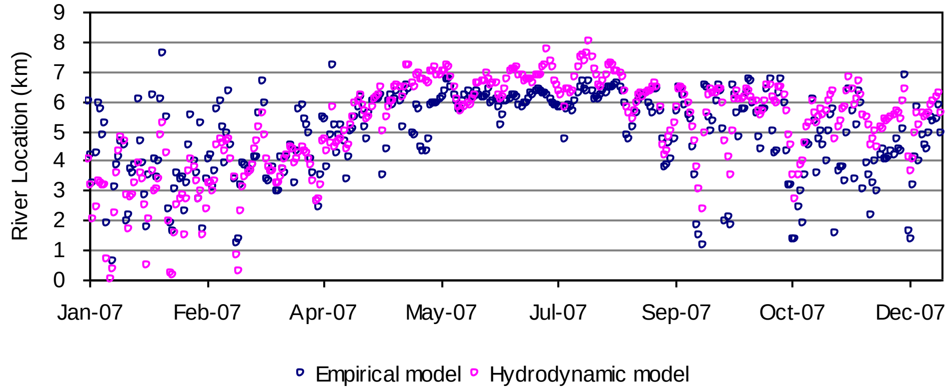

3-psu depth average isohaline location versus time
River Location (km)
13
12
11
10
9
8
7
6
Jan-07
Feb-07
Apr-07
May-07
Jul-07
Sep-07
Oct-07
Dec-07
Empirical model
Hydrodynamic model


5-psu surface isohaline location versus time
River Location (km)
12
11
10
9
8
7
6
5
4
Jan-07
Feb-07
Apr-07
May-07
Jul-07
Sep-07
Oct-07
Dec-07
Empirical model
Hydrdynamic model

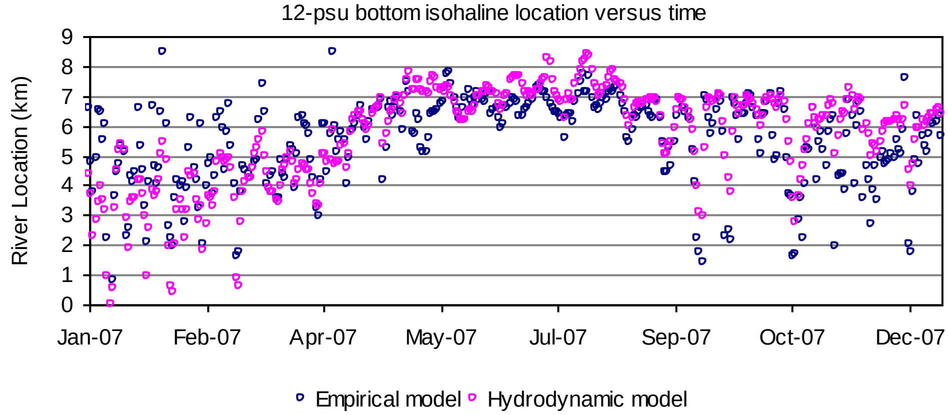

5-psu bottom isohaline location versus time
River Location (km)
12
11
10
9
8
7
6
5
4
Jan-07
Feb-07
Apr-07
May-07
Jul-07
Sep-07
Oct-07
Dec-07
Empirical model
Hydrodynamic model


5-psu depth average isohaline location versus time
River Location (km)
12
11
10
9
8
7
6
5
4
Jan-07
Feb-07
Apr-07
May-07
Jul-07
Sep-07
Oct-07
Dec-07
Empirical model
Hydrodynamic model

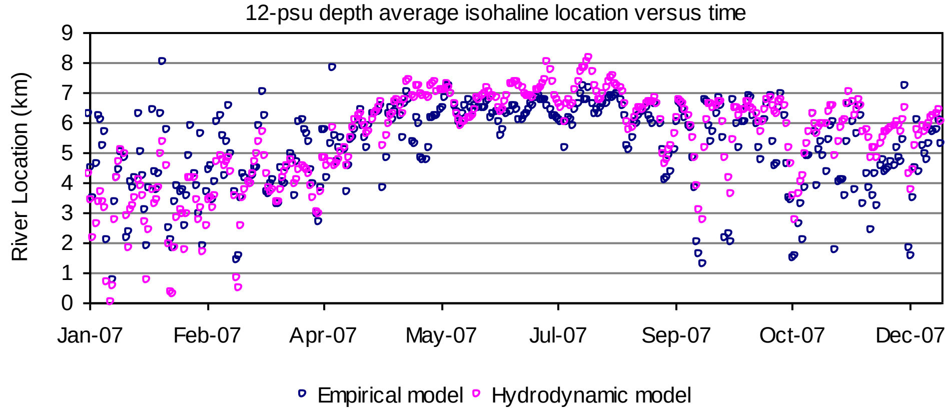
12-psu surface isohaline location versus time



12-psu bottom isohaline location versus time

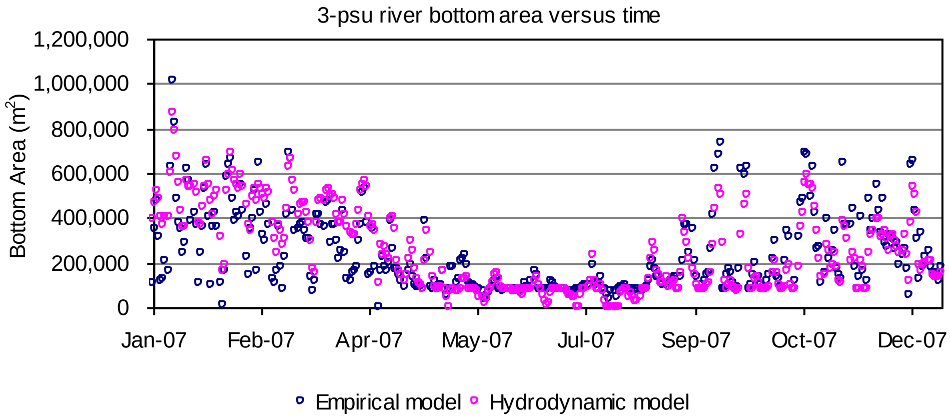


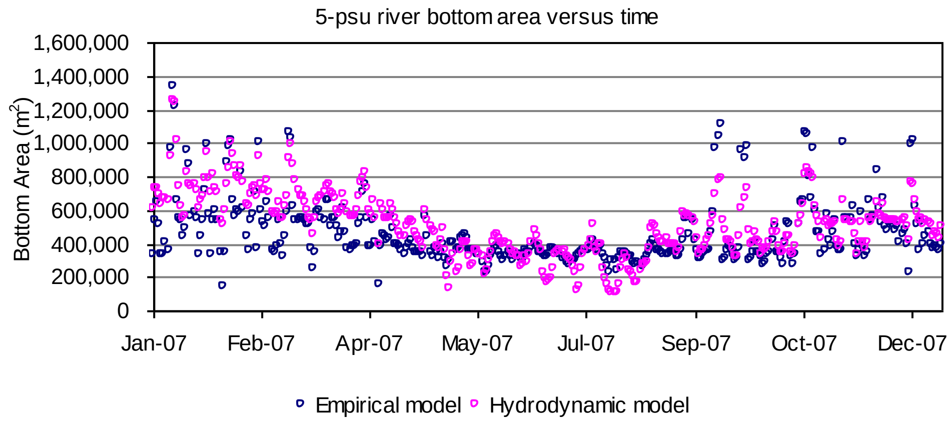
12-psu depth average isohaline location versus time

