APPENDIX IX

URS/ENTRIX Response to Coastal & Hydraulics Laboratory Review of

“HYDROLOGY AND HYDRAULIC ENVIRONMENT OF KNIK ARM”

TABLE OF CONTENTS

LIST OF TABLES

LIST OF NEW FIGURES

LIST OF REVISED FIGURES

LIST OF ATTACHMENTS

1 INTRODUCTION

The report, "Hydrology and Hydraulic Environment of Knik Arm" (HHEKA), was prepared by HDR Alaska and URS Corporation in November 2005 to address potential effects of the proposed Knik Arm Crossing (KAC) on the hydrodynamic and sedimentation environment in Knik Arm. Appendix III of the HHEKA described the modeling performed by URS to analyze the large-scale hydrodynamic and sedimentation effects of KAC. Six additional appendices provided details of field data collection and other analytical studies that supported HHEKA.

At the request of the USACE Alaska District, the HHEKA, and especially Appendix III, were reviewed by the Coastal Hydraulics Laboratory (CHL) of the U. S. Army Engineer Research and Development Center (ERDC), located in Vicksburg, MS. CHL provided a draft document with their comments on May 18, 2006, which has been included as Appendix VIII in this revision of HHEKA. Additional comments were received from CHL during a meeting in Vicksburg on July 26 and 27, 2006, with representatives of CHL, Alaska District, and URS in attendance.

This document describes the additional modeling that was performed by URS to address comments received from CHL in their written review and during the July 26-27 meeting. A summary of *all* CHL comments and URS responses is provided in Section 2. Comments, or comment categories, that required more detailed responses are addressed by topic in subsequent sections.

Two sets of figures accompany this report. The first set, called "New Figures," presents graphical depictions of the steps taken to calibrate and verify the model's operation with its revised seaward boundary, relocated some 22 km west of the original boundary. Also included in New Figures are detailed evaluations of hydrodynamic and sedimentation effects of KAC on the Port of Anchorage with a finer grid (15 m) than was used in the original modeling (45 m), as well as a comparison of the model's predicted sedimentation rates to some observed in conjunction with the Alaska District's Port dredging project. New figures have been numbered sequentially and have been placed at the end of the narrative portion of this report.

The second set of figures, called "Revised Figures," shows results of repeating many of the original evaluations of hydrodynamic effects of the proposed KAC. To aid comparison of the original (HHEKA, App. III) and revised (i.e. this report) modeling results, figures from the latter have the same numbers as their counterparts in Appendix III, but with the addition of "v2" added to the figure number. Revised Figures follow the New Figures after the report narrative. Seven Attachments that relate to the additional studies and data comparisons are included with this report (App. IX), and are located after the figures.

Results of the additional and revised modeling reported herein were incorporated as necessary for revisions of HHEKA, in support of the Knik Arm Crossing Final Environmental Impact Statement.

2 SUMMARY OF COMMENTS AND RESPONSES

Comment #	ERDC/CHL Comment / Question	URS/ENTRIX Response
1)	Boundary is close to POA and could be affecting the predictions at the POA.	To address this concern, the western (i.e. seaward) boundary of the model was relocated to a north-south line approximately 10 km west of Fire Island (Fig.4.1-3 v2). The tidal signal to be applied along the relocated seaward boundary was determined by establishing mathematical relationships through an iterative process, using a very limited tidal record at Fire Island, the continuous record at Port of Anchorage (POA), and tidal data collected in 2005 (Appendix I). Also, as part of the model's reconfiguration, model bathymetry was modified to be more consistent with that used in the ADCIRC model developed by the CHL for analysis of the POA expansion project. The ADCIRC bathymetry was used except where more recent data were available such as near the proposed bridge crossing. It was also determined that the bathymetry north of Eagle Bay in the ADCIRC model was likely too low (i.e. too deep) so the bottom elevations there were raised. More details on these changes are provided in Section 2 of Appendix IX. Following an extensive verification of the reconfigured model's capability to represent Knik Arm tides and currents satisfactorily, all model simulations with and without the proposed Knik Arm Crossing (KAC) were repeated. Relocation of the seaward boundary did result in some small changes to the numerical values of water surface elevations and velocities throughout the study area. These small changes were most notable near the proposed KAC alignment, but these are attributed to alterations made to the bathymetry north of the project site (i.e., Eagle Bay, Duck Flats), rather than to relocation of seaward boundary. South of the proposed KAC alignment, the revised model's predicted impacts of KAC are essentially the same as previously reported in the DEIS; that is, while the differences between Base Case and With KAC are discernible in numerical values of water levels and currents, these differences are very small and would not likely be measureable. The allegation that the location of the model's original seaward boundary was adversely affecting the model's capability to produce reliable results in the Port of Anchorage is not supported by the revised model's computational results.
2)	The reviewer was unable to determine how wetting and drying was handled in the URS model.	In the HD module of MIKE 21, a flooding depth and a drying depth are specified. The drying depth was set to 0.05 m and the flooding depth to 0.4 m. The flooding and drying depths determine when points are taken out and entered back into the computations. To reduce the instabilities associated with adding and removing points, a point is considered flooded when one of the water points directly above, below, to the

Comment #	ERDC/CHL Comment / Question	URS/ENTRIX Response
		left, or to the right of it is above the flooding depth. Similarly, a point will not go dry if the points immediately adjacent to it are above the specified flooding depth.
3)	The reviewer did not understand how the grid nesting was applied. The reviewer was not sure if only water surface elevation or if both water surface elevation and velocity were transferred across the grid.	The nested grids are dynamically linked so that there is a transfer of mass and momentum between each grid during each time step. In those areas where the nested grids overlap (e.g., POA), nodes within a grid take the values calculated from the finest grid (i.e., nodes that coincide in the 135m grid, 45m grid, and 15m grid all have the value calculated using the 15m grid). The boundary conditions of the finer grid are obtained from the coarse grid. There is a dynamic exchange of both momentum (velocity) and mass (water volume/ surface elevation) between the coarse grid and the finer nested grids.
4)	The reviewer is concerned that the size of the grid may be too coarse to fully represent the gyre and smaller eddies at the POA.	The grid used in the updated model does capture eddies located within the POA. However, the capability of any model to capture hydrodynamic features such as eddies will be limited to those that are larger than the grid size. In a turbulent environment there will always be smaller eddies that are not represented by the grid. The subgrid scale effects are included through the eddy viscosity. For the runs presented here, the Smagorinsky concept is used to estimate the eddy viscosity (DHI, 2007a). The Smagorinsky formulation calculates the eddy viscosity from velocity gradients.
	A grid size of 10 to 15 meters was used by the USACE in their ADCIRC model in the vicinity of the POA.	The 135-m grid was extended 10 km west of Fire Island, as described in (1) above. The region with the nested 45-m grid was also enlarged so that the western border was located at Point Woronzof. To allow for increased resolution at POA, a 15-m resolution grid was nested within the 45-m grid. The 15-m grid contained the detailed bathymetry data from the ADCIRC model in the vicinity of the POA. The model bathymetry is shown for the 8,200-foot bridge alternative in Figure 4.1-3v2.
	However, the reviewer wonders if an even smaller grid size is required.	A smaller grid could be used if fine port features needed to be added to the model (e.g., piers or other structures). However, the modeling study we conducted was looking at large scale changes within Knik Arm due to the bridge project, including changes in the POA but not micro level changes within the POA. Also, there needs to be consideration of the balance between the level of effort to conduct the modeling and the additional information that can be gained. For example, using a 5 m grid within the Port will provide a finer level of detail in the answer but not necessarily a better answer. Our ability to simulate fine scale turbulence on an estuarine wide level is limited. Also, the equations for erosion, deposition and sediment transport (e.g., calculating erosion proportional to excess shear stress) are true on an "average" sense but do not account for the actual physical process (e.g., sediment eroding from the bed in chunks or flakes).

