Appendix L
Model Configuration, Calibration and Validation

Basin: Cook Inlet (Cook)

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Watershed Background

The Cook Inlet watershed was selected as one of the 15 non-pilot application watersheds for the 20 Watershed study. Watershed modeling for the non-pilot areas was accomplished using the SWAT model only and model calibration and validation results are presented in abbreviated form.

Water Body Characteristics

The Cook Inlet stretches 180 miles (290 km) from the Gulf of Alaska to Anchorage in south-central Alaska. The watershed draining to Cook Inlet covers 47,000 square miles east of the Aleutian Range and south of the Alaska Range including the drainage area of Mount McKinley (Figure 1). The model area includes seven HUC8s within HUC 1902, encompassing about 22,200 mi^2 of the Cook Inlet watershed. The Cook Inlet watershed receives water from its tributaries the Kenai, the Susitna and Matanuska rivers from the melting snow and ice from Mount McKinley, the Chugach Mountains, and the Aleutian Range. Cook Inlet branches into the Knik Arm and Turnagain Arm at its northern end, almost surrounding Anchorage.

The watershed is dominated by igneous rocks in the mountains and by continental shelf and alluvial deposits in the lowlands. Glaciation has dramatically altered the landscape and glaciers are extensive on the southeastern and northwestern boundaries of the watershed. Five physiographic regions – grading from plains and lowlands to extremely high rugged mountains – are represented in the watershed. Altitude ranges from sea level to 20,320 ft at the highest point in North America, Mount McKinley. Rugged mountains surround Cook Inlet and include four active volcanoes on the western side of the inlet. Precipitation is closely associated with altitude and ranges from about 15 to more than 200 inches annually (USGS, 2008b).

Numerous river systems drain the watershed, including the Susitna, Matanuska, and Kenai Rivers. The largest river, the Susitna, drains about half of the watershed. Most rivers have relatively small drainages but yield large quantities of water because of substantial snowfall in the mountains. Many streams are fed by glaciers and have different physical characteristics than streams that do not have glacial contributions. Glacier-fed streams have periods of sustained high flow during summers and are more turbid than streams lacking glacial contributions. Numerous wetlands and lakes also influence the physical and chemical characteristics of streams by moderating peak flows and trapping sediment and nutrients.

Land cover in the model area is dominated by forests (24 percent), shrubland (38 percent), and barren land (19 percent). Glaciers cover 8 percent of the area, and lakes and wetlands cover another 10 percent. Less than 1 percent of the basin is used for agricultural purposes. The Municipality of Anchorage dominates the urban and residential features of the basin; however, the total urban and residential land cover is less than 1 percent of the basin. More than half of the state's population lives in the metropolitan Anchorage area. Expansion of suburban areas continues to the north of Anchorage and residential density is increasing throughout the municipality. The remainder of the basin is largely unpopulated; however, native villages exist at a number of locations.

Watersheds of the Cook Inlet basin are largely undeveloped and contain parts of four national parks totaling about 6,300 mi^2. Nearly 1,800 mi^2 of the Chugach National Forest and the 3,000 mi^2 Kenai National Wildlife Refuge also are within the boundaries of the watershed.

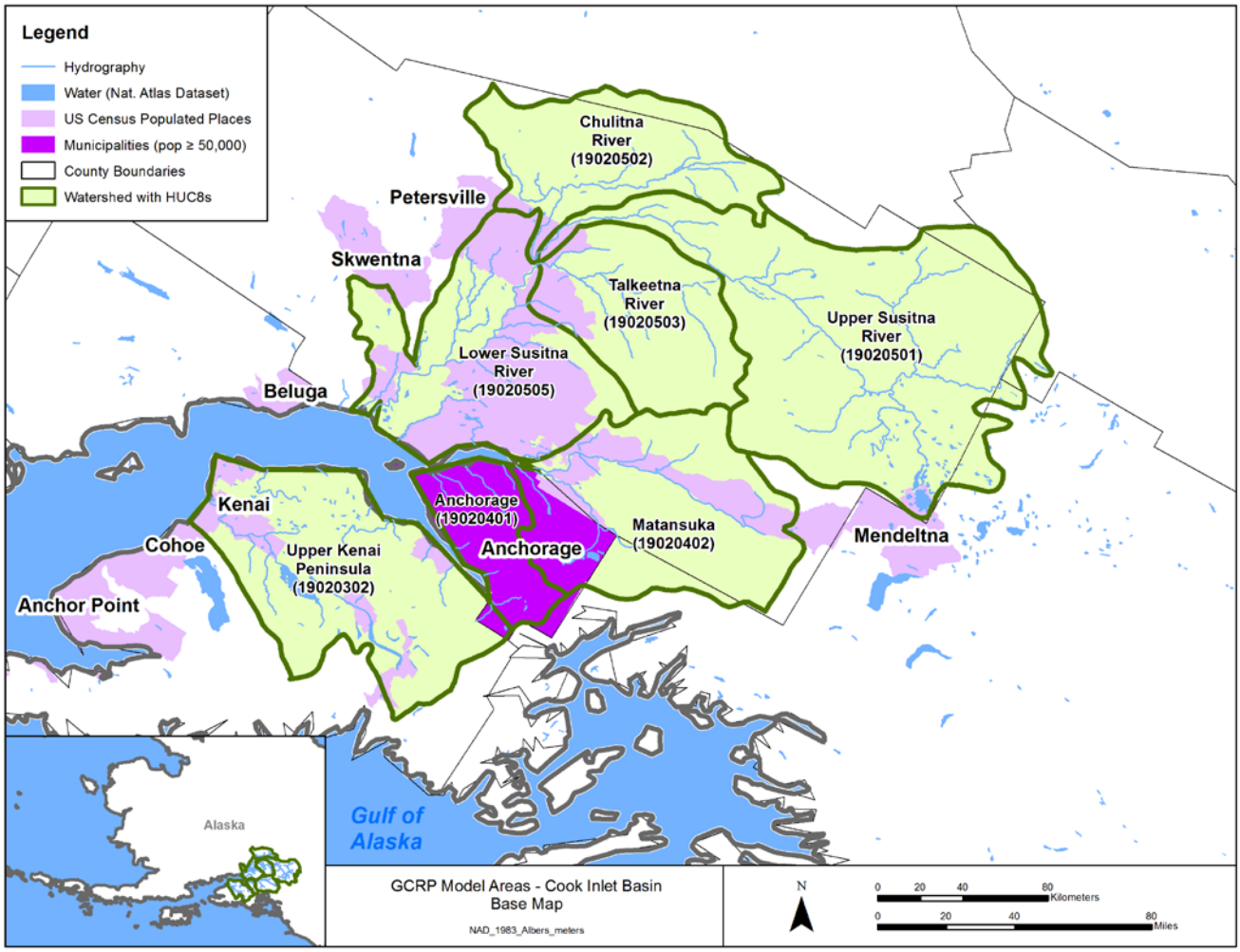

Figure 1. Location of the Cook Inlet watershed.

Soil Characteristics

Soils in the watershed, as described in STATSGO soil surveys, fall primarily into hydrologic soil groups (HSGs) B (moderately high infiltration capacity) and D (low infiltration capacity). SWAT uses information drawn directly from the soils data layer to populate the model.

Land Use Representation

Land use/cover in the watershed is based on the 2001 National Land Cover Database (NLCD) coverage and is predominantly rangeland (Figure 2). NLCD land cover classes were aggregated according to the scheme shown in Table 1 for representation in the 20 Watershed model. SWAT uses the built-in hydrologic response unit (HRU) overlay mechanism in the ArcSWAT interface. SWAT HRUs are formed from an intersection of land use and SSURGO major soils. The distribution of land use in the watershed is summarized in Table 2.

