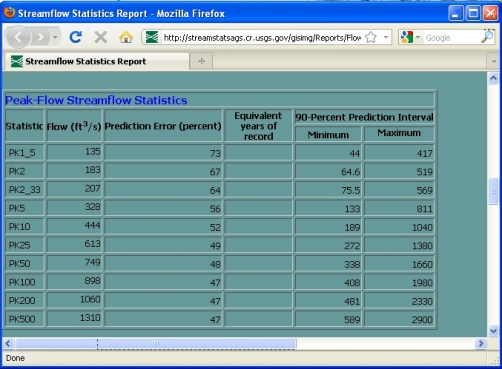
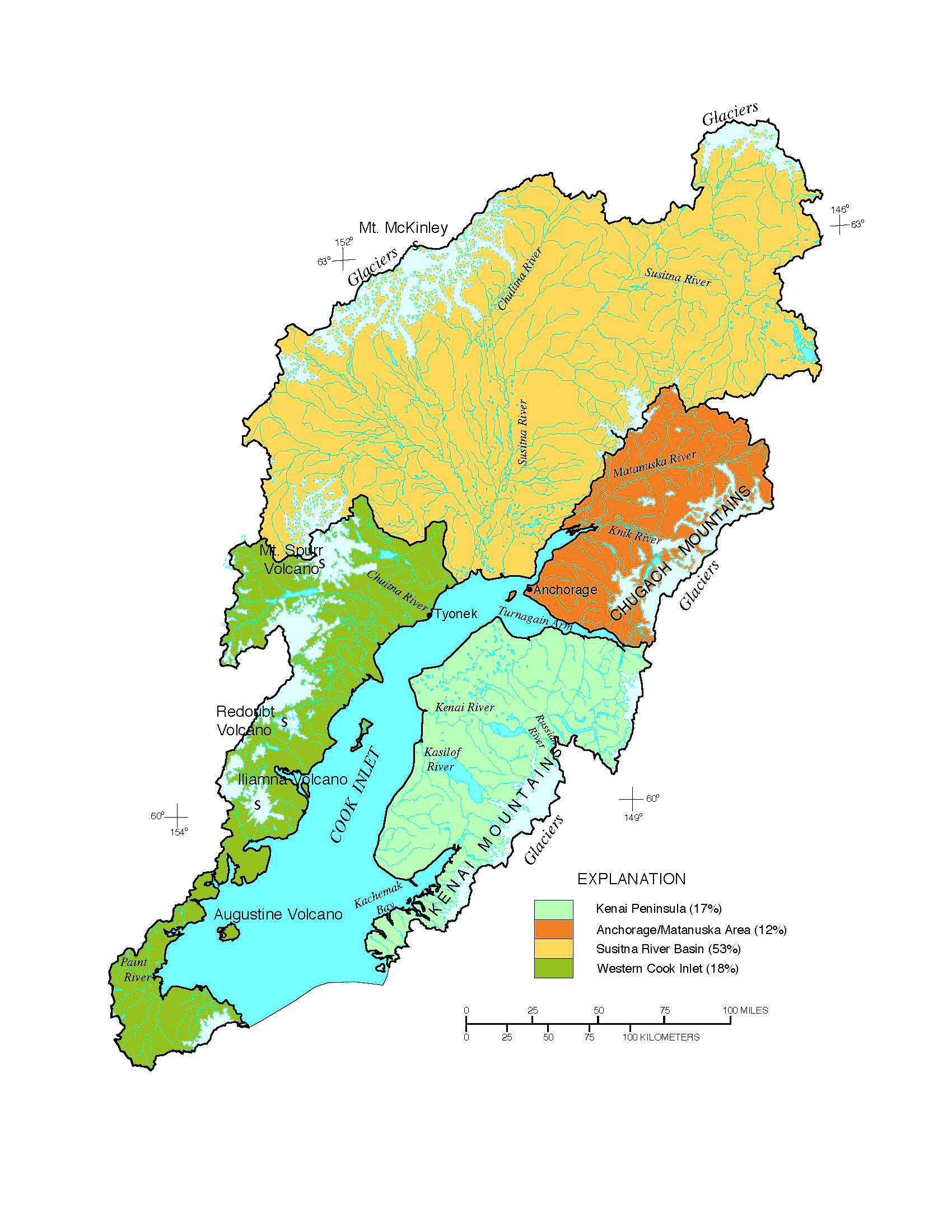
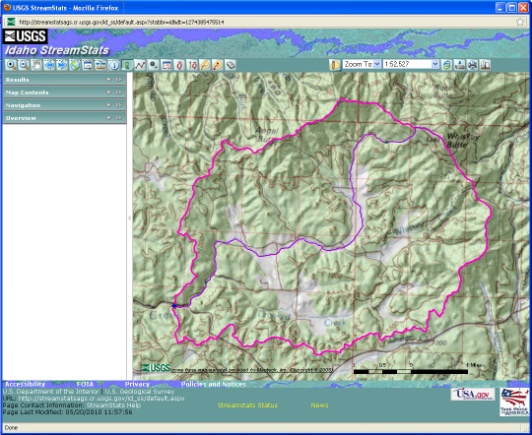