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5)	Horizontal looking ADCP measurements collected by NOAA show high frequency variations on the order of the mean signal predicted by the ADCIRC model.	A detailed comparison between the model and the measured horizontal looking ADCP results is provided in Attachment 3d. The model results are depth averaged. The NOAA ADCP was at a fixed elevation, so the data were collected at various depths that depended on the stage of the tide. Insofar as can be determined, the agreement between depth-averaged model velocities and the ADCP data is good. The high frequency variations (on the order of 12-30 minutes) are not evident in the model results.
	These may be important in understanding the sedimentation process.	Neither the cause, nor even the physical validity, of the “high frequency variations” has been identified, so there is no way to determine their importance to the sedimentation process.
6)	More verification is required to confirm that the URS model can match available water surface elevation and velocity measurements made at the POA.	Additional verification was conducted by comparing model runs to NOAA data. See responses to comments #5 and #8 for comparisons with velocity measurements. Velocity transect T5 is located near the POA. The comparisons of modeled and measured water surface elevations near the POA are provided in Figures 5.2-2 v2, 5.2-3a v2, 5.2-3b v2, and Figure 12. Discussion of the results is provided in Section 4 of Appendix IX.
7)	A 3-dimensional model may be needed to fully understand the velocity and shear stress associated with the gyre at the POA, which may be important to understanding sedimentation.	The two-dimensional model was selected because it provides a reasonable representation of the phenomena related to hydrodynamics and sediment transport that could be affected by the KAC. A three-dimensional model would have required substantially more computer processing time and an even more extensive data collection effort in order to determine that it was accurately depicting the hydrodynamic and sediment transport processes. Without a more recent survey of bathymetry within the entire model extents and additional data available for calibration, the three-dimensional model would not provide a better estimate of the hydrodynamics in Knik Arm.
8)	The NOAA data shows a 3-dimensional dominated hydrodynamic system between Point Woronzof and Cairn Point.	The model output between Point Woronzof and Cairn Point was compared to NOAA velocity transects measured on July 16 and 17, 2002. Attachment 3a provides a series of figures that compare the revised MIKE 21 output to the NOAA velocity transect T5, located across Knik Arm near the POA. The depth-averaged MIKE 21 output shows the velocity magnitude projected 35 degrees from true north with approximately the same color scale as the NOAA data. The direction of depicted velocity components was chosen to be parallel to the axis of Knik Arm at the location of the transect. The velocity vectors are shown on the MIKE 21 plot, and can be compared to the NOAA stick ship track, which also depicts the depth-averaged current speed and direction. Each figure in the series also shows the tide at Anchorage, with the time-period of the transect marked. Attachment 3b provides a series of similar figures that compare the revised MIKE 21 output to the NOAA velocity transect T7, which generally runs north-south across Knik

Comment #	ERDC/CHL Comment / Question	URS/ENTRIX Response
		Arm between Point Woronzof and Ship Creek. Attachment 3c provides the series of figures that compare the revised MIKE 21 output to the NOAA velocity transect T4, which runs across Knik Arm south of Point MacKenzie. The actual values of the depth-averaged velocities were not provided with the NOAA data. However, the figures in Attachments 3a, 3b, and 3c show general agreement between the modeled and measured current speeds and directions. The two-dimensional MIKE 21 model appears to be representing the important features of the three-dimensional environment fairly well.
9)	Hydrodynamics alone cannot be used to describe the sedimentation environment.	It was never argued that “hydrodynamics alone” could be used to describe the sedimentation environment. However, in the absence of evidence to the contrary, hydrodynamics is a useful and valid indicator because if there is no water movement, there is no sediment transport. Moreover, If there is no distinct *change* in water movement (i.e. change in speed and/or direction of flow), it is not unreasonable to conclude that there is no corresponding change in sediment transport.
10)	Additional field data are required to define the sedimentation processes in Knik Arm.	KABATA has sponsored the collection of a significant amount of additional data. The data collection efforts are completed. The data reports are included as Attachments to this response.
11)	Why did URS collect the CT data while raising the instrument rather than while lowering it? In the past, the reviewer has experienced problems with the collection of CT data while raising the instrument.	The primary reason for collecting CT (conductivity and temperature) data while raising the instrument is to ensure that it is fully equilibrated to its surroundings before data are collected. While this procedure might be inadvisable in very quiescent water, due to the risk of raising the instrument through the vertical “wake” left as a result of its descent, this is definitely not a problem in Knik Arm, which remains quite turbulent even during “slack” tide.
12)	One of the reviewer’s most serious concerns was with the OBS data and the calibration of that data to predict suspended sediment concentration. The reviewer is concerned that the predicted suspended sediment concentrations based on the OBS data are often higher than any of the measured concentrations.	The updated version of the model does not use predicted suspended sediment concentrations from the OBS measurements.