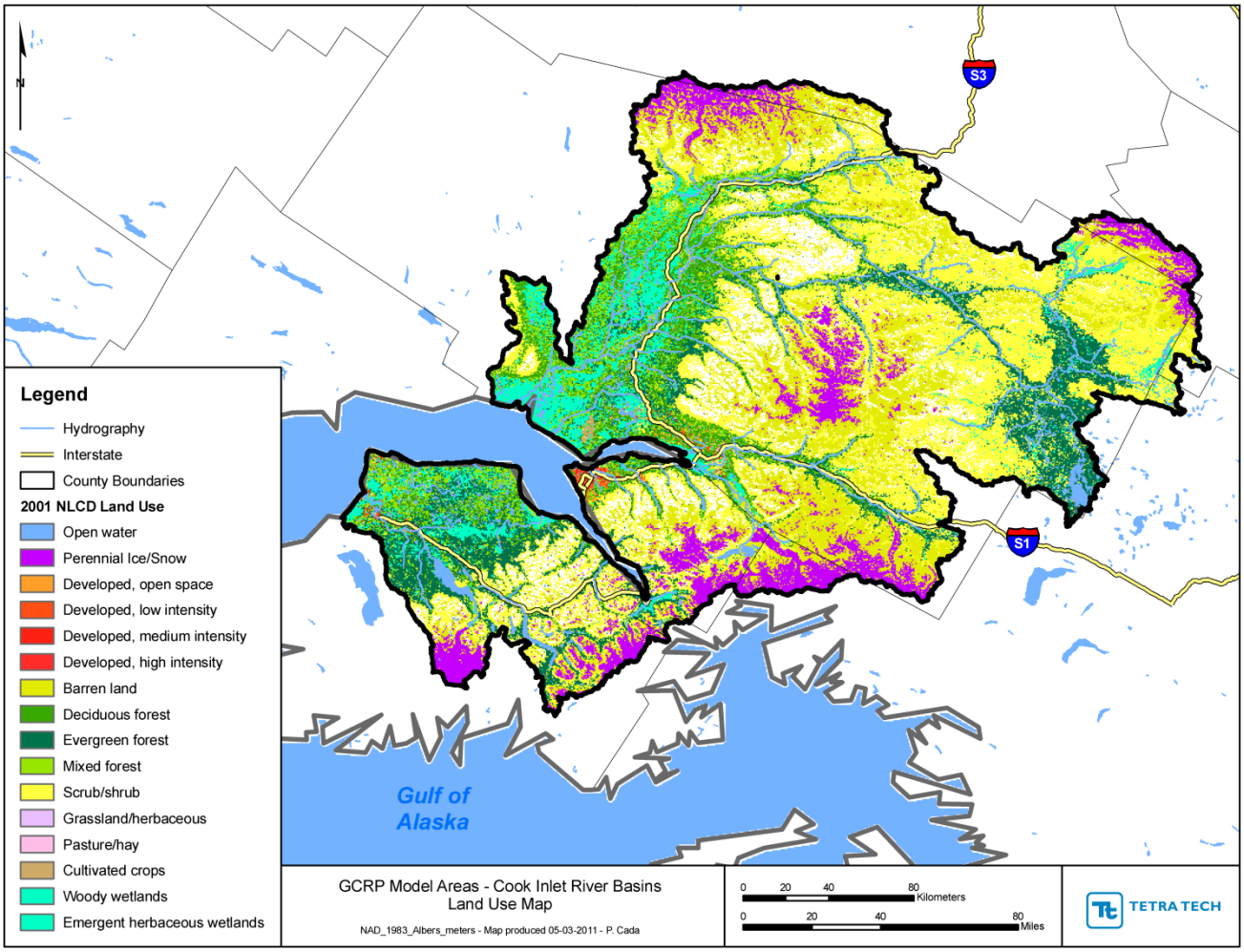

Figure 2. Land use in the Cook Inlet watershed.

Table 1. Aggregation of NLCD land cover classes

NLCD Class	Comments	SWAT class
11 Water	Water surface area usually accounted for as reach area	WATR
12 Perennial ice/snow		WATR
21 Developed open space		URLD
22 Dev. Low Intensity		URMD
23 Dev. Med. Intensity		URHD
24 Dev. High Intensity		UIDU
31 Barren Land		SWRN
41 Forest	Deciduous	FRSD
42 Forest	Evergreen	FRSE
43 Forest	Mixed	FRST
51-52 Shrubland		RNGB
71-74 Herbaceous Upland		RNGE
81 Pasture/Hay		HAY
82 Cultivated		AGRR
91-97 Wetland	Emergent & woody wetlands	WETF, WETL, WETN
98-99 Wetland	Aquatic bed wetlands (not emergent)	WATR

Table 2. Land use distribution for the Cook Inlet watershed (2001 NLCD) (mi^2)

HUC 8 watershed	Open water	Snow/Ice	Developed[a]				Barren land	Forest	Shrubland/ Herbaceous	Pasture/Hay	Cultivated	Wetland	Total
			Open space	Low density	Medium density	High density							
Upper Kenai Peninsula **19020302**	173.02	267.71	12.15	19.40	3.51	1.45	323.25	1,439.93	1,049.19	0.77	2.20	353.91	**3,646.48**
Anchorage **19020401**	8.44	115.51	20.60	35.73	15.43	6.13	161.42	202.26	430.64	0.67	0.67	32.80	**1,030.29**
Matansuka **19020402**	46.94	622.93	6.85	8.65	1.07	0.17	1,323.82	384.32	1,018.62	5.36	1.57	65.32	**3,485.63**
Upper Susitna River **19020501**	174.21	171.92	0.82	1.57	0.01	0.00	951.59	1,119.99	3,399.62	0.01	0.00	244.20	**6,063.93**
Chulitna River **19020502**	37.54	258.50	0.56	1.17	0.06	0.01	780.26	330.32	862.14	0.00	0.00	72.82	**2,343.37**
Talkeetna River **19020503**	16.67	258.25	0.76	0.21	0.03	0.01	492.99	384.80	1,141.99	0.80	0.43	28.20	**2,325.13**
Lower Susitna River **19020505**	110.38	17.59	21.47	22.71	2.17	0.36	186.08	1,499.68	555.86	2.69	19.16	890.55	**3,328.70**
Total	**567.20**	**1,712.40**	**63.21**	**89.44**	**22.26**	**8.13**	**4,219.40**	**5,361.30**	**8,458.06**	**10.30**	**24.02**	**1,687.80**	**22,223.53**

[a]The percent imperviousness applied to each of the developed land uses is as follows: open space (10.11%), low density (29.79%), medium density (61.48%), and high density (87.17%).

Point Sources

There are only two point source discharges in the watershed. Only the major dischargers, with a design flow greater than 1 MGD are included in the simulation (Table 3). The major dischargers are represented at long-term average flows, without accounting for changes over time or seasonal variations.

Table 3. Major point source discharges in the Cook Inlet watershed

NPID	NAME	Design Flow (MGD)	Observed Flow (MGD)
AK0022543	ANCHORAGE, MUNICIPALITY OF	2.5	1.843066667
AK0047856	ANCHORAGE, MUNICIPALITY OF	0.6	0.3767

The point sources were initially represented in the model with the median of reported values for TSS and an assumed total nitrogen concentration of 11.2 mg/L and assumed total phosphorus concentration of 7.0 mg/L for secondary treatment facilities (Tetra Tech 1999).

Meteorological Data

The required meteorological time series needed for the 20 Watershed SWAT simulations are precipitation and air temperature. The 20 Watershed simulations do not include water temperature simulation and use a degree-day method for snowmelt. SWAT estimates Penman-Monteith potential evapotranspiration using a statistical weather generator for inputs other than temperature and precipitation. These meteorological time series are drawn from the BASINS4 Meteorological Database (USEPA 2008), which provides a consistent, quality-assured set of nationwide data with gaps filled and records disaggregated. Scenario application requires simulation over 30 years, so the available stations are those with a common 30-year period of record (or one that can be filled from an approximately co-located station) that covers the year 2001. A total of 14 precipitation stations were identified for use in the Cook Inlet model with a common period of record of 10/1/1972-9/30/2002 (Table 4). Temperature records are sparser; where these are absent temperature was taken from nearby stations with an elevation correction.