Proposal: Updating Streamflow Estimation Equations for Ungaged Streams and Implementation of StreamStats, a Web-Based User Interface, for the Cook Inlet Basin, Alaska



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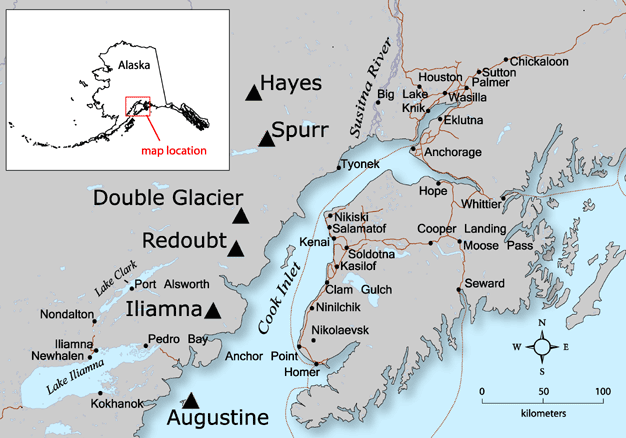
Anchorage, Alaska 99501-3577

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# Problem

The Cook Inlet Basin in southcentral Alaska (fig. 1) drains 39,325 mi2 and contains the most densely populated area of the state of Alaska as well as valuable aquatic resources. Streamflow information for rivers and streams in the Cook Inlet Basin frequently is used by various organizations to meet agency missions and legislative mandates. Information is needed at gaged sites with recorded flow data for some applications and at ungaged sites where no observed flow data are available for other applications. Estimation of streamflow statistics for both gaged and ungaged sites can be slow and resource intensive, might be performed using different methods with varying documentation and scientific validity, and often is not feasible for the public and non-hydrologists because they require training, multiple data sources, and expensive computer software and resources.



**Figure 1**. Cook Inlet and vicinity. Brown lines show terrestrial and marine highway routes, and triangles show the location of volcanoes.

Implementing StreamStats, a web-based Geographic Information System (GIS) application for computing streamflow statistics at any stream location, and updating streamflow statistics to take advantage of an additional 10 years of data, will improve the accuracy and delivery of streamflow information within the Cook Inlet Basin. StreamStats, developed by the USGS in cooperation with Environmental Systems Research Institute, Inc. (ERSI), is a nationally-standardized analytical tool that has been implemented or is underway for more than half the states in the nation. StreamStats is simple to use, requiring only that the user click on a map to identify the stream location of interest. If the location is at or near a streamgage, the web tool will provide the most recently published streamflow statistics from available streamflow records. If the location is ungaged, the web tool will delineate the basin boundary, determine basin characteristics, and calculate all streamflow statistics that can be estimated using regression equations reported by USGS. The user can then download a map of the basin and a streamflow-statistics summary that includes confidence intervals. The web tool is available to all so that the public as well as scientists and managers can quickly obtain information on basin characteristics and streamflow statistics. The USGS web site http://water.usgs.gov/osw/streamstats/ provides complete details on this application and links to areas where it is already functional.