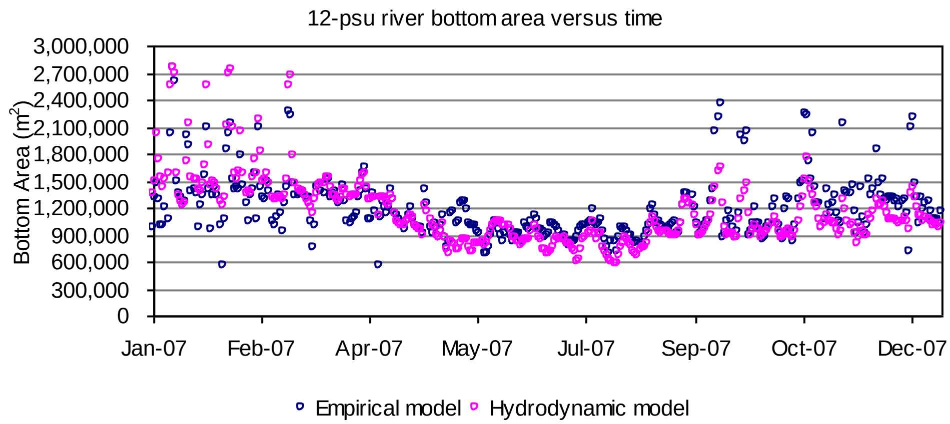


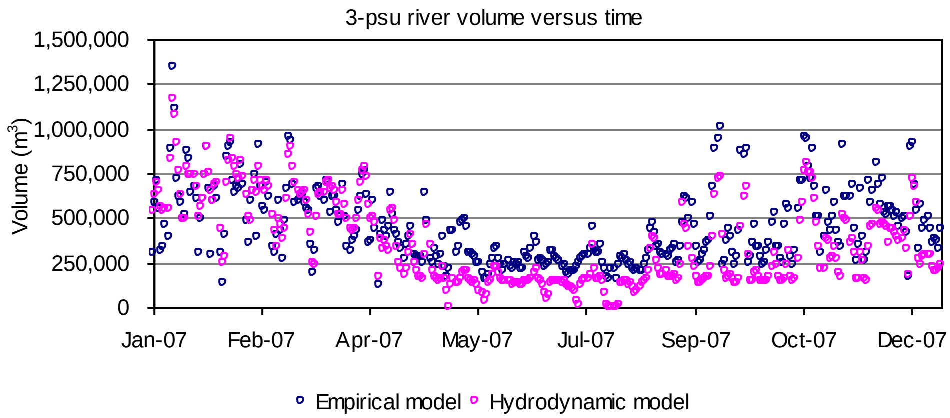
APPENDIX J-2

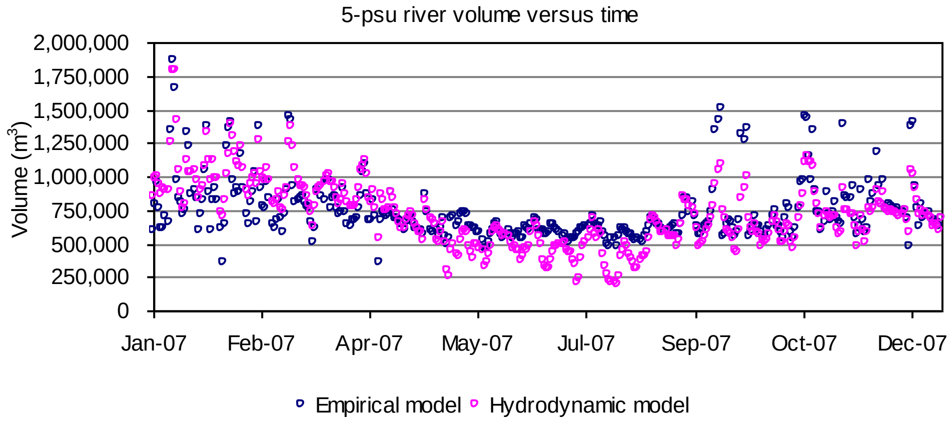
BOTTOM AREA AND VOLUME VERSUS TIME

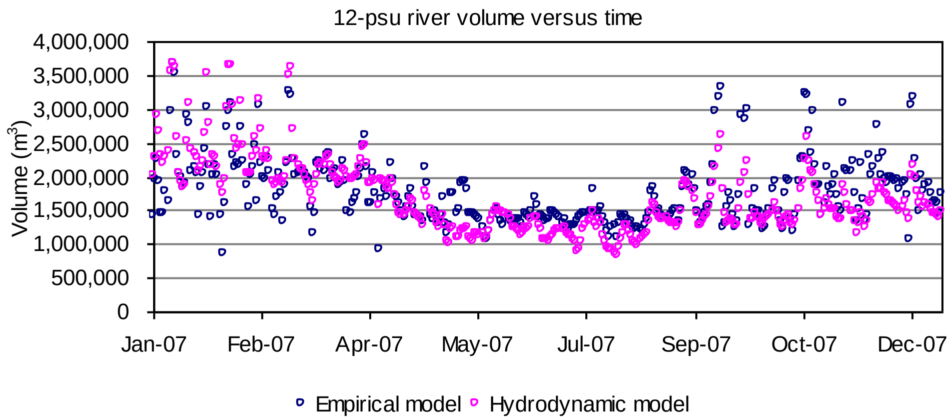

3-psu river bottom area versus time
Bottom Area (m2)
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
Jan-07
Feb-07
Apr-07
May-07
Jul-07
Sep-07
Oct-07
Dec-07
Empirical model
Hydrodynamic model


5-psu river bottom area versus time
Bottom Area (m2)
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
Jan-07
Feb-07
Apr-07
May-07
Jul-07
Sep-07
Oct-07
Dec-07
Empirical model
Hydrodynamic model