Table 4. Precipitation stations for the Cook Inlet watershed model

ID	Name	Latitude	Longitude	Elevation	Temperature
500243	AK500243	60.9584	-149.1100	83	Yes
500280	AK500280	61.1954	-150.0030	40	Yes
500302	AK500302	61.6245	-149.3390	140	Yes
500707	AK500707	61.5678	-149.1380	46	Yes
501926	AK501926	62.8293	-149.8960	433	Yes
502144	AK502144	60.3925	-149.6660	154	Yes
503299	AK503299	61.1001	-149.6930	689	Yes
504546	AK504546	60.5798	-151.2390	28	Yes
505733	AK505733	61.5665	-149.2540	52	Yes
506870	AK506870	61.4222	-149.0990	67	Yes
508371	AK508371	60.1040	-149.4430	34	Yes
508594	AK508594	62.0303	-146.6920	701	Yes
508976	AK508976	62.3201	-150.0940	107	Yes
509790	AK509790	61.7067	-149.9970	82	Yes

Watershed Segmentation

The Cook Inlet watershed was divided into 116 subwatersheds for the purposes of modeling (Figure 3). The model encompasses the complete watershed and does not require specification of any upstream boundary conditions for application.

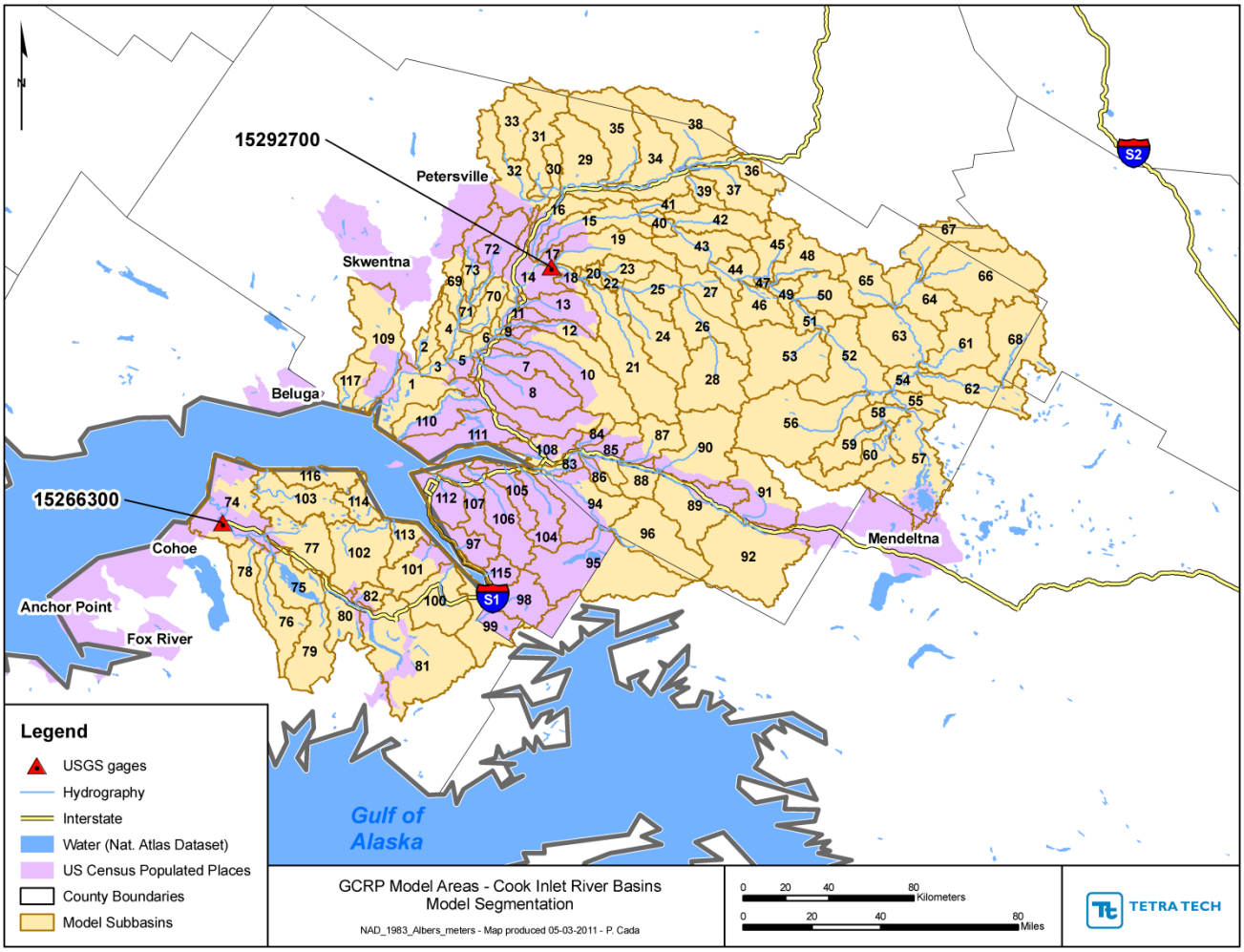

Figure 3. Model segmentation and USGS stations utilized for the Cook Inlet watershed.

Calibration Data and Locations

The specific site chosen for initial calibration was at the USGS station at the Kenai River at Soldotna, AK. Calibration and validation were pursued at two locations (Table 5).

Table 5. Calibration and validation locations in the Cook Inlet watershed

Station name	USGS ID	Drainage area (mi^2)	Hydrology calibration	Water quality calibration
Kenai River at Soldotna	15266300	1951	X	X
Talkeetna River near Talkeetna	15292700	1996	X	X

The model hydrology calibration period was set to Water Years 1992-2001 (within the 30-year period of record for modeling). Hydrologic validation was then performed on Water Years 1982-1991. Water quality calibration used calendar years 1985-2001, while validation used 1972-1984. However, there was some variation to this time period across the monitoring stations depending on the availability of monitored data.

SWAT Modeling

Assumptions

Two major reservoirs occur in the Cook Inlet watershed. Pertinent reservoir information including surface area and storage at principal (normal) and emergency spillway levels for the reservoirs modeled were obtained from the National Inventory of Dams (NID) database. The SWAT model provides four options to simulate reservoir outflow: measured daily outflow, measured monthly outflow, average annual release rate for uncontrolled reservoir, and controlled outflow with target release. Keeping in view the 20 Watershed climate change impact evaluation application, it was assumed that the best representation of the reservoirs was to simulate them without supplying time series of outflow records. Therefore, the target release approach was used in the GCRP-SWAT model.

Elevation bands were also created in the subwatersheds where elevation was above 500 m to account for the impact of higher elevation. Additionally, regions of permafrost were identified within the watershed and were accounted for by adding initial snow water content in the elevation bands.

Hydrology Calibration

A spatial calibration approach was adopted for GCRP-SWAT modeling for the Cook Inlet watershed; however, adjustments to specific subwatersheds were kept as minimal as possible. Moreover, a systematic adjustment of parameters was adopted and some adjustments were applied throughout the watershed. Most of the calibration efforts were geared toward getting a closer match between simulated and observed flows at one of the USGS gaging stations in the watershed.

Land Use/Soil/Slope Definition

A 5/10/5 percent threshold was used for land use/soil/slope in the SWAT model while defining the HRUs. Urban land use classes were exempted from the HRU overlay thresholds.

The parameters were adjusted within the practical range at the calibration focus area to obtain reasonable fit between the simulated and measured flows in terms of Nash-Sutcliffe modeling efficiency and the high flow and low flow components as well as the seasonal flows.

The water balance of the whole Cook Inlet watershed predicted by the SWAT model over the 30-year simulation period is as follows:

```
PRECIP =    653.3 MM
SNOW FALL =  351.55 MM
SNOW MELT =   544.51 MM
SUBLIMATION =    54.10 MM
SURFACE RUNOFF Q =    99.35 MM
LATERAL SOIL Q =  310.36 MM
TILE Q =     0.00 MM
GROUNDWATER (SHAL AQ) Q =   225.36 MM
REVAP (SHAL AQ => SOIL/PLANTS) =    6.71 MM
DEEP AQ RECHARGE =    26.93 MM
TOTAL AQ RECHARGE =  269.25 MM
TOTAL WATER YLD =   634.47 MM
```

```
PERCOLATION OUT OF SOIL =  269.04 MM
ET =    187.1 MM
PET =    405.8MM
TRANSMISSION LOSSES =     0.60 MM
```

Hydrologic calibration adjustments focused on the following parameters:

- Snow parameters SMTMP, SMFMX, SMFMN, TIMP
- Sol_AWC (available water capacity of the soil layer, mm water/mm of soil)
- Baseflow factor
- GW_DELAY (groundwater delay time)
- GWQMN (threshold depth of water in the shallow aquifer required for return flow to occur)
- SHALLST (Initial depth of water in the shallow aquifer)
- RevapMN (threshold depth of water in the shallow aquifer required for "revap" or percolation to the deep aquifer to occur
- Rchrg_DP
- CH_K2 (channel hydraulic conductivity)
- NDTarg
- Curve Number
- Temperature Lapse Rate
- Precipitation Lapse Rate

Calibration results for the Cook Inlet at Kenai River near Soldotna are summarized in the following Figures 4 through 7 and Table 6. In general, the model captured the timing of the peaks well but tends to underestimate both the high flows and the base flows resulting in overall underestimation of total volume by 18 percent (Figure 4, and Table 6).