The Alaska Department of Natural Resources (ADNR) is cooperating with the USGS Alaska Science Center to update streamflow statistics and implement StreamStats for the Cook Inlet Basin. This will further the goal of the Department of Natural Resources to manage water resource allocations with rapid retrieval of best available data to protect the environmental resource while furthering economic growth and the health and well being of people in the Cook Inlet Basin. Over or under allocation of water could result in damage to the physical environment, and the ecosystems upon which life is dependent. The StreamStats application directly addresses the allocation of water issue based on best available science as it provides the water right adjudicator consistent access to flow data and drainage basin information not currently easy to acquire.

# Objectives

The goal of this project is to update and improve delivery of streamflow statistics and information for the Cook Inlet Basin, Alaska. Specific tasks for this project include:

1. Gather required topographic, hydrographic, and watershed boundary datasets and available basin characteristic datasets and process to generate a hydrologically enforced DEM, pre-processed catchment information, and basin characteristic datasets in a preliminary Cook Inlet Basin StreamStats application prior to addition of streamflow information.
2. Compute basin characteristics for USGS streamgages in the Cook Inlet Basin, including new basin characteristics not previously available, using the preliminary Cook Inlet Basin StreamStats application.
3. Update streamflow statistics for peak streamflows and mean annual flow for USGS streamgages in the Cook Inlet Basin.
4. Revise streamflow analysis regions for the Cook Inlet Basin from those previously published for the state.
5. Develop new regional regression equations for estimating streamflow statistics at ungaged basins in the Cook Inlet Basin using statistically and hydrologically significant basin characteristics.
6. Integrate the streamflow statistics for streamgages, streamflow analysis regions, and regression equations for ungaged basins with the preliminary Cook Inlet Basin StreamStats application. Test the completed application for accuracy and complete the final adjustments for public release of Cook Inlet Basin StreamStats.

# Relevance and Benefits to USGS

# A more efficient delivery of streamflow statistics directly addresses three of the science directions identified in the USGS strategic plan (2007). The Water Census goal of forecasting the likely outcomes for water availability caused by changes in land use and land cover, natural and engineered infrastructure, water use, and climate can be addressed more effectively with efficient, reproducible estimates of streamflow that have identified accuracy. The widest use of previous statewide regressions is to estimate the magnitude of various frequency floods from ungaged basins to better mitigate flooding, better engineer road crossings and riparian structures, and identify flood-hazard zones, addressing the National Hazards, Risk, and Resilience Assessment Program. New statewide assessments of hydrokinetic and hydropower resources rely heavily on rapid assessments of average discharge and streamflow duration at ungaged locations around Alaska, addressing Energy and Minerals for America’s Future.

# Approach

The general process of building a StreamStats application for a state has been refined by the USGS Office of Surface Water (OSW) through experience with more than half the states in the nation and is now conveyed in a USGS training class. Alaska project staff attended this training in May 2010 and will follow this general process for the Cook Inlet Basin application. Modifications required by new advances in StreamStats technology or by issues with Alaskan datasets will be resolved in collaboration with the OSW. The specific tasks include a GIS component, a hydrologic analysis component, and integration of these components into the StreamStats application.

The exact level of effort required to resolve Alaska-specific challenges to the process cannot be predicted, so processing will progress in a spatially tiered manner to maximize the area that can be completed. Major drainage basins in the Cook Inlet Basin (fig. 2) can be sectioned off for exclusion if needed to achieve a functional StreamStats application for priority areas. Individual sub-basins (HUC8s) will be completed according to the priorities shown in figure 3. The highest priority areas include those parts of the Cook Inlet Basin with streamgages and more developed areas.