12-psu river bottom area versus time
Bottom Area (m2)
3,000,000
2,700,000
2,400,000
2,100,000
1,800,000
1,500,000
1,200,000
900,000
600,000
300,000
0
Jan-07
Feb-07
Apr-07
May-07
Jul-07
Sep-07
Oct-07
Dec-07
Empirical model
Hydrodynamic model

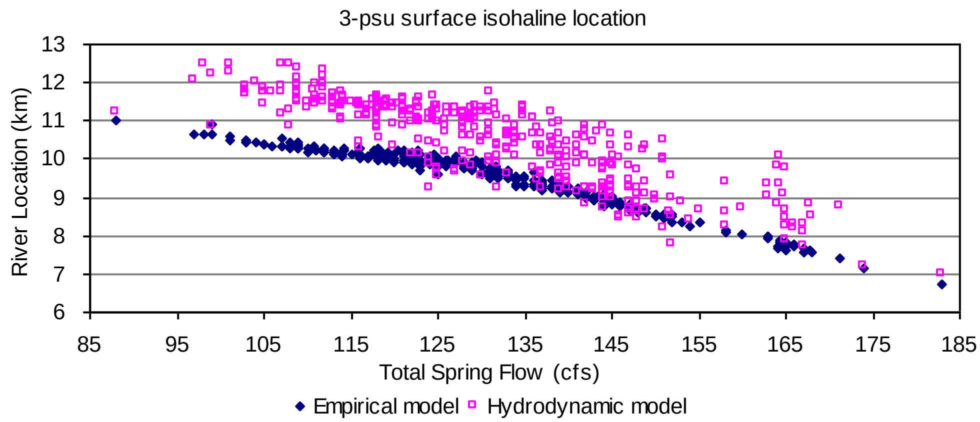

3-psu river volume versus time
Volume (m3)
1,500,000
1,250,000
1,000,000
750,000
500,000
250,000
0
Jan-07
Feb-07
Apr-07
May-07
Jul-07
Sep-07
Oct-07
Dec-07
Empirical model
Hydrodynamic model

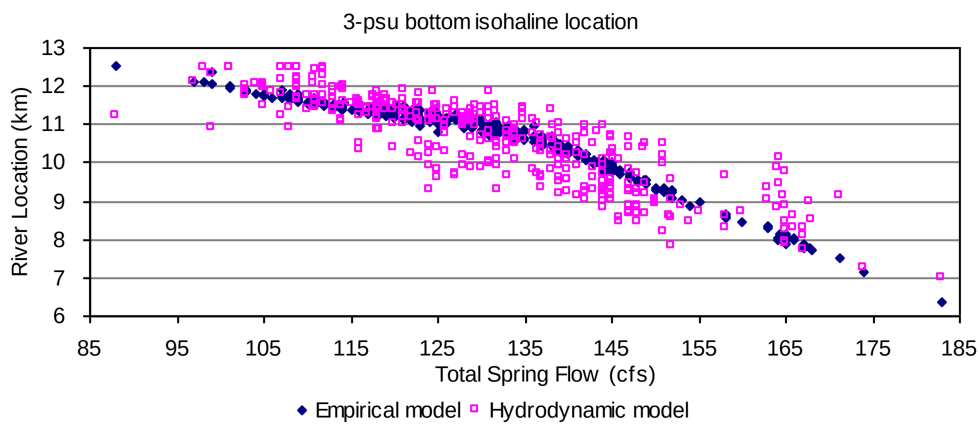

5-psu river volume versus time
Volume (m3)
2,000,000
1,750,000
1,500,000
1,250,000
1,000,000
750,000
500,000
250,000
0
Jan-07
Feb-07
Apr-07
May-07
Jul-07
Sep-07
Oct-07
Dec-07
Empirical model
Hydrodynamic model

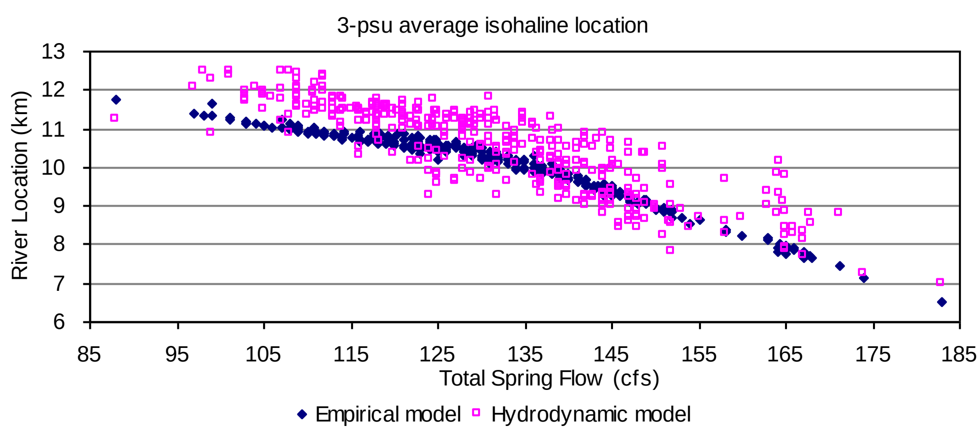

12-psu river volume versus time
Volume (m3)
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
Jan-07
Feb-07
Apr-07
May-07
Jul-07
Sep-07
Oct-07
Dec-07
Empirical model
Hydrodynamic model