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13)	The reviewer is concerned that URS used a constant bed gradation throughout the model and felt that at least the mud flats should be represented differently and with a higher percentage of silt. The reviewer felt that he could see trends in the field data, and that some attempt should be made to represent those trends.	The model was modified to use two different bed conditions, one representing the mudflats and one representing the channel like areas. Figure 40 shows the area covered by each bed type. Each bed consisted of two layers. The upper layer consisted of 90% silt/clay and 10% sand. The second layer was assumed to consist of 80% sand and 20% silt. In the mudflat areas the top layer was 30 cm thick, and in the channel like areas the top layer was 3 cm thick. In the channel areas, the top layer was quickly eroded, leaving only the lower sandy layer. The top layer would sometimes reappear (during times of low current speed) then disappear again.
14)	The reviewer feels the critical concentration for flocculated particles is lower than the level used in the URS model.	Flocculation was not actually included in the previous modeling for the EIS. For the revised model, the minimum concentration for flocculation to occur was set to 1,000 mg/L. Above this value the settling velocity increased as a linear function of the suspended sediment concentration.
15)	Hindered settling was not included in the URS model and may be an important sedimentation process in Knik Arm.	Long tube (7 feet) settling tests were conducted with samples of Knik Arm water with TSS ranging from 1200_ to 3000 mg/L. The results are described in Attachment 1a. The tests were run for 24 hours. No hindered settling was observed in any of the settling columns. The Settling Column test report suggests that the absence of hindered settling could be due to the relatively low concentrations (i.e., relative to water samples from dredging operations where hindered settling is observed) and the high percentage of silt in the sediment.
16)	The reviewer felt that the settling velocity used for silt in the URS model was too small.	The settling velocity for the silt fraction was increased. The minimum velocity was 0.00025 m/s. However, because of flocculation the settling velocity varied throughout the tide cycle with a maximum of about 0.0075 m/s occurring occasionally (~1% of the time). For comparison, the minimum velocity of 0.00025 m/s corresponds to a particle with a diameter of about 0.01-0.02 mm based on Stokes Law. This value was based on the Settling Velocity Evaluations for Suspended Sediment report provided in Attachment 1a.
17)	The reviewer felt that a significant short coming of the URS model was that a time variant suspended sediment concentration profile was not used.	The assumed shape of the sediment concentration profile has an effect on deposition in the MIKE21 model because the near-bed concentration that is used to estimate deposition is calculated from the assumed profile. The Rouse profile was used to simulate the variation in sediment concentration over the water column. The Rouse profile assumes a balance between the upward movement of particles due to dispersion and the downward movement due to settling. Although the shape will change over time due to changes in the eddy viscosity (which is calculated from the bottom shear stress) the near bed concentration will always be the same fraction of the depth-averaged concentration. An alternative would be to use the Teeter profile (DHI, 2007). This profile assumes the concentration profile based on the

Comment #	ERDC/CHL Comment / Question	URS/ENTRIX Response
		Peclet number (very similar to the Rouse number used in the Rouse profile, see DHI 2007 for more details). This results in the near bottom concentration being a function of the excess shear stress on the bottom rather than the bottom shear stress. The calculation of erosion and deposition in the model is under-constrained, that is, there are more “knobs” available to turn than there are output parameters available to uniquely define the “knobs” values. One approach to overcome this (and that was used in this analysis) is to fix some of the inputs to a reasonable value and therefore limit the number of “knobs” available to adjust. The Rouse profile provides a simple representation of the near bottom concentration. If we were to update the model again, we would start with the results we now have and possibly use the Teeter profile (which would be affected by our choice of critical shear stress of deposition). However, this might just result in a change in the erosion and deposition parameters presently selected to a new set of parameters, maybe better, maybe not.
18)	The reviewer feels that fluid mud may be important to the sedimentation process at the POA, but has no data to support the hypothesis at this time. However, a field program will be conducted this summer (2006) to identify the likely presence or absence of fluid mud.	A fluid mud layer was not included in the model. If a mud layer were assumed to exist, an exponential erosion rate would have been added to the top layer. Due to the high currents and the large bottom shear stresses that occur in Knik Arm, it was assumed that a fluid mud layer could not be sustained. Data collected for the Sedflume study support this (see Attachment 2). The bulk densities measured in the top ~5 cm of the cores varied from over 1400 kg/m^3 to over 1800 kg/m^3.
19)	Reviewer did not approve of how the suspended sediment concentration was adjusted at the boundary to make the model work and felt that the suspended sediment concentrations used in the model were probably too high.	A suspended sediment concentration of 1.13 kg/m3 was used at the boundary near Fire Island. This is the average of the data collected in Sept 2007 at three stations near the model boundary. The three stations (FNOR, FMID, and FSOU) are shown in Figure 2 of the Current and Suspended Sediment Investigation Report provided in Attachment 1b. Only data collected at high tide or on a flood tide were used to calculate the average. A total of 12 measurements were used in the average collected on two different days: one day during a spring tide and one day during a neap tide.
20)	The construction of the proposed Knik Arm crossing may cause impacts different from those of the completed structure.	There will be impacts from construction of Knik Arm Crossing that are different from those caused by the completed structure. Hydrodynamic effects will be less during construction because there will be less disruption of the tidal flows in Knik Arm. Placement of the gravel fill for the bridge approach embankments can be expected to contribute to the suspended sediment load of Knik Arm as fines are washed out of the gravel and swept away by the currents. The latter will be a short-term effect that will amount to a fraction of the suspended sediment load that Knik Arm normally carries.
21)	USACE is concerned that an increase in velocity at the Port of Mackenzie could be	Over the 28 days simulated from 6/22/04 to 7/20/04, the maximum speed immediately in front of Port MacKenzie increased with the bridge compared to base case by

Comment #	ERDC/CHL Comment / Question	URS/ENTRIX Response
	a problem for the Port MacKenzie.	between 0.01 to 0.04 m/s. The average RMS speed in front of the dock over that same 28 day period actually decreased slightly (by less than 0.1 m/s).
22)	Other concerns with the proposed Knik Arm Crossing are expressed in the 2005 document titled “Knik Arm Crossing Section 905 (B) (WRDA 86) Analysis, Section 6.3.	Concerns expressed by the District Engineer, USACE Alaska District, in the Section 905(B) (WRDA 86) Analysis, Item 6.3, are acknowledged. The preparers of the Knik Arm Crossing EIS, and its numerous supporting technical reports (including this one), have addressed all relevant concerns expressed in the aforementioned document, which was prepared for the purpose of requesting funds to undertake model studies to address all of the concerns stated therein.
23)	The proposed Knik Arm Bridge (both abutments and/or piers) might significantly alter the sediment regime at the POA.	The sediment transport model developed for Knik Arm was run for the conditions with and without the bridge. The difference between the two runs provides a measure of the level of alteration in the sediment regime. Figure 38 shows the estimated sedimentation rates for the Base Case and with the KAC Alternative 1. Figure 39 shows the difference between the two (KAC Alternative 1 minus Base Case). The rates shown are the maximum that could be expected (bathymetry was not updated, so presumably the rate of sedimentation would decrease as the elevation of the estuary bottom rose). Section 8 of Appendix IX describes how the modeled sedimentation rates are quite similar to maximum sedimentation rates measured near the POA. Figure 39 shows that maximum sedimentation rates near the POA could increase or decrease by approximately 0.05 m/day. The area showing increases is limited to the northern end of the POA.
24)	It is not known whether the sedimentation at the POA is the result of settling suspended sediment and/or fluid mud.	See response to comment #18. Given the high shear stress values in Knik Arm and the apparent bulk densities, we believe suspended sediment is the main source of the silt material depositing in the POA.
	Fluid mud was defined by the USACE personnel present at the meeting as a density driven current with a suspended sediment concentration greater than 5 to 10 grams/liter.	Suspended sediment concentrations of over 5 g/L have been measured in Knik Arm near the seabed. However, we would not define such concentrations as fluid mud.
	The USACE is conducting a program this summer (2006) to confirm the presence or absence of fluid mud.	Noted.
	The results of the program may be available sometime between October and December of this year.	Noted.