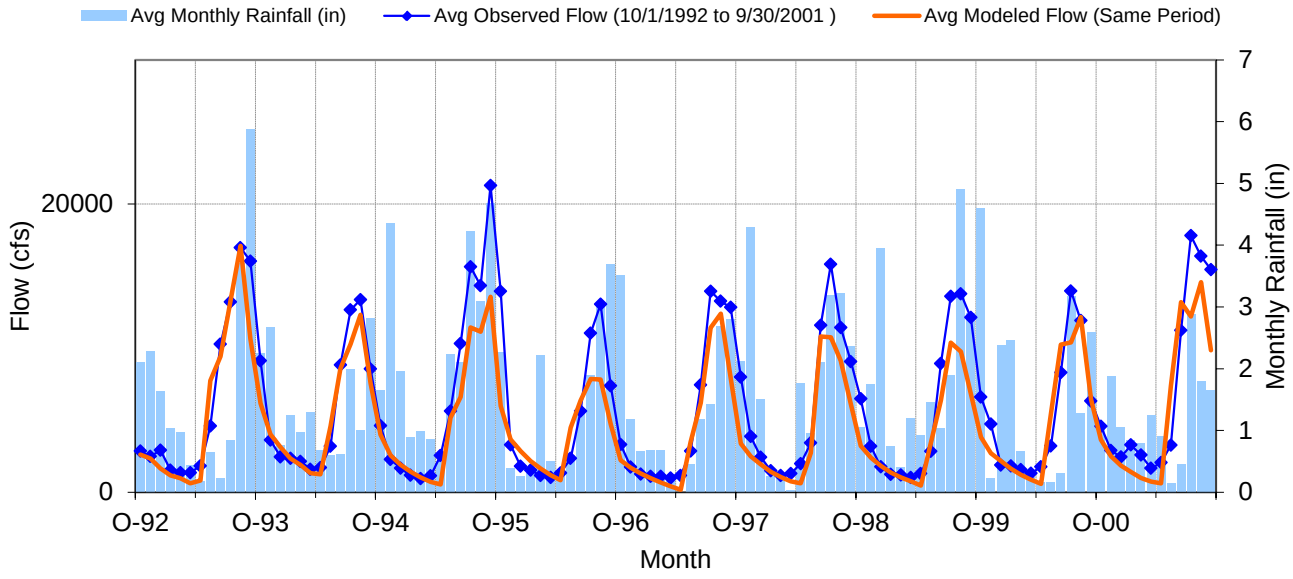

Figure 4. Mean monthly flow at USGS 15266300 Kenai River at Soldotna, AK - calibration period.

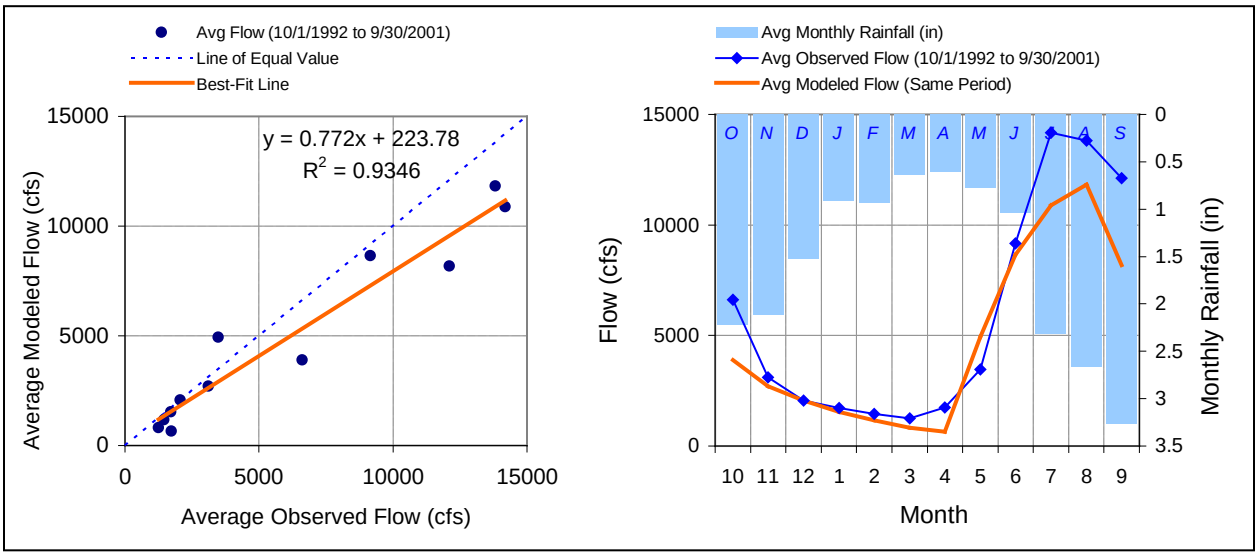

Figure 5. Seasonal regression and temporal aggregate at USGS 15266300 Kenai River at Soldotna, AK - calibration period.

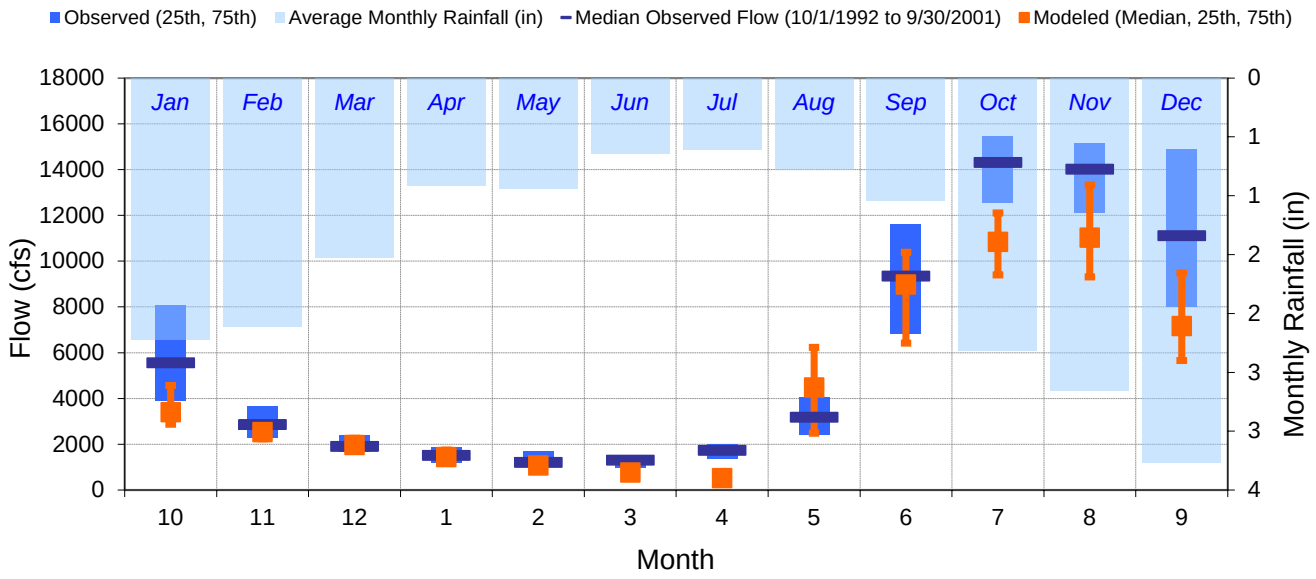

Figure 6. Seasonal medians and ranges at USGS 15266300 Kenai River at Soldotna, AK - calibration period.