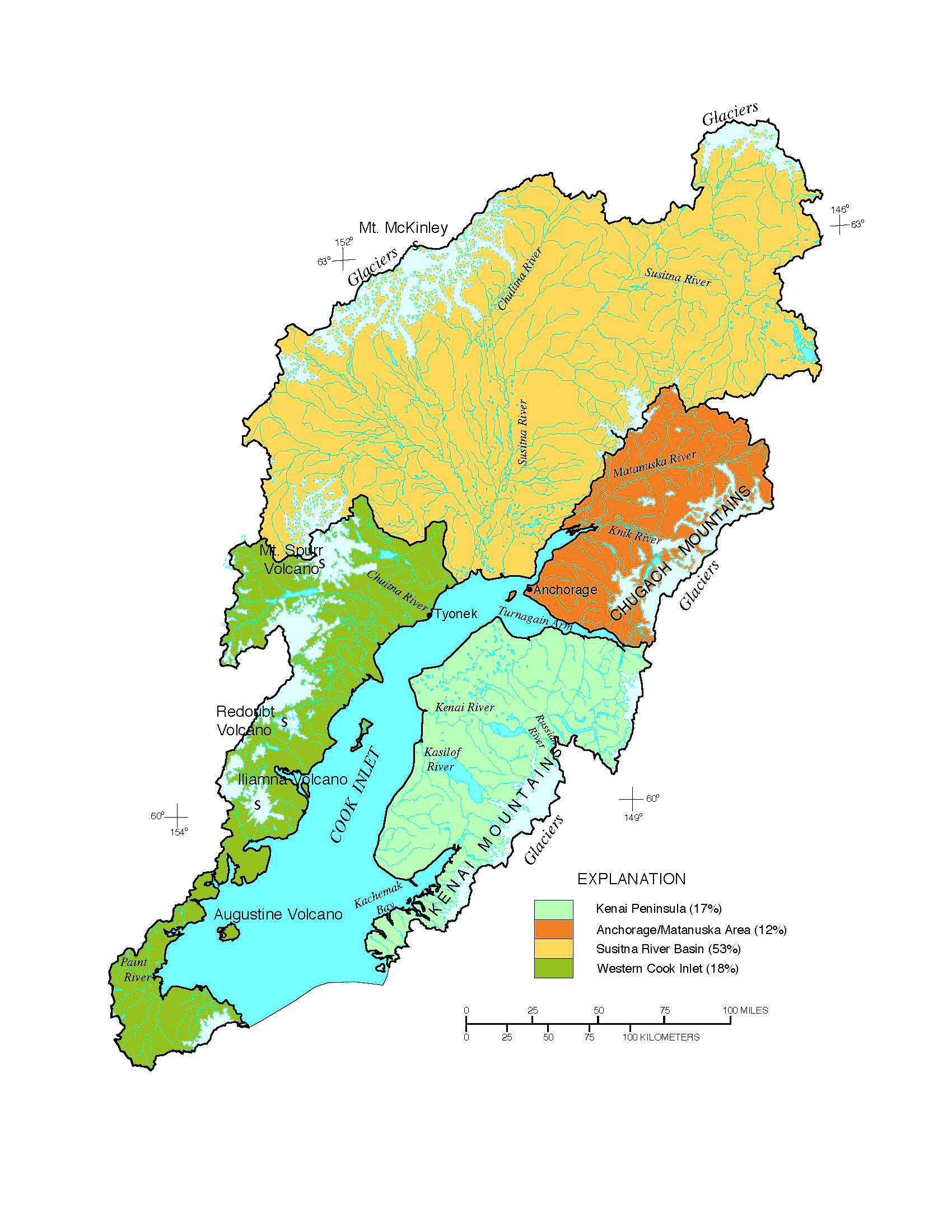


Figure 2 Major drainage basins in the Cook Inlet Basin, Alaska

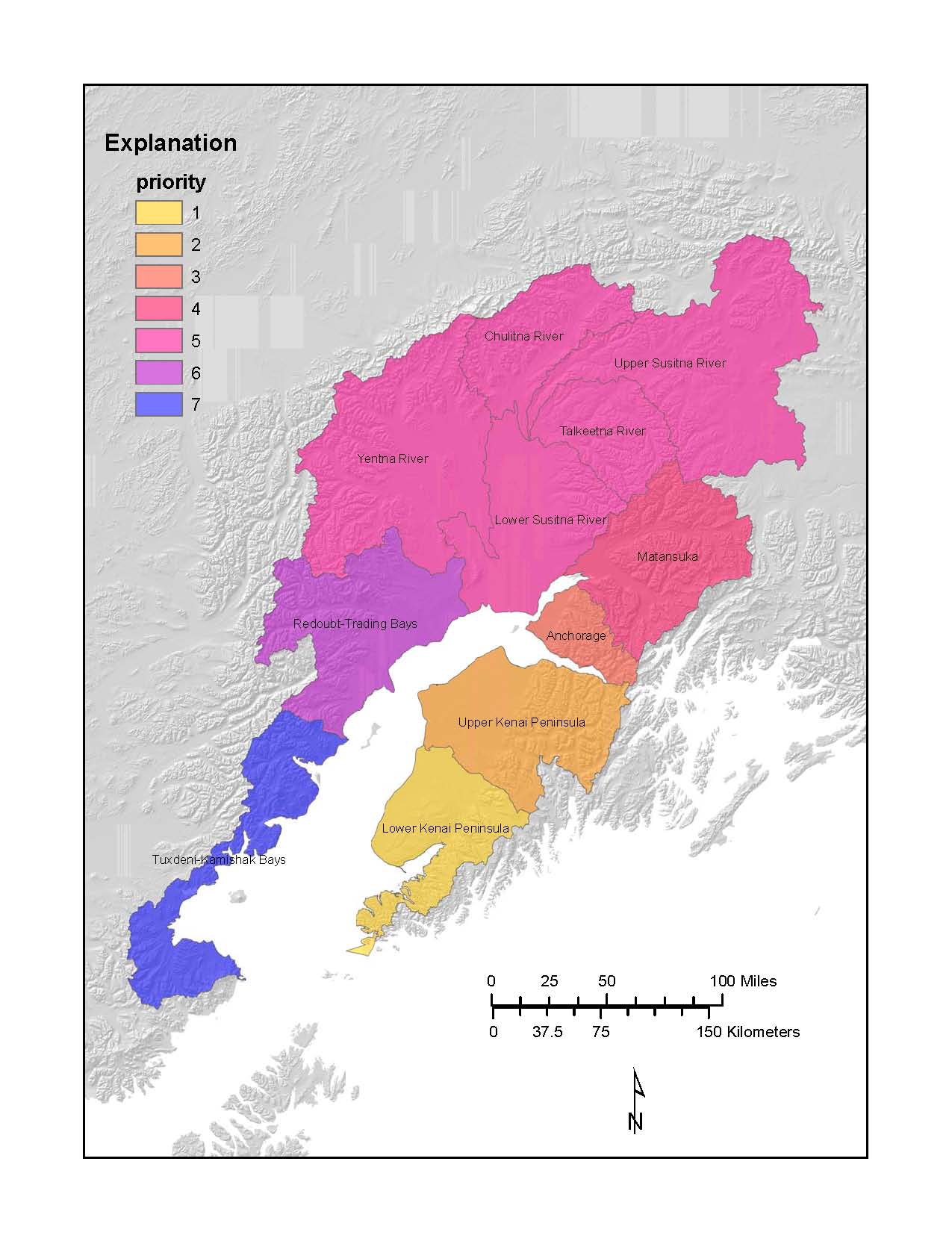


Figure 3 HUC8s in the Cook Inlet Basin ranked by priority for order of completion

## Task 1: Gather and prepare topographic, hydrographic, and watershed datasets for use in StreamStats

Datasets required for building StreamStats are a DEM, a hydrography dataset, and watershed boundaries. For most states, NED elevation data, NHD or NHD+ hydrographic data, and WBD or HUC boundaries are available and applicable in scale. For Alaska, issues with resolution or data quality will require different datasets or adjustment of existing datasets before processing for StreamStats can begin.