Comment #	ERDC/CHL Comment / Question	URS/ENTRIX Response
25)	The gyre at the POA plays a significant part in defining the sedimentation environment at the POA.	While this allegation might be true, it is not substantiated by any data that could be used to define the importance of the eddy near the POA in the sedimentation environment. The hydrodynamic model developed for Knik Arm and described here does include the eddy in the neighborhood of the POA.
	Thus, changes to the gyre resulting from the construction of the proposed Knik Arm Bridge may result in changes in the sedimentation environment at the POA.	The hydrodynamic model does capture changes in the eddy that can be attributed to the proposed Knik Arm Crossing. Accordingly, the model does provide capability to evaluate consequent changes to the sedimentation environment subject, of course, to limitations of the model itself.

3 MODEL DOMAIN, GEOMETRY, AND RESOLUTION

Three comments capture the principal CHL issues with the HHEKA modeling:

Comment 1: The model boundary is close to the Port of Anchorage (POA) and could be affecting the predictions at the POA.

Comment 3: The reviewer did not understand how the grid nesting was applied. The reviewer was not sure if only water surface elevation or if both water surface elevation and velocity were transferred across the grid.

Comment 4: The reviewer is concerned that the size of the grid may be too coarse to fully represent the gyre and smaller eddies at the POA. A grid size of 10 to 15 meters was used by the CHL in their ADCIRC model in the immediate vicinity of the POA. However, the reviewer wonders if an even smaller grid size is required.

The western boundary of the model was moved approximately 10 kilometers west of Fire Island, which is approximately 22 kilometers west of the previous model boundary located at Point Woronzof. In order to obtain a flow direction closer to perpendicular to the model boundary, the grid was rotated back so that model north was equivalent to true north. With the assumption that the flow entering Knik Arm comes from Cook Inlet and passes to the north of Fire Island, the connection to Turnagain Arm was artificially severed by creating land elements extending to the east and west of the southern end of Fire Island. The reconfigured model domain and bathymetry are shown in Figure 4.1-3v2.

The following process was used to revise the bathymetry.

The previous bathymetry described in Appendix III of the HHEKA was revised along the shoreline and within the vicinity of Port MacKenzie and the POA by adopting the bathymetry used by CHL in their ADCIRC model of Cook Inlet. The region containing NOAA survey data from 1974 located within Eagle and Goose Bays and to the northeast that had been lowered during calibration of the previous model was converted back to the original elevations (with the same correction factors as used previously to convert from the MLLW datum to NAVD 88). Outside of the northeastern extent of the NOAA survey data, the data from the ADCIRC model was used as a first estimate of the bathymetry extending to the Knik and Matanuska Rivers. West of Point Woronzof, a combination of the 2000-2001 NOAA multi-beam survey and the ADCIRC model data was used.

ADCIRC is a finite element model so it utilizes a computational grid composed of nodes at the apexes of triangles that vary in size throughout the model domain. To incorporate the ADCIRC data with other bathymetry used in the MIKE 21 model, elevations in ADCIRC's triangle network were extracted to create a grid with a 15-meter resolution.

For the NOAA data originally referenced to MLLW, 3.138 m was subtracted from values between Fire Island and Point Woronzof, and 3.02 m was subtracted from values west of Fire Island, to obtain elevations referenced to NAVD 88.

The ADCIRC data had been referenced to a MSL datum (calculated as half the spring tidal range). The correction factors used by ERDC to convert elevations from MLLW to MSL (shown in Figure 13 of Appendix E of the Port of Anchorage Marine Terminal Redevelopment Environmental Assessment) were used to convert the ADCIRC data back to the MLLW datum. To convert the data from MLLW to NAVD88, the factors described above were applied (either described above or shown in Figure 4.1-2 of Appendix III of the HHEKA).

After running the model with input data from 2005, it was determined that the water surface elevations at the radar gauge located on the Glenn Highway Bridge were too low and had a much greater range than the measured data. In order to better match the measured data, the elevations near Glenn Highway and beyond the extents of the NOAA data near Duck Flats were raised.

To provide more stability at the model boundary west of Fire Island, depths within a narrow band along the mudflats were lowered so that the boundary would remain wet.

In response to Comment 4, a 15-meter resolution grid was used to cover the area from south of Ship Creek to Port MacKenzie. This grid contained the detailed bathymetry data from the ADCIRC model in the vicinity of the POA. The 15-meter grid was nested within a larger 45-m grid, which was nested within the 135-meter grid covering the entire model domain. In response to Comment 3, the MIKE21 model dynamically couples the nested grids within the larger grids such that the numerical calculations are performed using the most detailed bathymetry available for each region. There is a dynamic exchange of both momentum (velocity) and mass (water volume/ surface elevation) between the coarse grid and the finer nested grids. Results are transferred along the boundaries of the nested grids. The revised model bathymetry is shown in Figure 4.1-3v2 for the alternative with the 8,200-foot bridge with the earthen approach embankments, however the embankments were not included for the simulations of existing conditions.

4 REVISED TIDAL BOUNDARY INPUT DATA

The model boundary was moved to the west of Fire Island. There are no continuous tidal data at this location. At Anchorage, 6-minute tidal data published by NOAA are available online beginning in January 1997. At Fire Island, 6-minute data are available from May through September of 2001. To develop the tidal boundary input, the tide was first estimated at Fire Island based by comparing the measured tide at Anchorage to the measured tide at Fire Island during 2001. Figure 1 shows the water surface elevations at these locations during a spring tide. The tidal boundary input was then calculated by making adjustments to the estimated tide at Fire Island until water levels at measured stations within the model boundary were matched by the model output. The water level at the boundary was applied uniformly along the entire boundary at each time step.

Figures 2 through 7 compare the measured tide at Fire Island to the calculated tide at each step of the process used to estimate the tide at Fire Island based on the measured tide at Anchorage. The process is described in more detail below.

Except for the 144 minutes before the high and low tides, the time at Fire Island was calculated by subtracting 24 minutes from the date/time at Anchorage. This is close to the average time difference based on the 6-minute data measured at Fire Island and Anchorage in 2001. On average, the low tide at Fire Island occurs 28 minutes before the low tide at Anchorage, and the high tide occurs 17 minutes before the high tide at Anchorage.

The values in the periods 144 minutes before high and low tides were calculated in two steps. The first step was based on a regression equation developed by fitting a line through plots of the high tide time difference and the low tide time difference versus the height difference between consecutive low and high tides at Anchorage (for high tide time differences) and the height differences from high to low tide at Anchorage (for the low tide time differences). This is shown in Figure 8.

The time differences were calculated at high and low tide as follows.