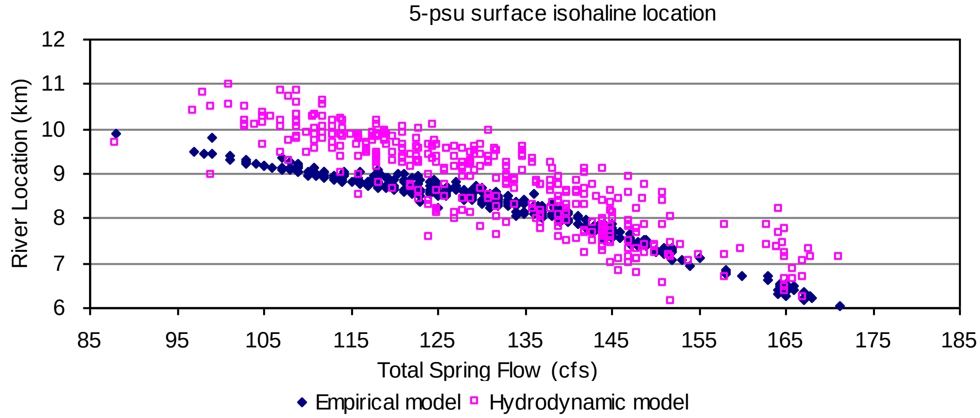
APPENDIX J-3

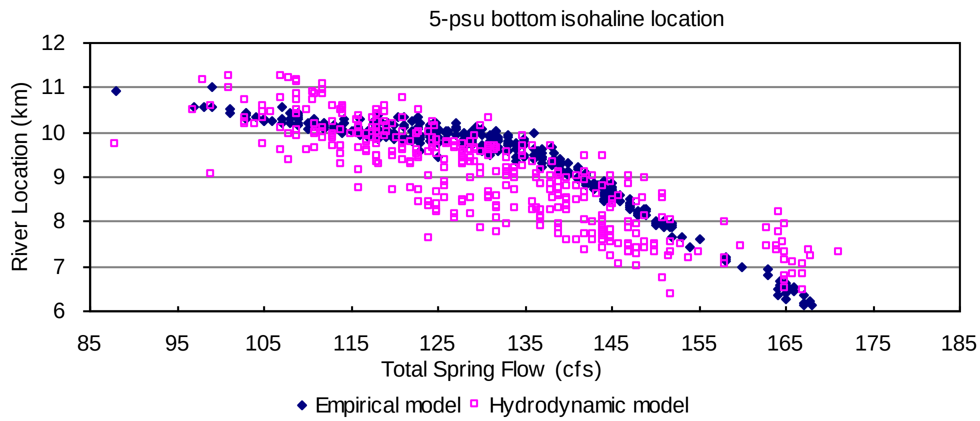
ISOHALINE LOCATION VERSUS TOTAL SPRING FLOW

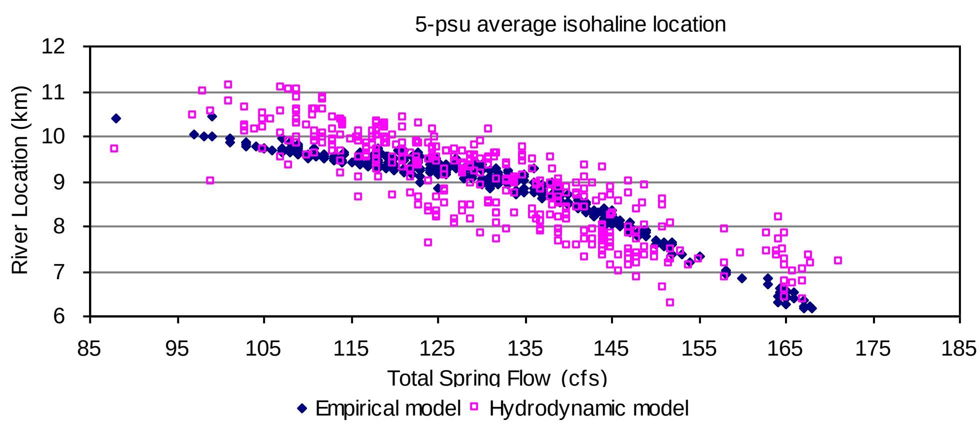

3-psu surface isohaline location
River Location (km)
13
12
11
10
9
8
7
6
85
95
105
115
125
135
145
155
165
175
185
Total Spring Flow (cfs)
Empirical model
Hydrodynamic model

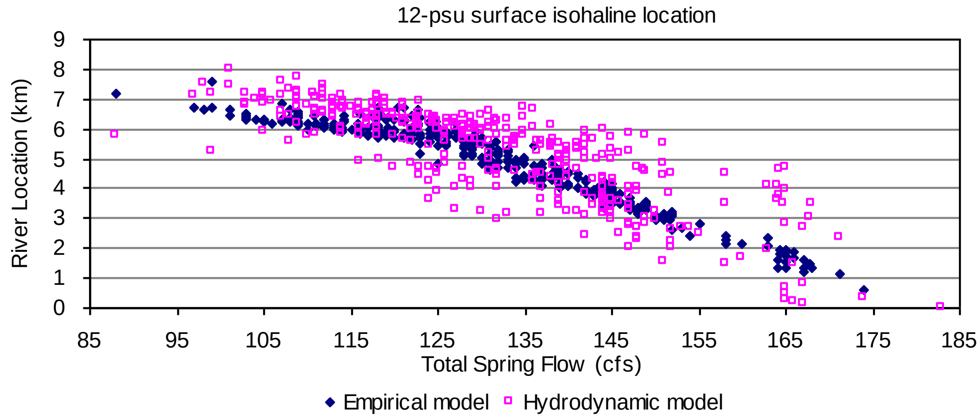

3-psu bottom isohaline location
River Location (km)
13
12
11
10
9
8
7
6
85
95
105
115
125
135
145
155
165
175
185
Total Spring Flow (cfs)
Empirical model
Hydrodynamic model

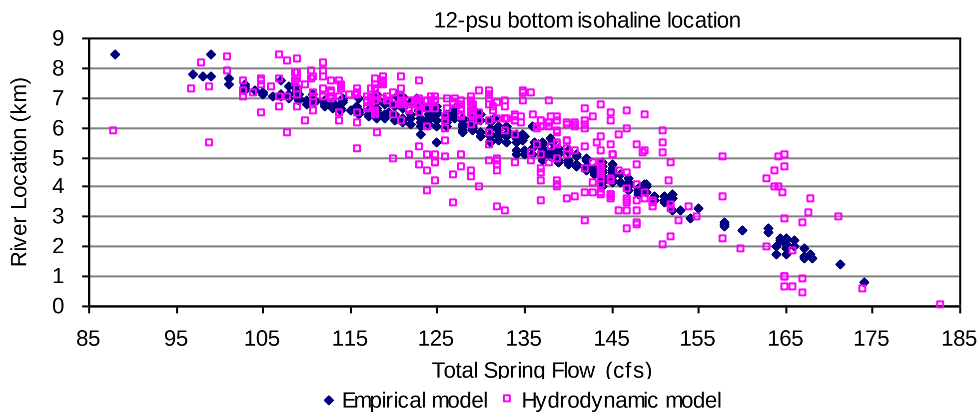

3-psu average isohaline location
River Location (km)
13
12
11
10
9
8
7
6
85
95
105
115
125
135
145
155
165
175
185
Total Spring Flow (cfs)
Empirical model
Hydrodynamic model