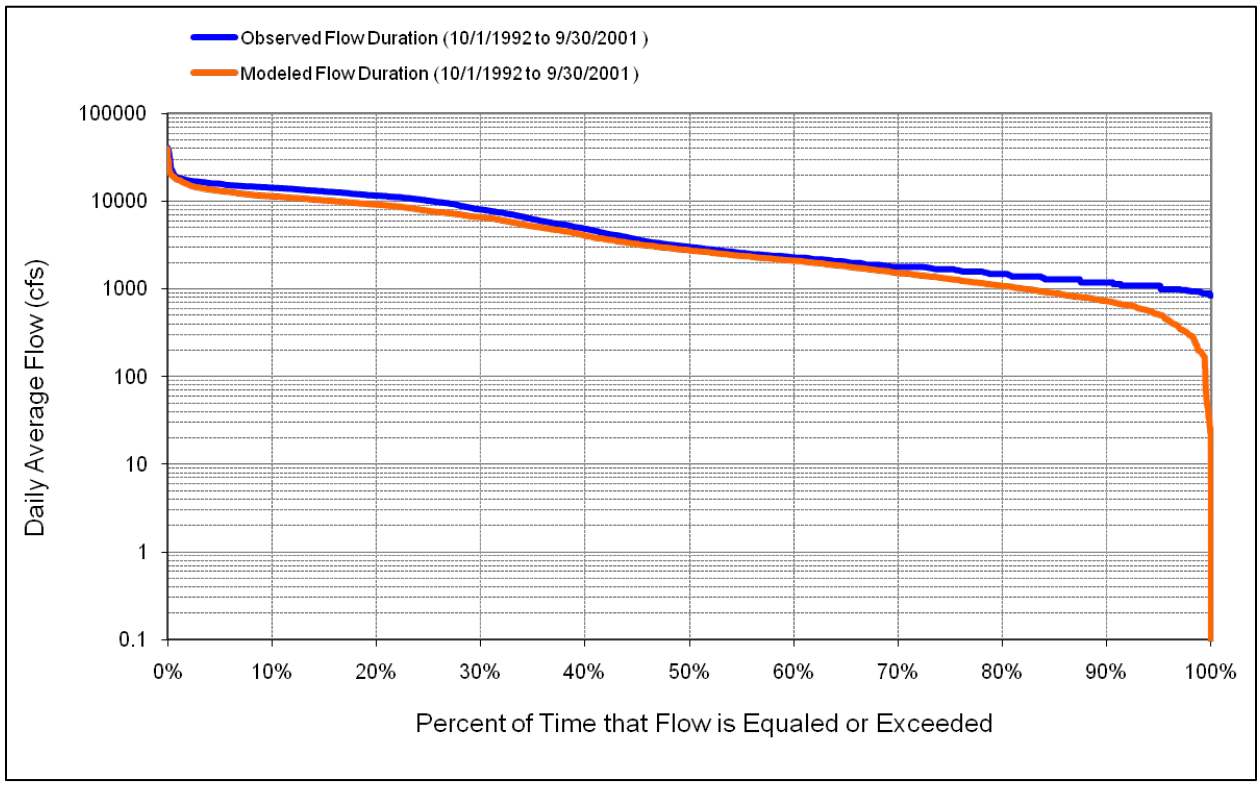

Figure 4. Flow exceedance at USGS 15266300 Kenai River at Soldotna, AK - calibration period.

Table 6. Summary statistics at USGS 15266300 Kenai River at Soldotna, AK - calibration period

SWAT Simulated Flow		Observed Flow Gage	
REACH OUTFLOW FROM OUTLET 74 9-Year Analysis Period: 10/1/1992 - 9/30/2001 Flow volumes are (inches/year) for upstream drainage area		USGS 15266300 Kenai R at Soldotna, AK Hydrologic Unit Code:19020302 Latitude: 60.4775 Longitude: -151.0738 Drainage Area (sq-mi): 1951	
Total Simulated In-stream Flow:	**21.27**	Total Observed In-stream Flow:	**26.24**
Total of simulated highest 10% flows:	**6.31**	Total of Observed highest 10% flows:	**7.52**
Total of Simulated lowest 50% flows:	**3.07**	Total of Observed Lowest 50% flows:	**3.87**
Simulated Summer Flow Volume (months 7-9):	**11.52**	Observed Summer Flow Volume (7-9):	**14.95**
Simulated Fall Flow Volume (months 10-12):	**3.22**	Observed Fall Flow Volume (10-12):	**4.40**
Simulated Winter Flow Volume (months 1-3):	**1.29**	Observed Winter Flow Volume (1-3):	**1.62**
Simulated Spring Flow Volume (months 4-6):	**5.24**	Observed Spring Flow Volume (4-6):	**5.28**
Total Simulated Storm Volume:	**3.41**	Total Observed Storm Volume:	**2.29**
Simulated Summer Storm Volume (7-9):	**1.85**	Observed Summer Storm Volume (7-9):	**1.22**
Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*	
Error in total volume:	**-18.96**	**10**	
Error in 50% lowest flows:	**-20.69**	**10**	
Error in 10% highest flows:	**-16.10**	**15**	
Seasonal volume error - Summer:	-22.93	30	
Seasonal volume error - Fall:	-26.68	30	
Seasonal volume error - Winter:	-20.76	30	
Seasonal volume error - Spring:	-0.72	30	
Error in storm volumes:	**48.87**	**20**	
Error in summer storm volumes:	**51.66**	**50**	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.684	Model accuracy increases as E or E' approaches 1.0	
Baseline adjusted coefficient (Garrick), E':	0.592		
Monthly NSE	0.800		

Hydrology Validation

Hydrology validation for the Cook Inlet was performed for the period 10/1/1983 through 9/30/1992. Results are presented in Figures 8 through 11 and Table 7. The validation achieves a high coefficient of model fit efficiency, but is over predicted on 50 percent low volume, fall and winter volume and thereby the total flow is also overpredicted (Figure 5, Table 7).

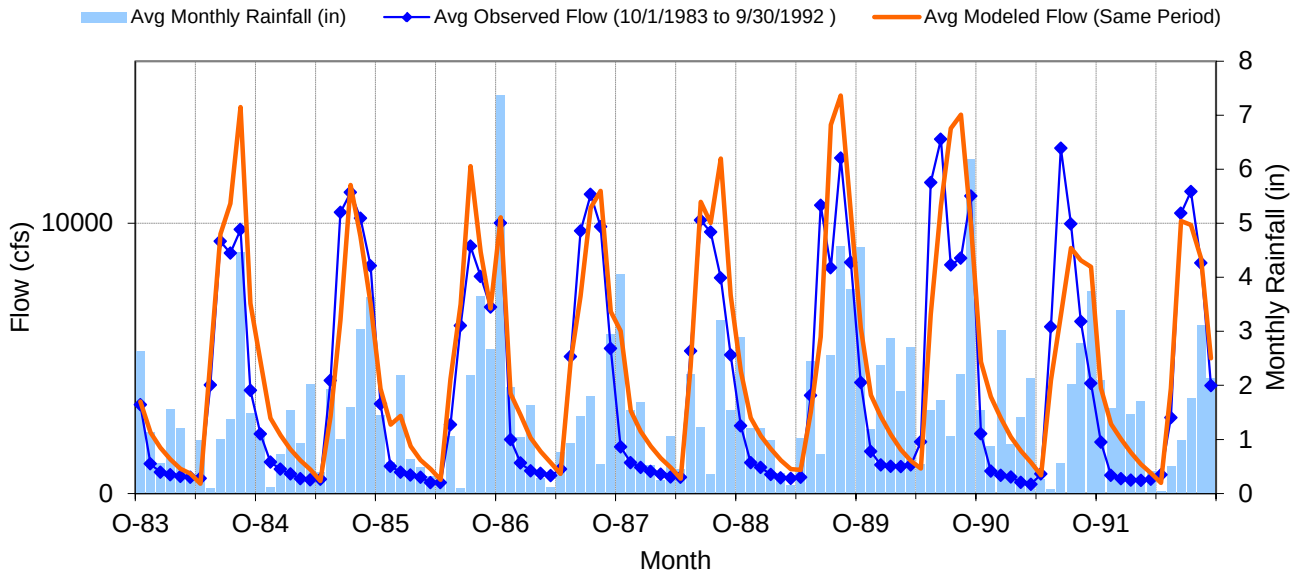

Figure 8. Mean monthly flow at USGS 15266300 Kenai River at Soldotna, AK - validation period.