The 60-m DEMs now available for Alaska from NED data are inadequate for this project. A 30-m DEM of Cook Inlet Basin prepared for the previously completed NAWQA project is of sufficient resolution for the project and is buffered to include area beyond the coastlines, a feature necessary for processing hydrographic data for StreamStats.

NHD+ has not yet been created for the Cook Inlet Basin. The 1:63,360 scale NHD hydrography is lower resolution than the typical 1:24,000 NHD used for most states, but it is appropriate for use with the 30-m DEM. The Alaskan data in NHD has many known issues including disconnected lines, reversed flow directions, and poor attributes. Errors in this category will need to be resolved before processing for StreamStats can begin. Errors in stream locations or extent are abundant given the resolution of the 1:63,360 source data, but correcting these errors is beyond the scope of this project.

A Watershed Boundary Dataset is newly available for Alaska and includes 12-digit HUCs, a reasonable resolution for working within the Cook Inlet Basin. The WBD will be augmented with ASC’s independently prepared internal library of basin boundaries for streamgages. Although the basin outlines do not match the HUCs exactly, options for specifying the boundary to use during the process of building StreamStats are expected to eliminate the need to merge the basin boundaries into the WBD as a new product.

## Task 2: Process topographic, hydrographic, and watershed datasets for use in StreamStats

The first processing step for developing StreamStats consists of building an infrastructure of artificial walls, cliffs, lake gradients, and other features to enforce basin and flow definition. Hydrography is burned into topography to ensure consistency between datasets. The end result of this step is a functional HydroDEM model ready for analysis of catchments. Although this represents a significant amount of the preparation of any StreamStats project, the length of coastline in the Cook Inlet Basin represents a significant additional processing burden, as the NHD requires manipulation to ensure proper flow into the ocean. This is an emerging issue for StreamStats developers and will require collaboration with others familiar with the problem. Preliminary discussions have indicated that a solution used for other states might be applicable here as well.

## Task 3: Prepare pre-processed catchment products

This processing step is standard for any StreamStats project and consists of construction of catchment data that are stockpiled as pre-processed packages for speeding online processing during StreamStats use. These internal, intermediate products are only accessed in the background of the StreamStats program. Once these products are complete, StreamStats is functional for basin delineation and computation of basin characteristics involving topographic and hydrographic data only.

## Task 4: Use preliminary Cook Inlet Basin StreamStats to compute basin characteristics for all streamgages to be used in regression

Datasets for basin characteristics including precipitation and temperature from PRISM models, vegetation cover, and glacier cover will be loaded into StreamStats for development of regression equations. Other basin characteristics are computed directly from the hydrographic and topographic data loaded into StreamStats. The preliminary Cook Inlet Basin StreamStats application will be used to derive basin outlines and basin characteristics for streamgages used in the regressions to ensure consistency between source data for regression development and end users.