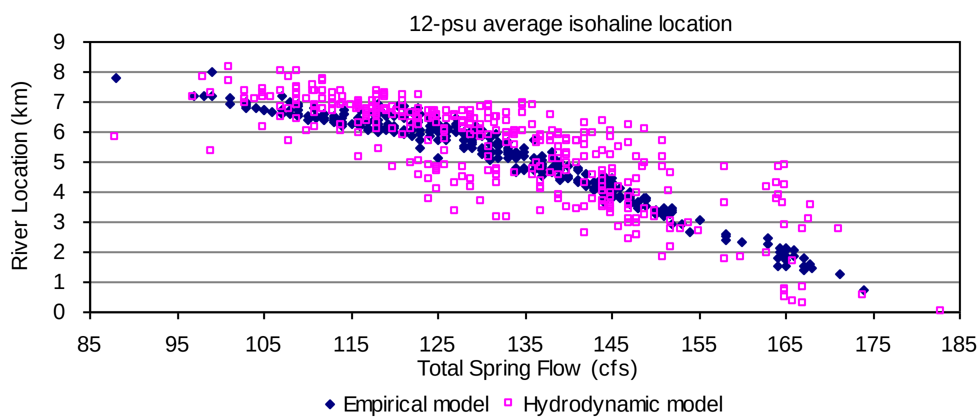

5-psu surface isohaline location
River Location (km)
12
11
10
9
8
7
6
85
95
105
115
125
135
145
155
165
175
185
Total Spring Flow (cfs)
Empirical model
Hydrodynamic model


5-psu bottom isohaline location
River Location (km)
12
11
10
9
8
7
6
85
95
105
115
125
135
145
155
165
175
185
Total Spring Flow (cfs)
Empirical model
Hydrodynamic model


5-psu average isohaline location
River Location (km)
12
11
10
9
8
7
6
85
95
105
115
125
135
145
155
165
175
185
Total Spring Flow (cfs)
Empirical model
Hydrodynamic model

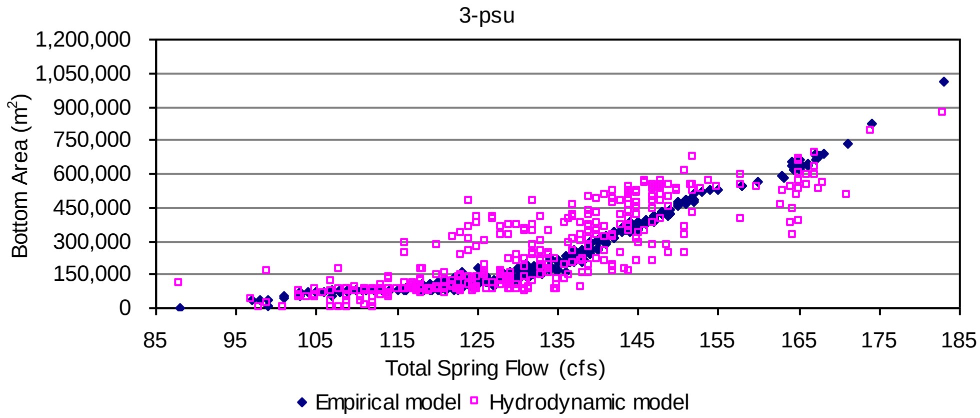

12-psu surface isohaline location
River Location (km)
Total Spring Flow (cfs)
Empirical model
Hydrodynamic model

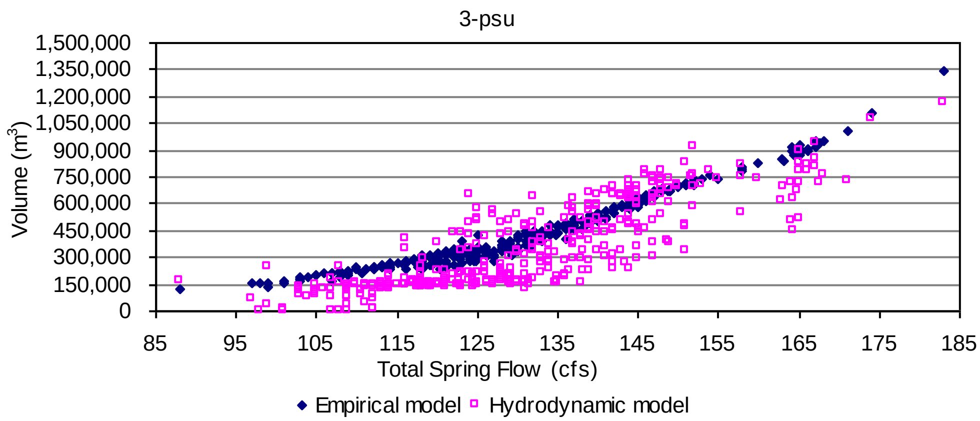

12-psu bottom isohaline location
River Location (km)
Total Spring Flow (cfs)
Empirical model
Hydrodynamic model

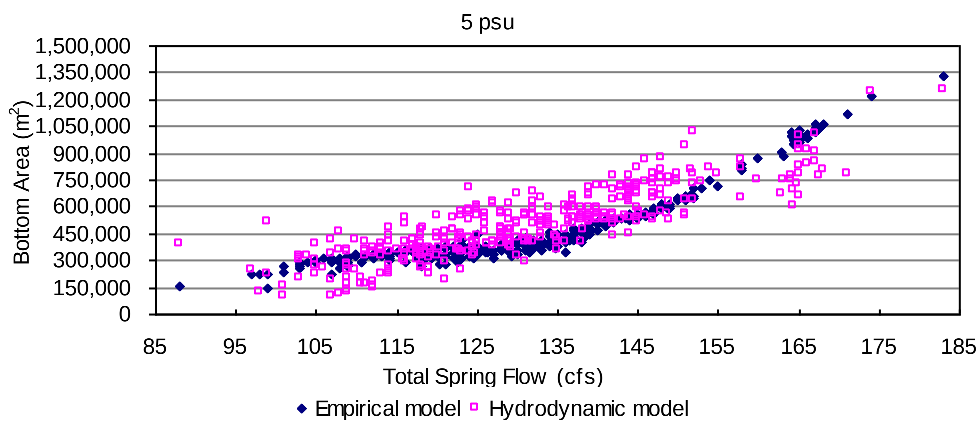

12-psu average isohaline location
River Location (km)
Total Spring Flow (cfs)
Empirical model
Hydrodynamic model