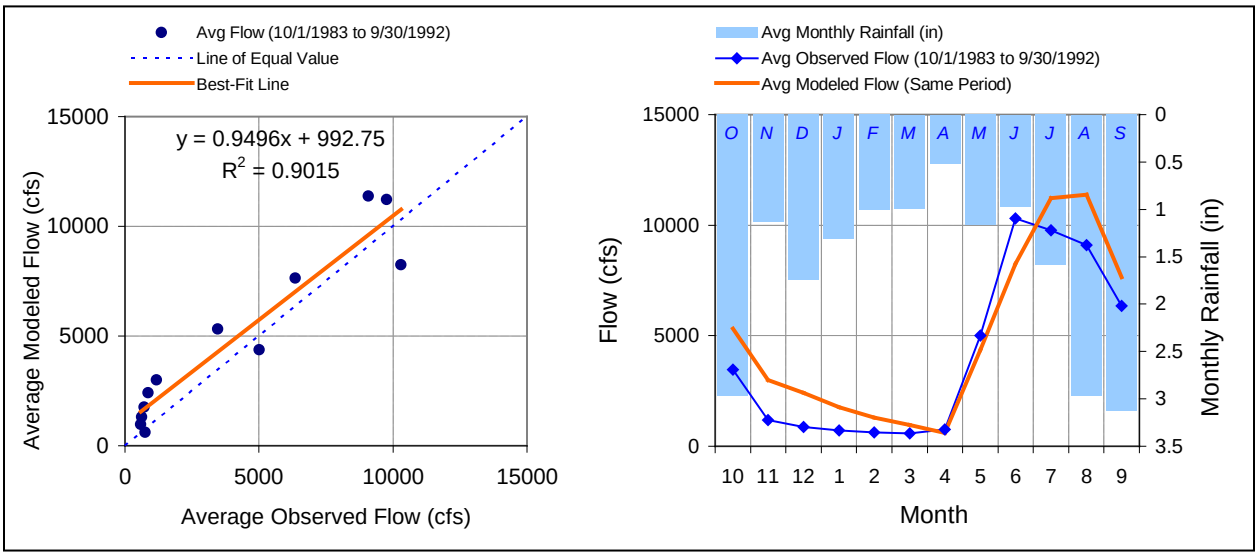

Figure 9. Seasonal regression and temporal aggregate at USGS 15266300 Kenai River At Soldotna, AK - validation period.

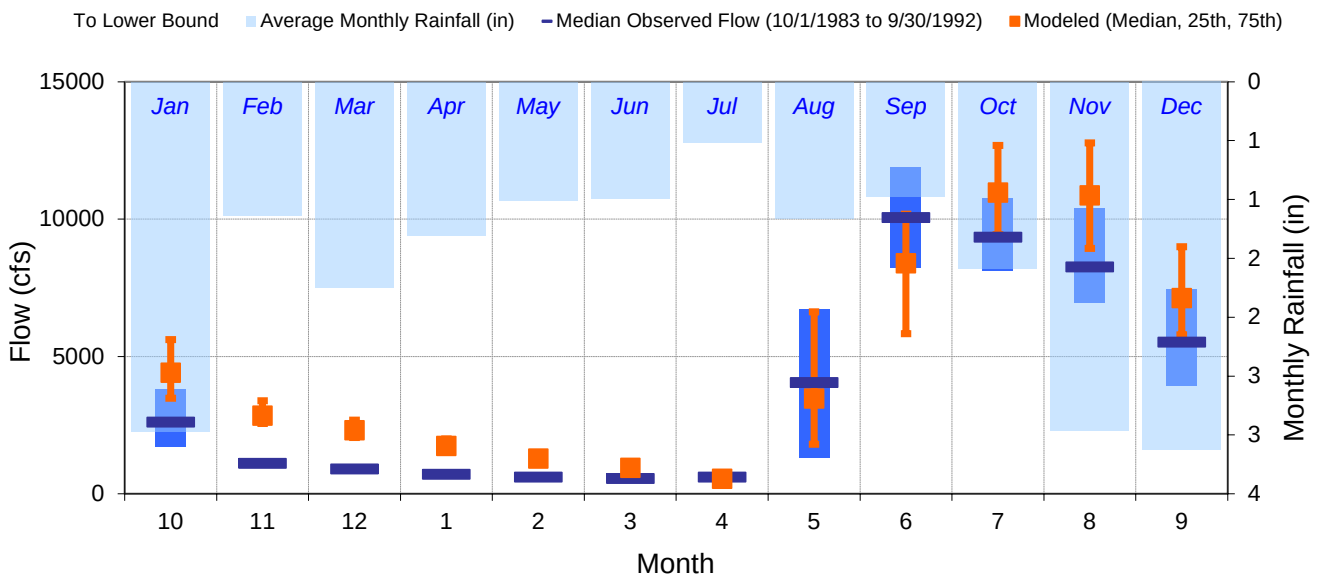

Figure 10. Seasonal medians and ranges at USGS 15266300 Kenai River at Soldotna, AK - validation period.

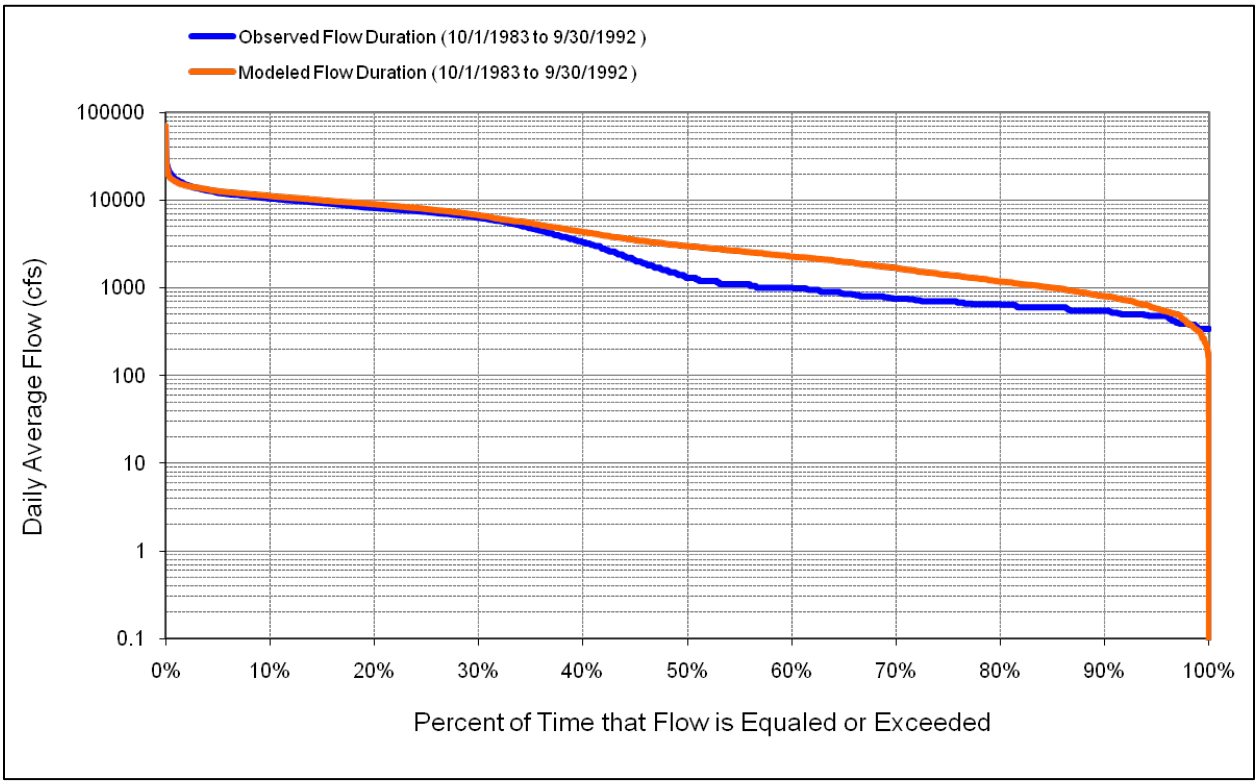

Figure 5. Flow exceedance at USGS 15266300 Kenai River at Soldotna, AK - validation period.