## Task 5: Compute streamflow statistics for streamgages

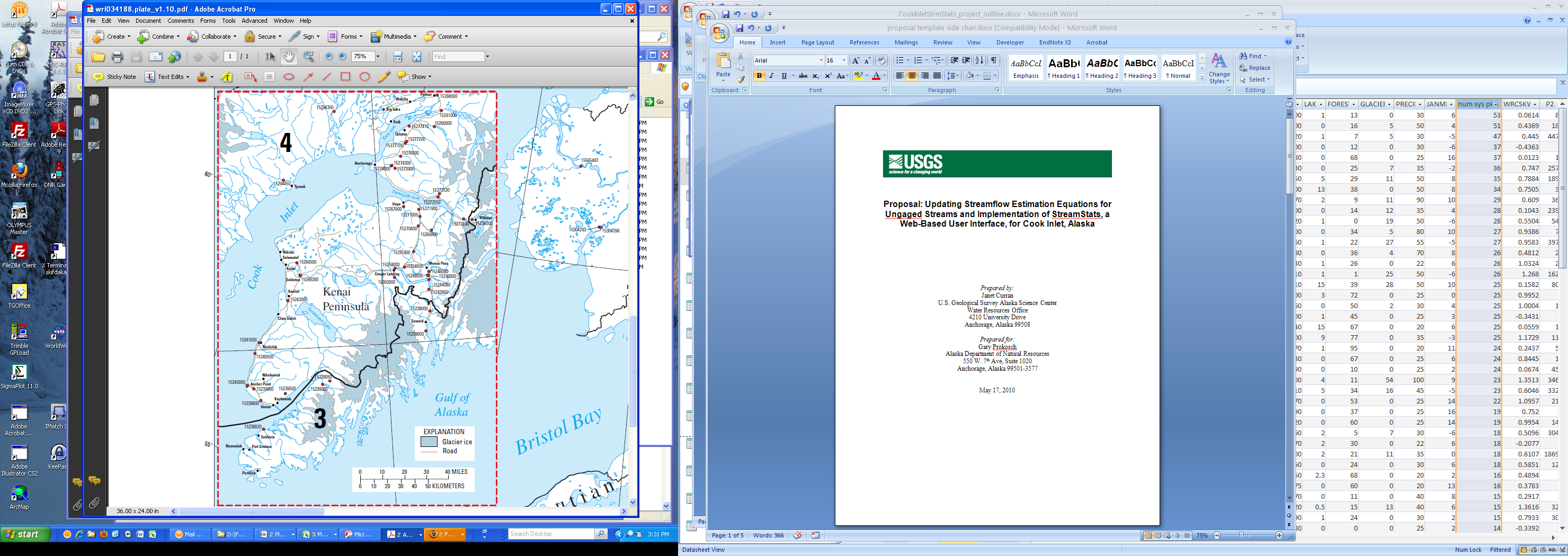
Streamflow statistics for peak streamflows and mean annual flow will be prepared for USGS streamgages in the Cook Inlet Basin with at least 10 years of data through water year 2009. Statistics to be computed include the peak streamflow statistics 50, 20, 10, 4, 2, 1, 0.5, and 0.2 percent chance flood (the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year recurrence interval flows, respectively), and mean annual flow. For peak streamflows, 63 stations from the previous analysis through water year 1999 (Curran and others, 2003) (fig. 4) will be combined with as many as 16 stations previously having fewer than 10 years of record. Fewer stations will be available for updating the previous mean annual flow analysis of Parks and Madison (1985) because this analysis requires a daily record not available at all stations. Peak streamflow statistics will be computed using a log-Pearson Type III analysis in accordance with the procedures in Bulletin 17B (Interagency Advisory Committee on Water Data, 1982).

## Task 6: Develop regression equations for estimating streamflow statistics for ungaged basins.

New basin characteristics will be explored to determine the most statistically and physically relevant estimators of streamflow. At present, nearly all of the Cook Inlet Basin streamgages fall in streamflow analysis region 4, so a single streamflow analysis region will be a default option. However, new streamflow analysis regions subdividing the Cook Inlet Basin will be statistically explored to capitalize on factors like the physiographic and climatic differences between the Kenai and Mat-Su regions. A new regional skew will be computed using stations with at least 25 years of record. The USGS program WREG (Eng and others, 2009), specifically designed for production of streamflow estimation equations, will be used to produce final regression equations. The streamflow statistics and basin characteristics for streamgages, and the regression equations derived from them to be used to predict flow from ungaged basins, will be published in a USGS report.

## Task 7: Add hydrologic data and equations to StreamStats, check for errors, and release final StreamStats application

Streamgage streamflow statistics and basin characteristics, streamflow analysis regions, regression equations for ungaged basins, and metadata will be loaded into the Cook Inlet Basin StreamStats application. This fully functional, non-public version of StreamStats will be used to complete an error checking process that includes comparison of previously determined basin characteristics for streamgages and StreamStats derived values. The final application will be customized for user interface attributes such as display of basin characteristics datasets and released to the public at the end of the project.



**Figure 4. S**treamgages and streamflow analysis regions used in the most recent study for estimating peak streamflows, Curran and others (2003).