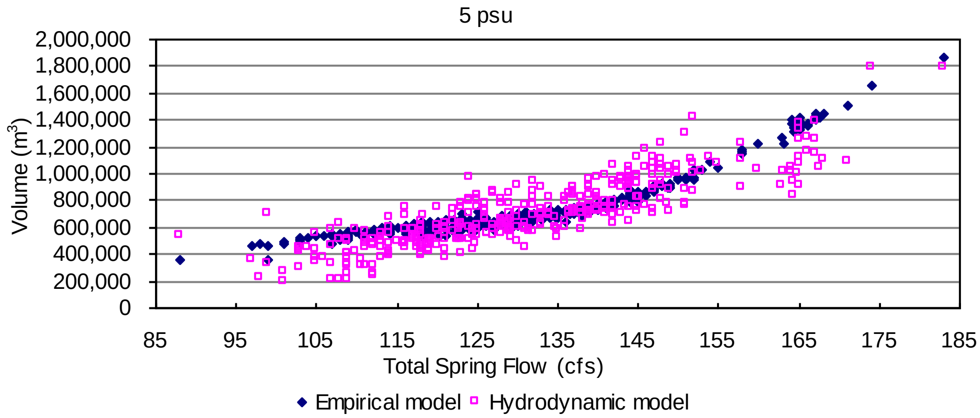
APPENDIX J-4

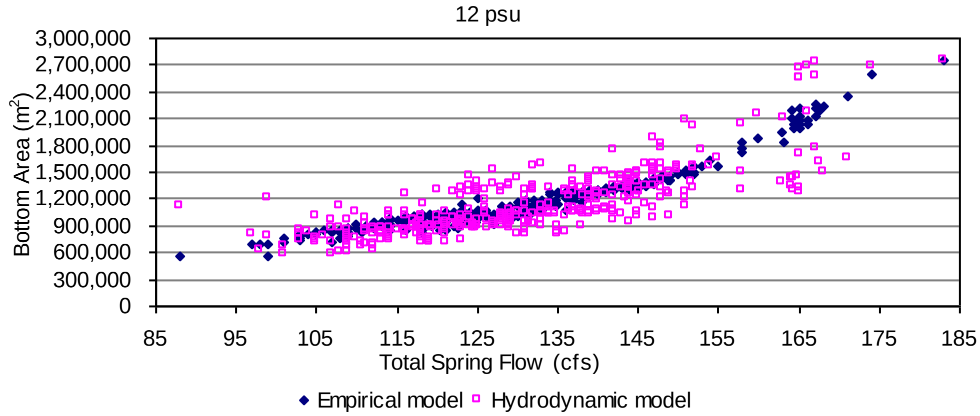
RIVER BOTTOM AREA AND VOLUME VERSUS TOTAL SPRING FLOW

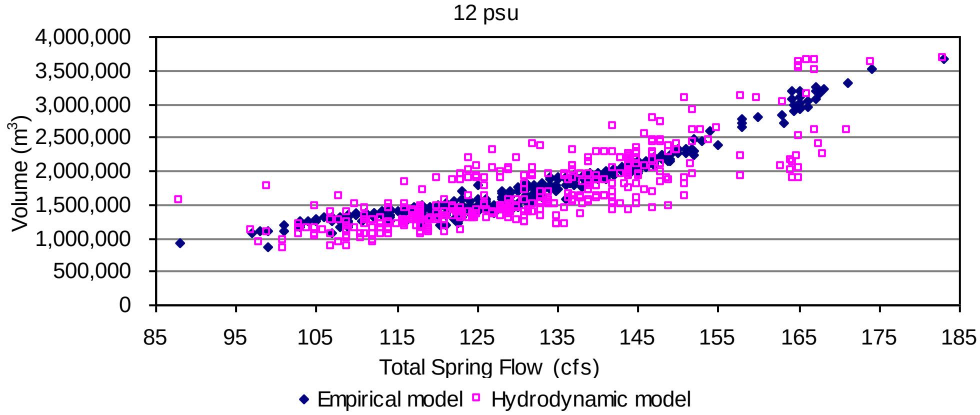

3-psu
1,200,000
1,050,000
900,000
750,000
600,000
450,000
300,000
150,000
0
Bottom Area (m2)
85
95
105
115
125
135
145
155
165
175
185
Total Spring Flow (cfs)
Empirical model
Hydrodynamic model


3-psu
1,500,000
1,350,000
1,200,000
1,050,000
900,000
750,000
600,000
450,000
300,000
150,000
0
Volume (m3)
85
95
105
115
125
135
145
155
165
175
185
Total Spring Flow (cfs)
Empirical model
Hydrodynamic model


5 psu
1,500,000
1,350,000
1,200,000
1,050,000
900,000
750,000
600,000
450,000
300,000
150,000
0
Bottom Area (m2)
85
95
105
115
125
135
145
155
165
175
185
Total Spring Flow (cfs)
Empirical model
Hydrodynamic model

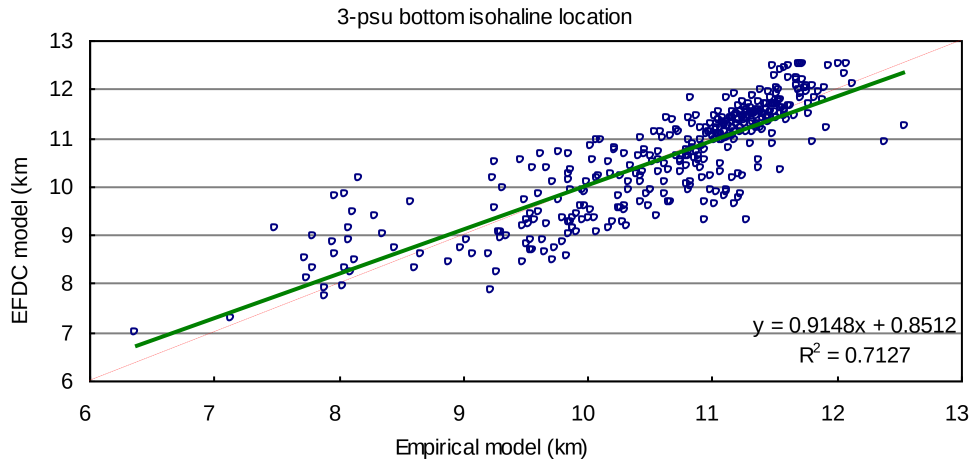

5 psu
Volume (m3)
2,000,000
1,800,000
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
85
95
105
115
125
135
145
155
165
175
185
Total Spring Flow (cfs)
Empirical model
Hydrodynamic model

