# ALASKA STAND-ALONE GAS PIPELINE GEOHAZARDS STUDY

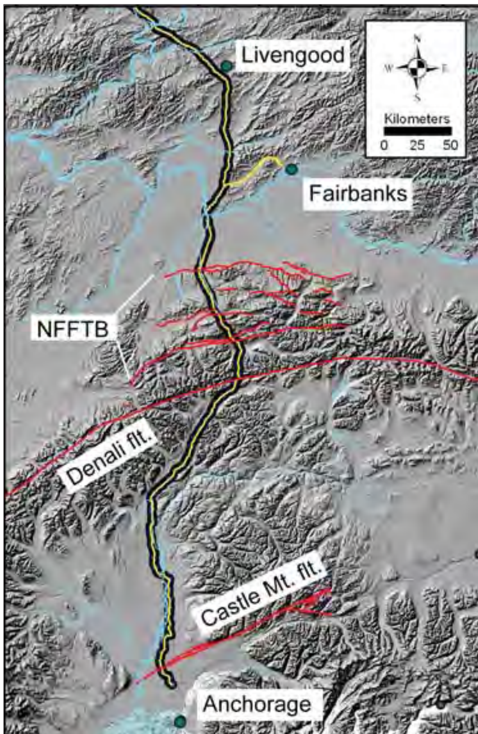


*Figure 1. Hillshade map showing southern portion of proposed Alaska Stand-Alone Gas Pipeline (ASAP) route alignment and major faults. Primary gas line shown in black and yellow, smaller spur line to Fairbanks in yellow. NFFTB denotes Northern Foothills Fold and Thrust Belt.*

In 2011, the Alaska Division of Geological & Geophysical Surveys (DGGS) initiated a multi-year geohazards investigation along the proposed Alaska Stand-Alone Gas Pipeline (ASAP) from Livengood to Anchorage (fig. 1). The ASAP project is being considered as an in-state pipeline designed to provide long-term supplies of natural gas from the North Slope to local markets. The purpose of the DGGS investigation is to characterize a variety of geologic hazards including earthquakes, mass movements, and cryogenic processes that could potentially affect pipeline route feasibility, design, and construction. DGGS's approach is to systematically evaluate geohazards along the proposed route based on a series of sequential studies that progress from more general to specific as detailed information develops.

During the 2011 summer field season, DGGS geologists compiled existing maps and data, contracted and acquired new high-resolution airborne lidar data (described separately, p. 54), and performed helicopter and field reconnaissance aimed at characterizing geologic hazards (fig. 2). Relevant geospatial data sources were integrated into a common Geographic Information System (GIS) where all the available data could be cataloged, georeferenced, and analyzed at the same scale. The project geodatabase will be used to archive specific data related to the assessment of geologic hazards and the pipeline alignment, including soil characteristics, Quaternary geology, active fault traces, landslide scarps, floodplains, and permafrost issues. The project GIS data were also used to plan logistics for daily field programs, which were conducted out of four base camps near Willow, Talkeetna, Cantwell, and Healy.

DGGS geologists have begun to produce a preliminary geohazards report and map showing areas susceptible to geologic hazards along the pipeline route. Hazard maps originally compiled on topographic maps will be reevaluated and upgraded based on our interpretation of the recently acquired lidar data. Final maps will show the location, distribution, and relative importance of specific geologic hazards, which will be useful to assess route alignment and sites for more detailed, site-specific analyses. Critical geologic hazards identified during the 2011 field season will be further investigated in 2012. In particular, site-specific fault studies along the Castle Mountain and Denali faults (fig. 1) will help define fault displacement parameters necessary for adequate pipeline design considerations. Funding for this project was provided by the Alaska Gasline Development Corporation.


*Figure 2. DGGS geologist measuring a stream offset along the Denali fault east of Cantwell. Photo by Rich Koehler, June 12, 2011.*

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## ASSESSMENTS OF GEOLOGIC HAZARDS ASSOCIATED WITH CLIMATE CHANGE

Evidence indicates that most high-latitude northern regions have undergone rapid and substantial warming over the last few decades. Alaska is particularly sensitive to the effects of climate warming, as much of its social and economic activity is affected by the conditions of snow, ice, and permafrost. Changes in climate can modify natural processes and could increase the magnitude and frequency of certain types of geologic hazards (such as flooding, erosion, slope instability, and thawing permafrost) (fig. 1) and, if not properly addressed, can have a direct effect on Alaska communities and infrastructure, as well as on the livelihoods and lifestyles of Alaskans. The State can help preserve the integrity of its infrastructure and the health and safety of Alaska's people by being prepared for potential emergency situations resulting from geologic hazards that are caused or amplified by climate change. A critical first step is to perform the necessary sound science to identify high-risk areas where proactive mitigation efforts will be needed and useful, and areas where design structure and proper, informed planning can alleviate the need for future mitigation.