Table 7. Summary statistics at USGS 15266300 Kenai River at Soldotna, AK - validation period

SWAT Simulated Flow		Observed Flow Gage	
REACH OUTFLOW FROM OUTLET 74		USGS 15266300 Kenai R at Soldotna, AK	
9-Year Analysis Period: 10/1/1983 - 9/30/1992 Flow volumes are (inches/year) for upstream drainage area		Hydrologic Unit Code:19020302 Latitude: 60.4775 Longitude: -151.0738 Drainage Area (sq-mi): 1951	
Total Simulated In-stream Flow:	**21.61**	Total Observed In-stream Flow:	**18.08**
Total of simulated highest 10% flows:	**6.15**	Total of Observed highest 10% flows:	**6.01**
Total of Simulated lowest 50% flows:	**3.40**	Total of Observed Lowest 50% flows:	**1.64**
Simulated Summer Flow Volume (months 7-9):	**11.28**	Observed Summer Flow Volume (7-9):	**9.41**
Simulated Fall Flow Volume (months 10-12):	**3.99**	Observed Fall Flow Volume (10-12):	**2.06**
Simulated Winter Flow Volume (months 1-3):	**1.47**	Observed Winter Flow Volume (1-3):	**0.71**
Simulated Spring Flow Volume (months 4-6):	**4.87**	Observed Spring Flow Volume (4-6):	**5.91**
Total Simulated Storm Volume:	**3.57**	Total Observed Storm Volume:	**3.37**
Simulated Summer Storm Volume (7-9):	**1.81**	Observed Summer Storm Volume (7-9):	**1.77**
Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*	
Error in total volume:	**19.49**	**10**	
Error in 50% lowest flows:	**106.86**	**10**	
Error in 10% highest flows:	2.31	15	
Seasonal volume error - Summer:	19.94	30	
Seasonal volume error - Fall:	**94.13** >>	**30**	Clear
Seasonal volume error - Winter:	**107.45**	**30**	
Seasonal volume error - Spring:	-17.71	30	
Error in storm volumes:	6.05	20	
Error in summer storm volumes:	2.50	50	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.554	Model accuracy increases	
Baseline adjusted coefficient (Garrick), E':	0.487	as E or E' approaches 1.0	
Monthly NSE	0.749		

Hydrology Results for Larger Watershed

As described above, parameters determined for the Soldotna gage were fully transferable to other gages in the watershed. In addition, calibration and validation was pursued at 2 gages in the watershed. Calibration results were acceptable at both gages (Table 8). Results of the validation exercise are summarized in Table 9.

Table 8. Summary statistics (percent error): all stations - calibration period

Station	USGS 15266300 Kenai R at Soldotna, AK	USGS 152927000 Talkeetna R nr Talkeetna, AK
Error in total volume:	-18.96	-18.84
Error in 50% lowest flows:	-20.69	-38.31
Error in 10% highest flows:	-16.10	16.27
Seasonal volume error - Summer:	-22.93	-25.08
Seasonal volume error - Fall:	-26.68	-54.40
Seasonal volume error - Winter:	-20.76	-31.58
Seasonal volume error - Spring:	-0.72	1.23
Error in storm volumes:	48.87	146.88
Error in summer storm volumes:	51.66	125.74
Daily Nash-Sutcliffe Coefficient of Efficiency, E:	0.684	0.240
Baseline adjusted coefficient (Garrick), E':	0.592	0.427
Monthly Nash-Sutcliffe Coefficient of Efficiency, E:	0.800	0.762

Table 9. Summary statistics: all stations - validation period

Station	USGS 15266300 Kenai R at Soldotna, AK	USGS 152927000 Talkeetna R nr Talkeetna, AK
Error in total volume:	19.49	2.40
Error in 50% lowest flows:	106.86	-9.55
Error in 10% highest flows:	2.31	35.16
Seasonal volume error - Summer:	19.94	2.03
Seasonal volume error - Fall:	94.13	-39.48
Seasonal volume error - Winter:	107.45	-9.75
Seasonal volume error - Spring:	-17.71	25.47
Error in storm volumes:	6.05	143.61
Error in summer storm volumes:	2.50	137.59
Daily Nash-Sutcliffe Coefficient of Efficiency, E:	0.554	0.174
Baseline adjusted coefficient (Garrick), E':	0.487	0.431
Monthly Nash-Sutcliffe Coefficient of Efficiency, E:	0.749	0.739

Water Quality Calibration and Validation

Initial calibration and validation of water quality was done on Cook Inlet at USGS 152927000 Talkeetna River near Talkeetna, AK, using 1985-2001 for calibration and 1972-1984 for validation. As with hydrology, calibration was performed on the later period as this better reflects the land use included in the model. The start of the validation period is constrained by data availability.

Calibration adjustments for sediment focused on the following parameters:

- SPCON (Linear parameters for estimating maximum amount of sediment that can be re-entrained during channel sediment routing)
- CH_COV (Channel cover factor)
- CH_EROD (Channel erodibility factor)

Simulated and estimated sediment loads at the USGS 152927000 Talkeetna River station for both the calibration and validation periods are shown in Figure 6 and statistics for the two periods are provided separately in Table 10. The key statistic in Table 10 is the relative percent error, which shows the error in the prediction of monthly load normalized to the estimated load. Table 10 also shows the relative average absolute error, which is the average of the relative magnitude of errors in individual monthly load predictions. This number is inflated by outlier months in which the simulated and estimated loads differ by large amounts (which may be as easily due to uncertainty in the estimated load due to limited data as to problems with the model) and the third statistic, the relative median absolute error, is likely more relevant and shows better agreement.

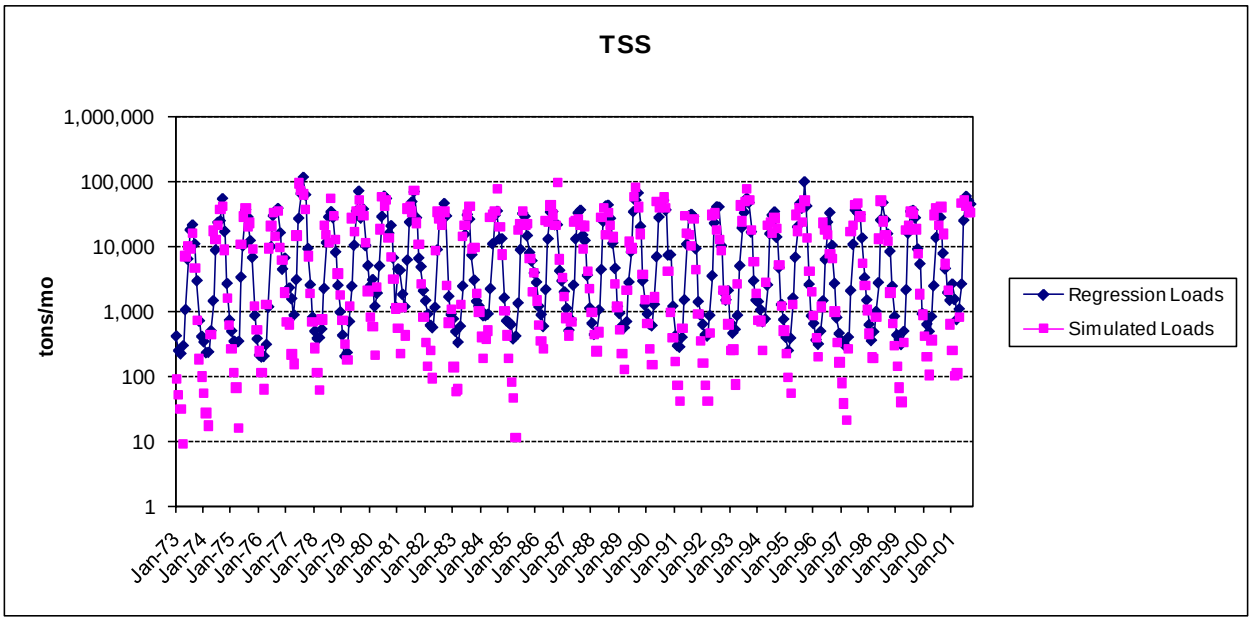

Figure 6. Fit for monthly load of TSS at USGS 152927000 Talkeetna River near Talkeetna, AK.