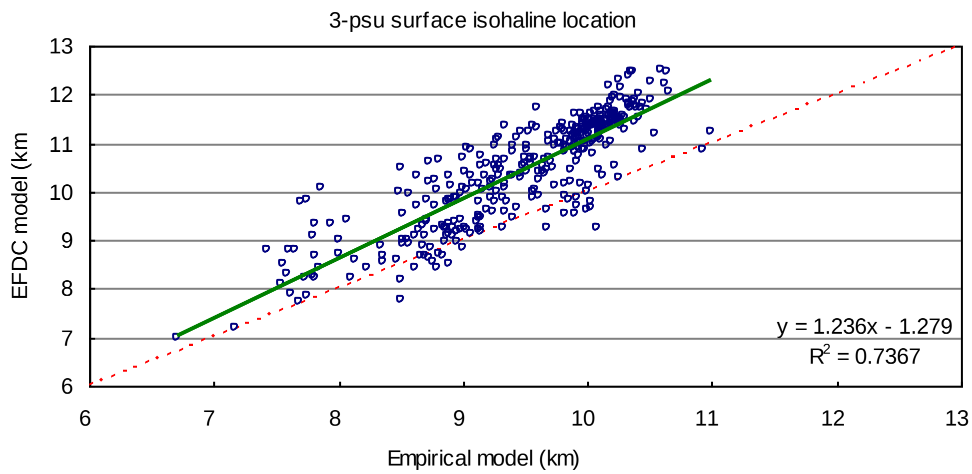

12 psu
Bottom Area (m2)
3,000,000
2,700,000
2,400,000
2,100,000
1,800,000
1,500,000
1,200,000
900,000
600,000
300,000
0
85
95
105
115
125
135
145
155
165
175
185
Total Spring Flow (cfs)
Empirical model
Hydrodynamic model

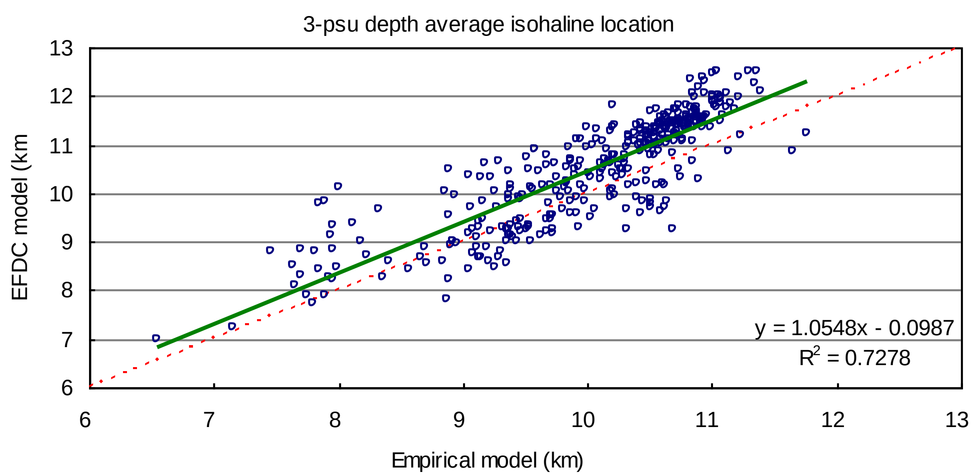

12 psu
Volume (m3)
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
85
95
105
115
125
135
145
155
165
175
185
Total Spring Flow (cfs)
Empirical model
Hydrodynamic model

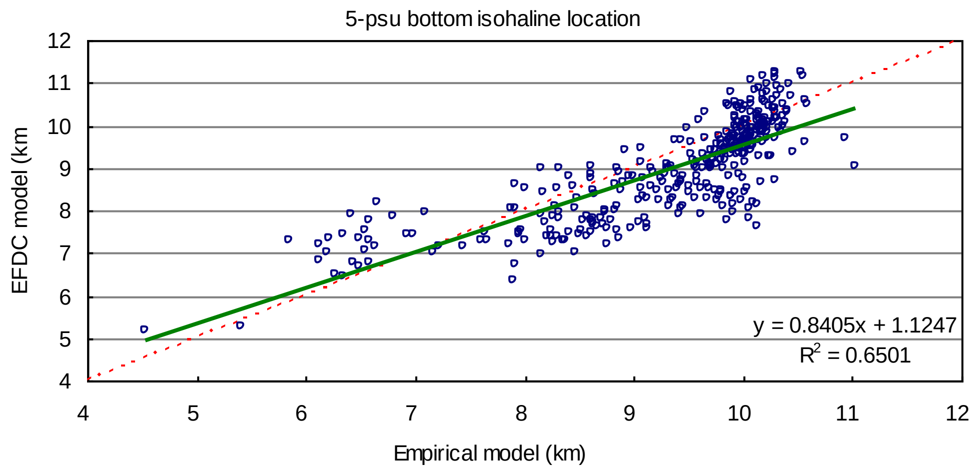
APPENDIX J-5

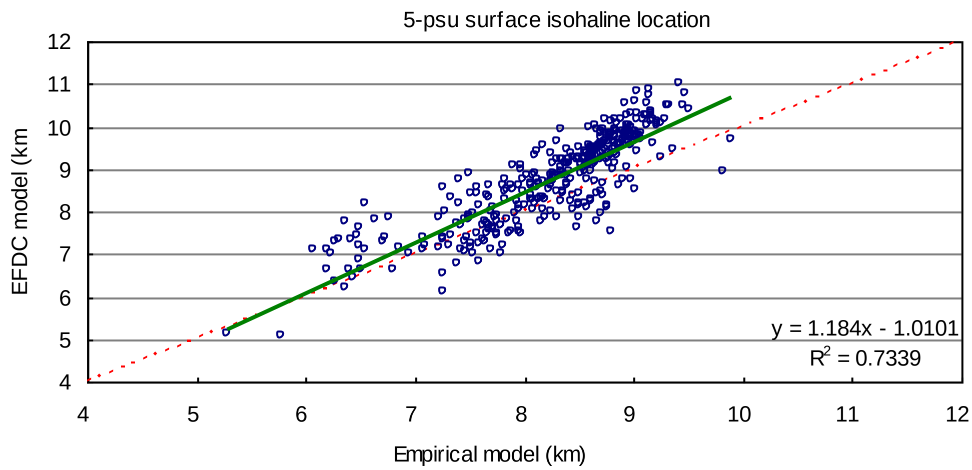
EMPERICAL MODEL VERSUS HYDRODYNAMIC MODEL