To calculate the high tide time difference, use the following equation:

$$\Delta T_H = 1.643 \cdot Z_{LH} - 3.664$$

where

ΔT_H = Time difference, in minutes, between high tides at Fire Island and Anchorage.

Z_{LH} = Height difference, in meters, from low to high tide at Anchorage.

To calculate the low tide time difference, use the following equation:

$$\Delta T_L = -2.493 \cdot Z_{HL} - 8.075$$

where

ΔT_L = Time difference, in minutes, between low tides at Fire Island and Anchorage.

Z_{HL} = Height difference, in meters, from high to low tide at Anchorage.

These negative time differences were added to the date/time of the high and low tides at Anchorage to obtain the time of the high and low tides at Fire Island. In order to fill in the times between the high and low, the time between each high and low (or low and high) at Fire Island was divided by the number of 6-minute increments between the high and low tides at Anchorage. This increment (generally slightly different than 6 minutes) was used to fill in the times between high and low tides by adding it to each previous time step. This new time series makes up the first part of calculating the date/time values used to fill in the periods 144 minutes before high and low tides at Fire Island.

By using the two different estimates for calculating the date and time of the tide at Fire Island, there is the possibility of obtaining times that do not progress chronologically when changing from one method to the other. The second step for calculating the date/time values within 144 minutes of high and low tides was to make adjustments to the times where the differences between sequential time steps were negative. For any time steps with a negative difference, the current date/time was calculated as the average of the date/time immediately preceding and immediately following the current time step. If this still resulted in negative time increments, one minute was subtracted from the date/time immediately preceding the current time, and one minute was added to the date/time immediately following the current time. This process was repeated until all time steps progressed chronologically.

The first estimate of the water level at Fire Island was based on a regression equation developed by plotting the high and low tide elevations relative to the mean lower low water (MLLW) datum at Fire Island versus Anchorage from data measured in 2001. This is shown in Figure 9. The elevation at Fire Island (m, MLLW) = 0.9188*[elevation at Anchorage (m, MLLW)] + 0.0305.

The estimated water levels using the 2001 tide at Anchorage were compared to the measured water levels at Fire Island. The greatest error occurred on the rising tide. To decrease this error, a relationship was developed with the maximum difference between the calculated and measured tide during each rising tide and the incremental change in successive heights (approximately 6 minutes apart). Figure 10 shows the difference between calculated and measured tidal elevations at Fire Island for 2001 plotted against the incremental change in successive heights at Fire Island. The regression equation was used to calculate a correction factor that could be subtracted from the calculated tide at Fire Island. The correction factor was calculated to be 3.477*[difference in successive calculated heights in meters at Fire Island (current minus previous time step)] – 0.059. The correction factor was applied between 1 and 4 hours after each low tide to obtain the second estimate of water levels at Fire Island.

To obtain the third estimate of water levels at Fire Island, the tidal elevations were adjusted again by averaging the water levels from the first and second estimates during the 2nd and 4th hours after low tide. During all other times, the first estimate of the water level was used.

The fourth estimate of the water level at Fire Island was essentially based on smoothing the values obtained in the third estimate. From 36 to 258 minutes after low tide, the calculated water level at Fire Island was based on the 30-minute average of the estimated values, centered at that time step.

To convert the elevations relative to MLLW to elevations relative to the North American Vertical Datum of 1988 (NAVD), 3.02 meters was subtracted from each value. This value was calculated using a distance-based interpolation of the difference between NAVD and MLLW at Nikiski (2.060 m) and Anchorage (3.197 m).

To obtain water levels at even 6-minute increments, the time-series interpolation feature in the MIKE Zero toolbox was used with the calculated dates/times and the water levels referenced to NAVD.

Since the model boundary was located west of Fire Island, the calculated tide was adjusted further. The time at the boundary was calculated by subtracting 12 minutes from the date/time at Fire Island. The water level at the boundary was adjusted by adding 0.2 meters to the calculated tide at Fire Island. These adjustments were based on calibration of water levels measured in 2005 at Point MacKenzie (S1), Anchorage, N1, N2, and at the radar gauge at Palmer Bridge. The locations of the water level stations are shown in Figure 4.1-3v2. The tide was applied uniformly along the boundary with no change in phase or amplitude. The results of the field study conducted by John Oswald and Associates in 2005 (included in Appendix I, Section G, of the HHEKA) showed a phase difference of approximately three minutes across the width of Knik Arm in the vicinity of the KAC. It is possible that the phase difference near Fire Island would be similarly minor.

5 RE-CALIBRATION OF HYDRODYNAMIC MODEL

The model calibration runs were performed with the 45-meter grid nested within the 135-meter grid. The water level output from the final calibration runs is shown in the attached figures numbered from 5.2-1a v2 to 5.2-12 v2 at stations with data measured in 2005. Model results from the previous version of HHEKA are labeled as “EIS Modeled.” Results obtained with the re-configured model have been labeled as “Revised Model.” The water levels at Anchorage are shown in Figures 5.2-2 v2, 5.2-3a v2, and 5.2-3b v2. The tidal elevations during neap tide are generally matched within 0.25 meters. The tidal elevations during spring tide are generally matched within 0.4 to 0.8 meters, with the larger error occurring because of the slight phase shift at low tide. The agreement is not quite as close as the previous EIS modeling; however, this is likely due to the use of different geometry northeast of Eagle and Goose Bays. Since this geometry is not known with any reasonable accuracy, it was determined that the agreement between the measured and modeled water surface elevations was close enough such that additional changes to the bathymetry were not warranted. These figures were provided as part of the response to Comment 6.

Comparisons between the measured and modeled water surface elevations are also shown in Figures 11 through 17 (see Figure 4.1-3v2 for the tide station locations). Figure 11 compares the measured water surface elevation at S1, plotted on the x-axis, to the modeled water surface elevation at S1, plotted on the y-axis. If there were perfect agreement, the slope of the best fit line would be equal to one, the y-intercept would be zero, and the correlation coefficient R^2 would be one. The previous EIS model output is shown along with the revised model output. Both sets of modeled data show very close agreement with the measured data, although the revised model output has a little more spread around the line of best fit. This is due to moving the model boundary approximately 22 km west of the previous model boundary location. The previous model boundary location was very close to station S1. Figures 12 through 16, from Anchorage to station N2, show very similar results.

At the Glenn Highway Bridge, the measured data have a much smaller range (approximately 1 meter), and the output from the revised model does not coincide as well over the entire range of measured data shown in Figure 17. The assumed bathymetry near this location has a significant effect on the model results. As shown in Figure 5.2-12 v2, the revised model output follows the same general pattern as the measured data. As mentioned above, it was determined that the measured and modeled water surface elevations were sufficiently close such that additional changes to the bathymetry were not warranted.