Products

New streamflow statistics for streamgages and new regression equations for estimating streamflow statistics in the Cook Inlet Basin will be published in a USGS Scientific Investigations Report describing their development, accuracy, use, and limitations. The final Cook Inlet Basin, Alaska StreamStats application will house the new hydrologic data and equations as well as all processed digital datasets needed for use of StreamStats. Metadata documenting relevant components will be accessible through the StreamStats application.

Budget

Costs for this project total $538,477 and are divided between ADNR and USGS as shown in the table below. The project is planned for three years, following the state fiscal year of July-June. The project would span federal fiscal years FY10-13 to account for the shift in timing of fiscal years.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **ADNR** | **USGS** | **Totals** |
| Year 1 (state FY11) | $125,000 | $51,159 | $176,159 |
| Year 2 (state FY12) | $125,000 | $56,159 | $181,159 |
| Year 3 (state FY13) | $125,000 | $56,159 | $181,159 |
| **Totals** | $375,000 | $163,477 | $538,477 |

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Year 1** | **Year 2** | **Year 3** |
| SUPPLIES AND EQUIPMENT |  |  |  |
| Field and office supplies, equipment, transportation | $1,000 | $1,000 | $1000 |
|  |  |  |  |
| TRAVEL |  |  |  |
| Lodging, meals, incidentals, fuel | $1000 | $1,000 | $1,000 |
|  |  |  |  |
|  |  |  |  |
| SALARIES |  |  |  |
| Hydrologist | $44,040 | $45,289 | $45,289 |
| Biologist | $130,119 | $133,870 | $133,870 |
| **Totals** | **$176,159** | **$181,159** | **$181,159** |

Personnel

Personnel required for this project are available from the USGS Alaska Science Center. Consultation with OSW staff and other Science Center staff is expected, and the StreamStats staff will install the preliminary and final models on the appropriate national servers. Janet Curran, Hydrologist, will serve as Project Chief and will produce new streamflow statistics at gaged sites and regression equations for ungaged sites. Robert Ourso, Biologist, will adjust GIS datasets and build the GIS infrastructure for StreamStats.

# Work Plan

Concurrent processing of GIS data and compilation of streamflow statistics at streamgages can proceed in the first year. The GIS components of the Cook Inlet Basin StreamStats application must be fully built to enable acquisition of basin characteristics for completing hydrologic analysis and development of regression equations in the second year. Although error checking will occur throughout the process, a systematic verification of StreamStats results with previously computed results at streamgages will occur in the final year. The table below shows the expected timing of tasks by year and quarter to avoid confusion with state and federal fiscal years.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Tasks** | **Year 1** | | | | **Year 2** | | | | **Year 3** | | | |
| **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** | 1 | **2** | **3** | **4** |
| 1. Gather and prepare GIS datasets | X | X |  |  |  |  |  |  |  |  |  |  |
| 1. Process GIS datasets for StreamStats (complete HydroDEM) |  | X | X | X | X |  |  |  |  |  |  |  |
| 1. Prepare pre-processed catchment products |  |  |  | X | X | X |  |  |  |  |  |  |
| 1. Compute basin characteristics |  |  |  |  |  |  | X | X |  |  |  |  |
| 1. Compute streamflow statstics at streamgages | X | X | X |  |  |  |  |  |  |  |  |  |
| 1. Develop regression equations |  |  |  |  |  |  |  | X | X |  |  |  |
| 1. Add streamflow data and equations to StreamStats |  |  |  |  |  |  |  |  | X |  |  |  |
| 1. Check for errors |  |  |  |  |  |  |  |  | X | X |  |  |
| 1. Finalize StreamStats |  |  |  |  |  |  |  |  |  |  | X | X |
| 1. Prepare report |  |  |  |  |  |  |  |  | X | X | X |  |
| **Products** | **Year 1** | | | | **Year 2** | | | | **Year 3** | | | |
| **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** | 1 | **2** | **3** | **4** |
| Publish regression equations in USGS Scientific Investigations Report |  |  |  |  |  |  |  |  |  |  | X |  |
| Release public version of Cook Inlet Basin StreamStats |  |  |  |  |  |  |  |  |  |  |  | X |

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