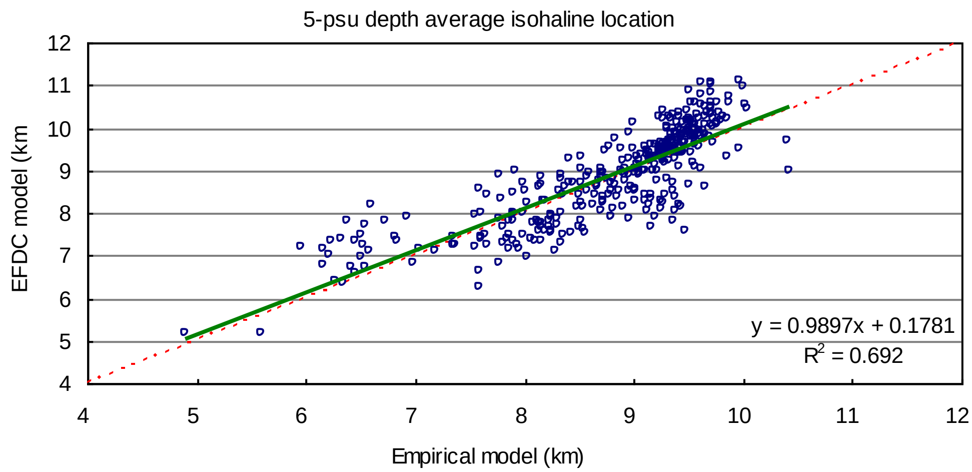

3-psu bottom isohaline location
EFDC model (km
Empirical model (km)
y = 0.9148x + 0.8512
R2 = 0.7127
6
7
8
9
10
11
12
13

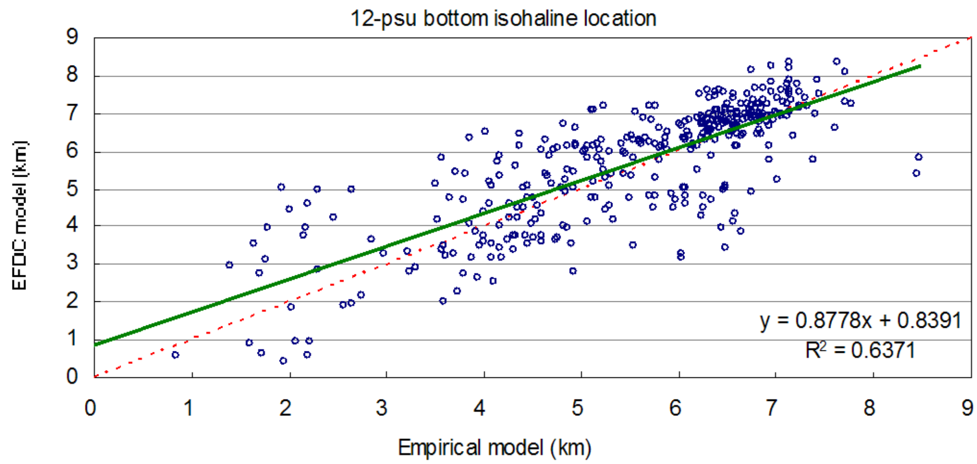

3-psu surface isohaline location
EFDC model (km
Empirical model (km)
y = 1.236x - 1.279
R2 = 0.7367
6
7
8
9
10
11
12
13


3-psu depth average isohaline location
EFDC model (km
Empirical model (km)
y = 1.0548x - 0.0987
R2 = 0.7278
6
7
8
9
10
11
12
13

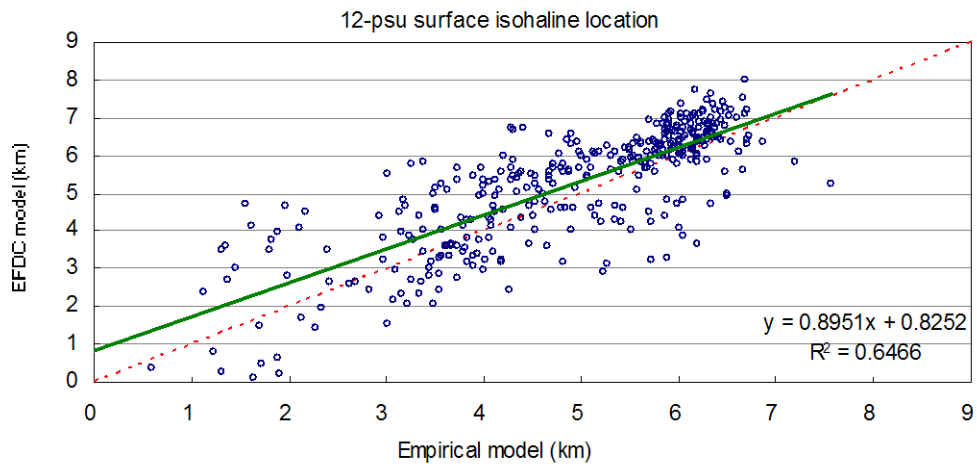

5-psu bottom isohaline location
EFDC model (km
Empirical model (km)
y = 0.8405x + 1.1247
R2 = 0.6501


5-psu surface isohaline location
EFDC model (km
Empirical model (km)
y = 1.184x - 1.0101
R2 = 0.7339

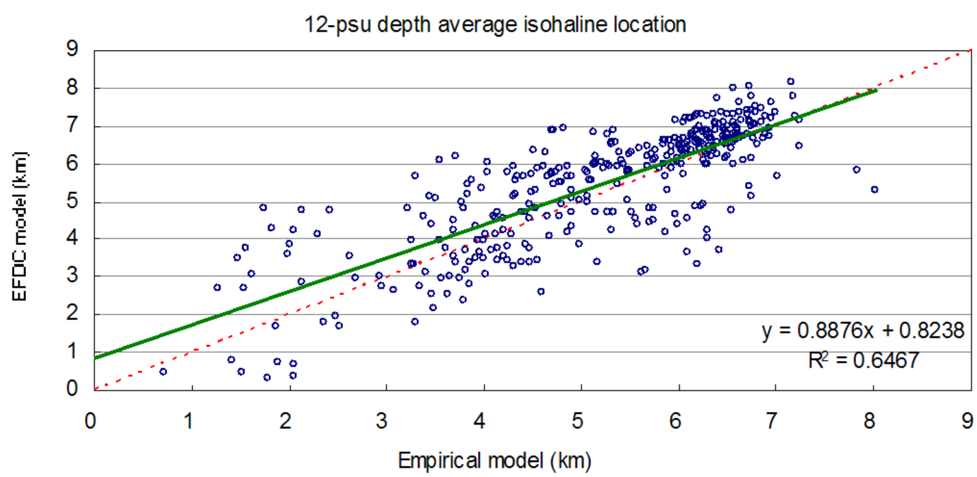

5-psu depth average isohaline location
EFDC model (km
Empirical model (km)
y = 0.9897x + 0.1781
R2 = 0.692



12-psu bottom isohaline location
EFDC model (km)
Empirical model (km)
y = 0.8778x + 0.8391
R² = 0.6371



12-psu surface isohaline location
EFDC model (km)
Empirical model (km)
y = 0.8951x + 0.8252
R² = 0.6466



12-psu depth average isohaline location
EFDC model (km)
Empirical model (km)
y = 0.8876x + 0.8238
R² = 0.6467