Figures 5.2-13 v2 to 5.2-18 v2 show the modeled and measured current speeds at the moorings placed at the end of the proposed east and west bridge embankments. The previous results are labeled “EIS modeled,” and the revised results are labeled “MIKE21 r24.” The revised results are similar to the previous results. Based on previous runs, the current speeds were found to be affected by the bathymetry north of Eagle and Goose Bays. The differences in the previous and revised modeling results are most likely due to the differences in bathymetry northeast of Eagle and Goose Bays.

Comparisons were also made between the revised and previous EIS modeling and measured Acoustic Doppler Current Profiler (ADCP) transects. Figure 5.2-19 v2 shows the modeled current speeds in the area of the bridge alignment during a spring ebb tide in 2004. The transect where modeled current speeds were extracted for comparing to measured speeds is shown as a line across the grid. When compared to the previous EIS modeling, the velocities show the same trends, but are slightly lower. Figure 5.2-20 v2 shows the comparison of modeled versus depth-averaged measured current speeds during the spring ebb tide along that transect. Both of the modeled current speeds are below the maximum measured current speeds. The peak current speeds from the revised model are approximately 0.2 m/s lower than the peak speeds from the previous EIS model.

Figure 5.2-21 v2 shows the modeled flood and ebb current speeds near Cairn Point during a spring tide in 2005. During flood tide, the revised model velocities toward the center of the channel are slightly faster than the previously modeled velocities. During ebb tide, the revised model velocities are slightly lower than previously modeled. The line across the grid shows the transect where modeled current speeds were extracted for plotting in comparison with the measured depth-averaged current speeds as shown in Figure 5.2-22 v2 for the flood tide, and in Figure 5.2-23 v2 for the ebb tide. Figure 5.2-22 v2 shows that both the previous model and the revised model underestimate the peak velocities in the center of the channel. Compared to the previous model, the revised model output shows peak flood speeds spread out more uniformly across the channel. The revised model output is closer to both the previous model output and the measured velocities in Figure 5.2-23 v2.

In response to Comment 6, which implied that the previous modeling had not been sufficiently verified, additional verification was conducted by comparing model output of depth-averaged current speeds along transects where NOAA collected velocity profiles. Attachment 3a contains velocity comparisons at transect T5, which crosses Knik Arm near the POA. Attachment 3b provides velocity comparisons at NOAA transect T7, which generally runs north-south across Knik Arm starting from a location midway between Point Woronzof and Ship Creek. Attachment 3c provides velocity comparisons at NOAA transect T4, which runs across Knik Arm south of Point MacKenzie. The first page of each attachment describes the layout of the plots. The actual values of the depth-averaged velocities were not provided with the NOAA data. However, the figures in Attachments 3a, 3b, and 3c show general agreement between the modeled and measured current speeds and directions. In response to Comment 8, with regard to the NOAA data showing a "3-dimensional dominated hydrodynamic system between Point Woronzof and Cairn Point," the two-dimensional MIKE 21 model appears to be representing satisfactorily the important features of that system.

Output of the reconfigured model was also compared to the side-looking ADCP data collected by NOAA at the POA (Attachment 3d). The second page of the attachment compares a time-series of the measured and modeled current direction for about a day and a half in August, 2002. The third page of the attachment compares the measured and modeled current speeds. The tide at Anchorage is also shown for reference. It should be noted that most of the brief spikes in the measured current direction occurred when the current speed was very low. Examples of these spikes occurred at 8/14/02 a little after 8:00, 8/14/02 at 11:30, and 8/14/02 around 14:30. Aside from these spikes, whose origin is not readily evident, the modeled current directions match the measured data extremely well except for a few occasions at mid-flood tide.

The depth-averaged current speeds from the revised model generally match the measured current speeds shown on the second page of Attachment 3d. However, they do not change as rapidly, so some of the higher frequency variations are not captured. The model provides depth-averaged velocities, while the measured data are velocities recorded at the same elevation in the water column (3.9 m MLLW), which means that the depth was changing with the tide. The peaks in velocities at the end of the falling tide, and the troughs occurring during the rising tide, do not appear to be captured by the model. However, the modeled current speeds reach similar magnitudes and show a similar pattern of rising and falling during the flood tide, with a similar shorter velocity peak at the beginning of ebb tide. Attachment 3d provides "snapshots" at 12-minute intervals of the modeled velocities in the vicinity of the POA. The two-dimensional plots can be compared to the time-series showing the measured and modeled speeds at the time of each snapshot. A smaller eddy can be seen forming along the shoreline at the POA in the vicinity of the measured data (denoted by the black dot in the two-dimensional output), and the larger eddies forming in the lee of Cairn Point are also clearly visible.

6 EFFECTS OF KNIK ARM CROSSING WITH REVISED BOUNDARY LOCATION

Figures 6.1-1 v2 and 6.1-2 v2 show the RMS speed and the maximum speed occurring over 28 days from 6/22/04 to 7/20/04. The region shown in the figure is approximately the same as the previous figures from Appendix III of the HHEKA. The visual differences are due to the orientation of the model grid, which was rotated 22 degrees counterclockwise from true north in the previous modeling, and to the larger scale of the revised presentation. The maximum current speeds with the revised model are as much as 0.3 m/s lower than the previous results; however the general patterns of results are very similar. These differences between the previous (EIS) and revised modeling are largely attributable to the altered bathymetry north of the project site.

To provide more detail near the POA, a grid with a 15-m resolution was nested within the 45-m and 135-m grids in the vicinity of the POA. Figures 18 and 19 show the RMS speeds and the maximum speeds occurring over 14 days from 6/30/04 to 7/14/04 within the area containing the 15-m grid. This 14-day period contains a high spring tide, so the speeds shown in Figure 18 are slightly faster than when averaged over the entire 28 days shown in Figure 6.1-1 v2. The maximum current speeds shown in Figure 19 are more likely to have occurred at the same time as the speeds shown in Figure 6.1-2 v2. The spottiness of the results along the shoreline is due to spuriously high velocities that can develop as grid cells are wetting and drying. These high velocities at individual grid cells are not representative of the currents speeds generally seen in these regions at other stages of the tide. This is evident by the very low average speeds shown along the shoreline in Figure 18, as well as the general pattern of the contours that are visible through the spots in Figure 19.

To determine whether the seaward boundary location was affecting the model results in the vicinity of the KAC and the POA (and to respond to Comment 1), figures showing differences due to the KAC were compared to the previous output. If the effects predicted by the revised model output using a boundary location moved to the west are similar to the previous results, it can be assumed that the boundary location was not unduly influencing results.

Figures 6.2-4 v2 and 6.2-5 v2 show the maximum speeds near the KAC for base case and with the KAC during spring flood and ebb tides, respectively. Figures 6.2-6 v2 and 6.2-7 v2 show the differences in the maximum speeds during spring flood and ebb tides. Figures 6.2-8 v2 and 6.2-9 v2 show the differences in the 28-day RMS speed and the 28-day maximum speeds. By comparing the plots of the differences with the figures in Appendix III of the HHEKA, it can be seen that the project effects are very similar. It is apparent that the location of the boundary was not causing significant changes to the results in the vicinity of the KAC.