Table 10. Model fit statistics (observed minus predicted) for monthly sediment loads using stratified regression at USGS 152927000 Talkeetna River near Talkeetna, AK

Statistic	Calibration period (1985-2001)	Validation period (1972-1984)
Relative Percent Error	66.4%	64.1%
Relative Average Absolute Error	69%	68%
Relative Median Absolute Error	3.4%	3.1%

Calibration adjustments for total phosphorus and total nitrogen focused on the following parameters:

- PHOSKD (phosphorus soil partitioning coefficient)
- RS2
- RS3
- RS4
- RS5
- BC1, BC2 and BC4
- MUMAX

Results for the phosphorus simulation are shown in Figure 7 and Table 11. Results for the nitrogen simulation are shown in Figure 8 and Table 12. The model fit is generally acceptable.

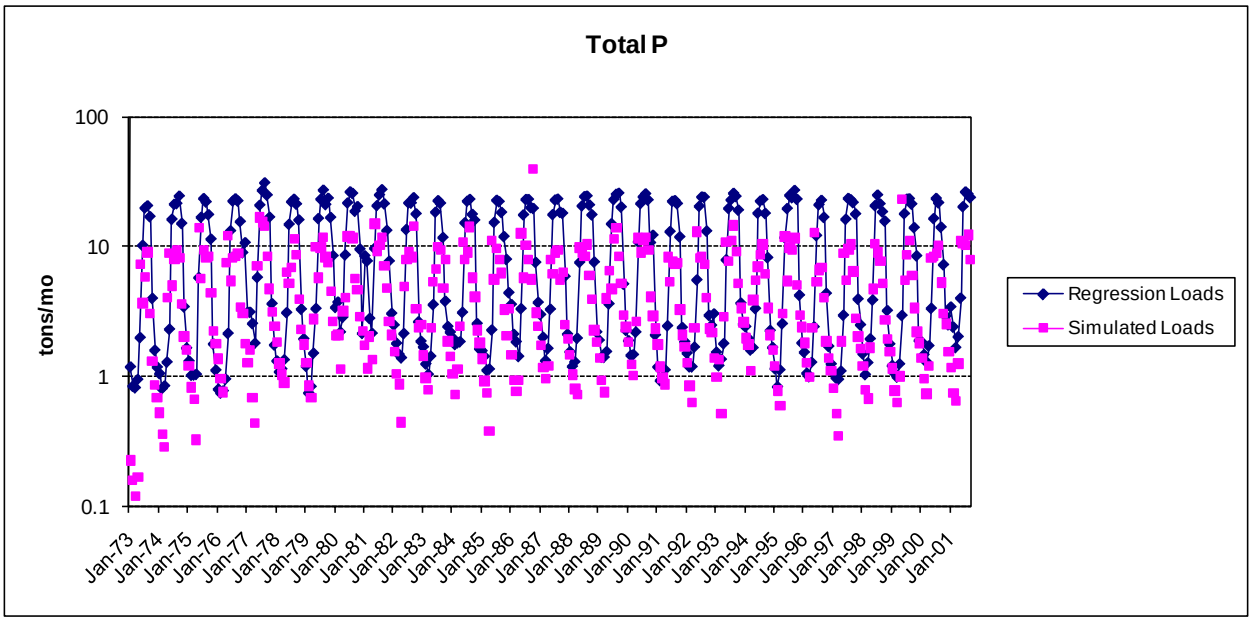

Figure 7. Fit for monthly load of total phosphorus at USGS 152927000 Talkeetna River near Talkeetna, AK.

Table 11. Model fit statistics (observed minus predicted) for monthly phosphorus loads using stratified regression at USGS 152927000 Talkeetna River near Talkeetna, AK

Statistic	Calibration period (1985-2001)	Validation period (1972-1984)
Relative Percent Error	83.2%	82.18%
Average Absolute Error	86%	88%
Median Absolute Error	8%	8.2%

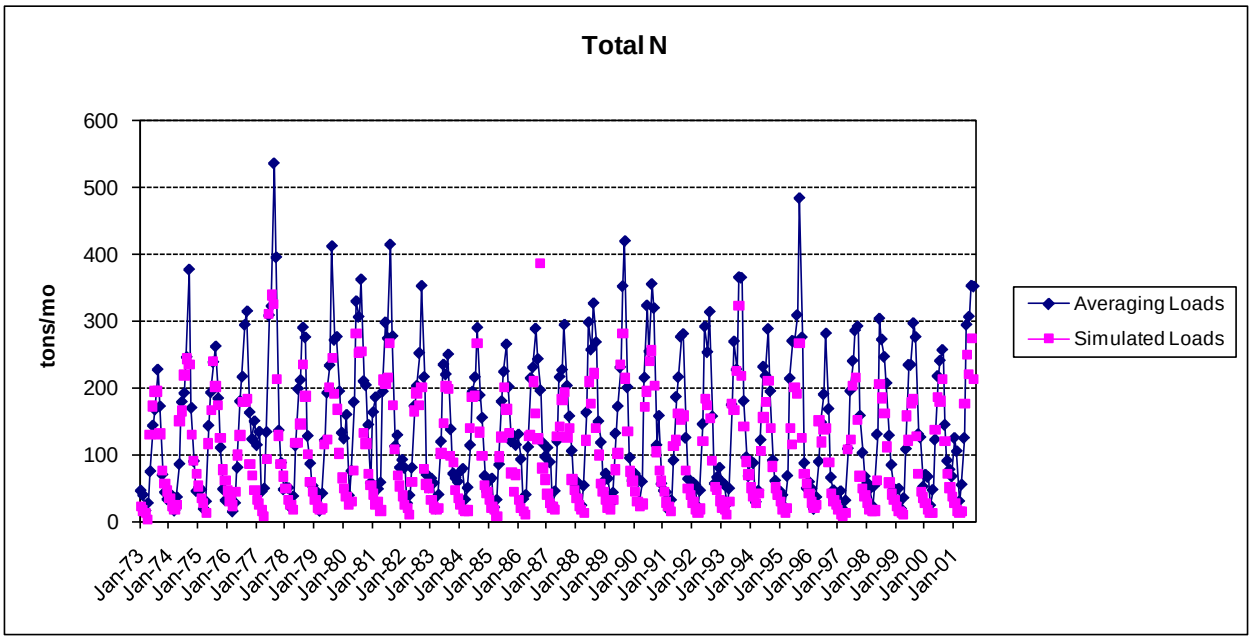

Figure 8. Fit for monthly load of total nitrogen at USGS 152927000 Talkeetna River near Talkeetna, AK.

Table 12. Model fit statistics (observed minus predicted) for monthly total nitrogen loads using averaging estimator at USGS 152927000 Talkeetna River near Talkeetna, AK

Statistic	Calibration period (1985-2001)	Validation period (1972-1984)
Relative Percent Error	57.3%	50.4%
Average Absolute Error	59%	51%
Median Absolute Error	22.1%	18.7%

Water Quality Results for Larger Watershed

As with hydrology, the SWAT model parameters used to calibrate at the Talkeetna River (USGS 152927000) station for water quality were directly transferred to other portions of the watershed. Application of the SWAT model without spatial adjustments resulted in relatively large errors in predicting loads and concentrations at some stations. Summary statistics for the SWAT water quality calibration and validation at other stations in the watershed are provided in Table 13 and Table 14.

Table 13. Summary statistics for water quality at all stations – calibration period 1985-2001

Station	USGS 15266300 Kenai R at Soldotna, AK	USGS 152927000 Talkeetna R nr Talkeetna, AK
Relative Percent Error TSS Load	-14.3%	66.4%
Relative Percent Error TP Load	49.8%	83.2%
Relative Percent Error TN Load	34.4%	57.3%

Table 14. Summary statistics for water quality at all stations – validation period 1971-1984

Station	USGS 15266300 Kenai R at Soldotna, AK	USGS 152927000 Talkeetna R nr Talkeetna, AK
Relative Percent Error TSS Load	-14.7%	64.1%
Relative Percent Error TP Load	50.24%	82.18%
Relative Percent Error TN Load	28.9%	50.4%

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