To provide more detail in the vicinity of the POA, the results in the figures referred to above were shown with output from model runs using the 15-m nested grid. Figures 20 and 21 show the maximum speeds during spring flood and ebb tides, respectively. Figures 22 and 23 show the differences in the maximum speeds during spring flood and ebb tides. The contour intervals were chosen to provide finer gradation so that the small current speed differences (KAC Alternative 1 minus Base Case) in the vicinity of the POA could be better determined. The results in Figure 22 show that during a spring flood tide, the KAC generally causes current speeds to decrease in the vicinity of the POA by as much as 0.05 m/s. There are a few small regions directly adjacent to the shoreline that show differences ranging from -0.1 m/s to 0.2 m/s. The results in Figure 23 show that during a spring ebb tide, there are both increases and decreases in current speeds due to the KAC. The differences range from -0.5 m/s (a decrease) to 0.75 m/s (an increase). The pattern of differences changes throughout ebb tide.

Figure 24 shows differences in the 14-day RMS speeds. The spots along the shoreline are probably due to differences in the spuriously high velocities that can occur during flooding and drying, and probably are less of an indicator of differences due to the KAC. On average, it appears that current speeds along the POA dock face would increase with the KAC (by as much as 0.05 m/s), except for a portion at the northern end of the dock, where current speeds would decrease by as much as 0.05 m/s.

Figure 25 shows differences in the 14-day maximum speeds. Again, the mottled area along the shoreline should be disregarded as it is a result of inconsistencies in the velocities that result during flooding and drying, and is not a direct result of the KAC. In the vicinity of the POA, the differences due to the KAC range from -0.1 m/s (a decrease) to about 0.2 m/s (an increase).

7 SEDIMENT SETTLING VELOCITY

Several CHL comments suggested that the previous work was deficient with regard to data necessary to describe Knik Arm sedimentation processes. To respond to the concern that insufficient data were available to address questions of settling velocity (Comments 10, 12-16, 19), a settling velocity study was conducted in Knik Arm (Kinnetic, 2006). The purpose of the study was to obtain data on the particle size distribution and settling characteristics of the suspended sediments in Knik Arm. Details of the study are provided in Attachment 1a.

Water samples were collected at three sites: in the channel between Pt. Woronzof and Pt MacKenzie in 46 meters of water (site CHAN), near the Port of Anchorage in 19m of water (site POA) and near the east end of the proposed bridge crossing in 10 m water (site EAST). These samples were analyzed for particle size distribution and settling velocity using 8 foot long settling tubes (filled to a depth of 7 feet). Detailed results are provided in Attachment 1a.

Figure 26 shows the concentration in the settling tube for the POA sample. The plots for the other stations are provided in Attachment 1a. The bimodal distribution for time 5 min is likely due to the incomplete initial mixing of the sample when poured into the settling tube. Settling velocities were estimated using procedures described in McLaughlin (1958). This method provides an estimate of the local mean settling velocity as a function of time in the settling tube. The mean settling velocity at a depth is the mean settling velocity of all the particles at the depth. Figure 27 shows the estimated local mean settling velocity for the POA sample. Figures 28 and 29 show the same plot for Stations CHAN and EAST. Stations POA and EAST were collected in shallow water and the combined samples contained less than 10% sand. The combined samples for Station CHAN contained over 20% sand. These percentages may not fully represent the percentage of sand over the entire water column in Knik Arm. The depth-averaged values calculated from the water samples, but without the near-bottom sample, resulted in less than 10% sand for all three stations.

The general pattern found in the results is that the local average velocity is high at the beginning of the test and decreases over time. This is due to the faster settling of the heavier particles. Also, the local average velocity increases with depth in the column. This is due to a higher concentration of heavier particles at greater depths.

The selection of the settling velocity for the model was based on the review of the data found in the Settling Velocity Evaluations Report (Attachment 1a) and verification runs with the model. Two material types are included in the model, a silt/clay fraction and a fine sand fraction. For silt, a minimum particle settling velocity of 0.025 cm/s (0.00025 m/s) was used. This fits with the results shown in Figures 27, 28, and 29 for the first 1 to 2 hours. For the coarse particles Stokes Law was used to represent the settling velocity for fine sand. Cores SF-3 and SF-4 collected for the Sedflume study (Sea Engineering 2007, see Attachment 2) were collected in a sandy area north of the proposed bridge location. The mean particle diameter for the sample at SF-3 was 200 µm. The mean particle diameter for the sample at SF-4 was 170 µm. Figure 2.2 from Vanoni (1975) shows that for 200 µm particles, the fall velocity is about 2 cm/s (0.02 m/s). This value was used to represent sand.

8 EROSION PARAMETERS

An acknowledged deficiency of the previous (EIS) modeling effort was the lack of any data on erodibility of Knik Arm seabed sediments (see also Comment 13). The MIKE21 sediment transport model simulates the erosion of consolidated cohesive sediment using the following relationship (DHI 2007):

$$S_E = E(\frac{\tau_b}{\tau_{ce}} - 1)^n, \tau_b > \tau_{ce} \qquad (7\text{-}1)$$

where:

S_E = erosion rate (kg/m^2/s)
E = erodibility of bed (kg/m^2/s)
τ_{ce} = critical bed shear stress for erosion (N/m^2)
τ_b = bed shear stress (N/m^2)
n = exponent of the relationship (assumed to equal 1)

To estimate the erosion parameters in Equation 7-1, five sediment cores were collected along the shoreline of Knik Arm. The locations where the cores were collected are shown in Figure 2 of Attachment 2. A Sedflume analysis was conducted on each of the cores to measure the critical shear stress for erosion and the erosion rate for a range of applied bed shear stresses. Test results were provided for approximately 5 cm thick sections of each core. A description of the test and results is provided in Attachment 2. Table 2 provides a summary of the test results. Detailed results are provided in Attachment 2.

Figures 30-34 were developed to estimate a value for erodibility of the seabed to use in the model. The average values are shown in Table 1. The critical shear stresses for samples SF-2 and SF-5 are almost an order of magnitude greater than the other three samples. These two samples contained a much higher percentage of silt and clay than the other three samples and, also, not much sand. Sample SF-1 also contained a large percentage of silt and clay but the sand fraction also contained much coarser sand than samples SF-3 and SF-4. SF-1 was also most difficult to collect, so the core was more likely to have been disturbed than the other samples.

Table 1. Results from Sedflume Analysis of Sediment Cores from Knik Arm

Sediment Core	Length of Core Analyzed (cm)	Average D_{50} (μm)	Average Bulk Density (g/cm^3)	Average Critical Shear Stress (N/m^2)	Erodibility g/cm^2/s
SF-1	4.5	34.9	1.72	0.23	0.0056
SF-2	19.4	7.8	1.76	1.64	0.0017
SF-3	33.0	198.1	1.90	0.08	0.0003 to 0.0148[b]
SF-4	20.9	172.1	1.87	0.18	0.0047 to 0.02[b]
SF-5	22.6	25.7	1.72	1.43[a]	0.0078

a. critical shear stress for top 5 cm was 3.47 N/m^2. Average critical shear stress for remainder of core was 0.92 N/m^2
b. The sample eroded even at the smallest applied shear stress for the top layer so critical shear stress is estimated for that layer

A critical shear stress of 1.5 N/m^2 was used for the critical shear stress for erosion in the mudflats based on samples SF-2 and SF-5. A value of 0.20 N/ m^2 was used for the non-mudflat areas that were assumed to contain sand. This is consistent with samples SF-4 and SF-1. It is also consistent with the critical shear stress for ~200 μm sand particle from the Shields Diagram (Vanoni 1975).

The erodibility for the mudflat areas varied from 0.0017 to 0.0078 g/cm^2/s from samples SF-2 and SF-5, which were considered representative of the mudflats. These values are 1 to 3 orders of magnitude greater than a summary of reported values listed in Krestenitis et al. (2007). A value of 0.002 g/cm^2/s (0.02 kg/m^2/s) was used in the model to represent mudflats. A value of 0.02 g/cm^2/s (0.2 kg/m^2/s) was used in the sandy areas. In the sandy areas much of the sediment transport could occur through bed load, which was not simulated in this study.

9 SEDIMENTATION

The Port of Anchorage experiences a large volume of deposition each summer. Evidence of this deposition can be seen in the series of bathymetric surveys conducted by the Alaska District in 2003 and presented as a series of slides (Attachment 6). A review of these slides shows that at the beginning of the summer 2003 there were areas at both the north end and the south end of the POA that accumulated sediment to an elevation above –30 ft, re: MLLW (i.e. the areas became shallower than -30 ft). The dredging project depth for the port is –35 feet relative to MLLW. As the summer progressed more of the Port area accumulated sediment to an elevation above –30 feet. The sedimentation rate was so large that some areas need to be dredged multiple times during the summer to stay close to the project depth of –35 feet. Estimates of the rates of sedimentation at four locations in the Port area were obtained from the slides found in Attachment 6. Figure 35 shows the locations, while Figure 36 shows the shoaling history for each location, based on data from Attachment 6. POA 2 illustrates the deposition rate before dredging began. POA 1, 3 and 4 illustrate deposition rates in areas that had been dredged earlier in the summer, with POA 3 at essentially the same location as POA 2.

The Alaska District conducted a shoaling study in Knik Arm just south of Ship Creek in 1971 and 1972 (Everts and Moore 1976). The study was conducted to determine a method to estimate shoaling rates in "half-tide" harbors in Alaska where large tides and high suspended sediment concentrations were common. Details of the study are found in Attachment 7.

"Half-tide" harbors are shallow small boat harbors constructed in tidal mudflats that have a sill across the navigation channel to prevent the harbor from draining during low tide. The Everts and Moore study was prompted by the large amount of sedimentation observed in these harbors that threatened their usefulness or required high maintenance costs. Everts and Moore constructed a 12-ft diameter sedimentation tank that they installed on the mudflats just south of Ship Creek. The tank was 30 feet tall with twenty feet located above the tidal flat elevation and 10 feet below. The elevation of the sediment in the tank was measured weekly during the summer of 1971 and 1972. Figure 37 shows the sedimentation rates measured in the sedimentation tank for comparison with the 2003 rates observed in POA. The results in Figure 37 show the increase in bed elevation from the start of measurements so that data collected at different times can be compared (i.e., zero time and zero elevation are the values on the first day of measurement). The results indicate that the sedimentation rates in the POA based on the bathymetry surveys are very similar to the sedimentation rates measured in the sedimentation tank constructed by Everts and Moore in 1971. It is noteworthy that Everts and Moore also observed that the sedimentation in their sedimentation tank was about 10 times the rate observed on the adjacent mudflats.

Results from the MIKE21 model are also included in Figure 37 for points at the same locations at POA #1 and POA #4 for the simulations with and without the KAC. Note that the sedimentation data measured from the Corps bathymetry was not used in the calibration of the model. The modeled sedimentation rate at POA #4 is about the same as the measured rate. At POA #1 it is about 3 times the measured rate. Comparing output from simulations with and without the KAC shows a predicted increase in the sedimentation rate at POA#4, which is located at the northern end of the POA, and a predicted decrease in sedimentation rate at POA#1, which is located toward the southern end of the POA.

Figure 38 shows the sedimentation rates for Base Case and with the KAC. The sedimentation rates were calculated over the period from 5/11/04 6:00 p.m. to 6/11/04 2:00 a.m., or 10.3 days. Since the morphology was not updated during the model simulations, these represent the maximum sedimentation rates that could be expected. Once areas fill in, it is likely that the sedimentation rate would decrease. The results in Figure 38 show deposition rates between approximately 0.02 m/day and 0.08 m/day near the POA. These rates are very similar to the maximum deposition rates calculated from the Corps bathymetry surveys. In Figure 38, only the areas of deposition are shown. The upper layer of the channel areas tends to erode more easily. The sandy bottom is most likely moving as bed load, and therefore would be more stable than the surface layer in the model.

Figure 39 shows how the KAC affects the rate of sedimentation in neighboring parts of Knik Arm. The differences are shown only for the depositional areas, so a negative change indicates a decrease in the rate of deposition, and a positive change represents an increase. The results show that the KAC would cause increased rates of deposition on either side of the bridge embankments, as well as near Port MacKenzie. In the POA there is a predicted increase in the sedimentation rate at the northern end of the POA. The rate of deposition would generally decrease starting from the midpoint of the dock face at the POA and would continue to decrease along the shoreline to Point Woronzof. Overall the rate of deposition in the POA will decrease with the KAC. On the western shoreline south of Port MacKenzie, the deposition rates both increase and decrease. For all areas shown in Figure 39 the decreases are all less than 0.05 m/day, and the increases are less than 0.2 m/day, with most less than 0.05 m/day.

The overall area and rate of deposition are affected by the choice of input parameters. Figure 40 shows how different properties were assigned to different regions in the model. The model was structured with two bed layers. Based on the bed properties shown on navigational charts of Upper Cook Inlet and from analysis of bed samples collected near the KAC (Smith, 2005), the bed layers were divided into two regions. Initial sediment model runs were performed with the same properties assigned to both regions of each layer. Based on these initial model runs, the areas of the two regions were adjusted to reflect areas of deposition and erosion. Depositional areas were given the properties associated with the silty mudflats, and erosional areas were assigned properties associated with the sandy channels.

This process could have been repeated in order to fine-tune the model. However, it is assumed that this would only affect smaller regions of the model and would not cause large differences in the sedimentation patterns. As described above, the results (provided in Figure 37) from the model are very similar to the measured data.

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