The Division of Geological & Geophysical Surveys (DGGS) has developed a Climate Change Hazards Program to rigorously assess geologic hazards associated with climate change and publish information to be used for planning, hazard mitigation, and emergency response in high-risk communities and developing areas. DGGS is accomplishing this by collecting the necessary field data to assess geologic hazards and publish peer-reviewed geologic-hazards maps and reports of high-risk communities and infrastructure in Alaska. We are completing these assessments at local and/or regional scales as needed to address specific local problems and to understand and evaluate the larger geologic context. This effort is a collaboration with relevant outside organizations including the Immediate Action Work Group of the Governor's Subcabinet on Climate Change, University of Alaska, Federal Emergency Management Agency, Alaska Division of Homeland Security & Emergency Management, Alaska Department of Commerce, Community and Economic Development, U.S. Geological Survey, and U.S. Army Corps of Engineers, and will provide valuable information to allow planners and design engineers to minimize the economic impacts and public safety risks associated with geologic hazards.

DGGS scientists conducted field-based geologic hazards assessments and mapping in and around the communities of Seward and Whittier during summer 2011, and expect to complete draft products for these communities in FY2012. The geologic-hazards maps will delineate areas where potential natural hazards such as avalanches, flooding, erosion, slope instability, and thawing permafrost should be considered at a more detailed level to fully evaluate risk for any given use and will be published in digital GIS format in conformance with national standards. Reports describing the geology and hazards will accompany the maps.

The Climate Change Hazards Program is funded by the State of Alaska as a Capital Improvement Project (CIP).

*Figure 1. Multiple transverse cracks indicate an unstable south-facing slope above Spruce Creek and Lowell Point near Seward, Alaska. Increases in temperature and the number of high-magnitude precipitation events can lead to an increase in landslide activity that can threaten property and infrastructure.*

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## GEOHAZARD EVALUATION AND GEOLOGIC MAPPING FOR COASTAL COMMUNITIES

According to the 2010 United States census, more than 60 percent of Alaskans reside in coastal communities. Many of these communities are exposed to a wide range of geologic hazards including erosion, landslides, wave attack, storm surge/flooding, tsunami and ivu (ice push). Since 2004, reports and recommendations from the U.S. General Accounting Office, the U.S. Army Corps of Engineers, and the Immediate Action Work Group of the Governor's Subcabinet on Climate Change have highlighted the imperiled or at-risk status of many Alaskan villages that are subject to severe flooding and erosion. In response to both existing risks and to shifts in the frequency and/or magnitude of geohazard-triggering events, including those that may be influenced by changing climate, communities throughout the state are becoming increasingly involved with mitigation or adaptation efforts in response to these natural hazards. Baseline data pertaining to local geology, coastal and oceanic processes, and historic natural hazard events are necessary to facilitate these efforts (fig. 1).


*Figure 1. Meagan DeRaps uses precision GPS equipment to measure elevations (a) perpendicular to a Unalakeet beach and (b) on a bluff ~10 miles east of Nome that was overtopped in the 2011 Bering Sea storm.*

In 2009, DGGS received federal funding from the Minerals Management Service (now Bureau of Ocean Energy Management) through the Coastal Impact Assistance Program (CIAP) to establish a coastal community geohazards evaluation and geologic mapping program in support of local and regional planning. Following an extensive review of existing data and consultation with numerous agencies and affected coastal districts, a priority mapping list was developed (fig. 2). The program was launched in 2010 with a pilot project in Kivalina (see p. 52), which leveraged State CIP funds and federal STATEMAP funds from the U.S. Geological Survey for an expanded scope. Subsequent fieldwork in the summer of 2011 was conducted in the communities of Shaktoolik and Unalakleet. Maps and reports for Kivalina will be published in 2012, and those for Shaktoolik and Unalakleet will be published in 2013.

The DGGS CIAP program will document the geologic context and dominant coastal processes near at least nine Alaskan communities by FY2014. A coastal geohazard map series tailored to the specialized needs of Alaska will identify local natural hazards that must be considered in the siting, design, construction, and operations of development projects to ensure protection of human life, property, and the coastal environment. Where necessary, surficial geologic mapping (1:63,360 scale) will also be completed. These maps will be published in GIS format with standard metadata. For communities that are seeking to relocate or to establish evacuation shelters/routes, these products will be a useful planning tool for informed decision making because they delineate areas where geologic hazards should be considered at a more detailed level to fully evaluate construction risk, identify potential sources of construction materials, and ensure that planned and proposed development will not exacerbate existing hazards.

Ongoing consultation and coordination with the Immediate Action Work Group, Alaska Division of Community & Regional Affairs, U.S. Army Corps of Engineers, Alaska Department of Transportation & Public Facilities, U.S. Geological Survey, National Oceanic and Atmospheric Administration, affected coastal communities, and private-sector geotechnical consultants will continue to shape this program and avoid duplication of efforts.

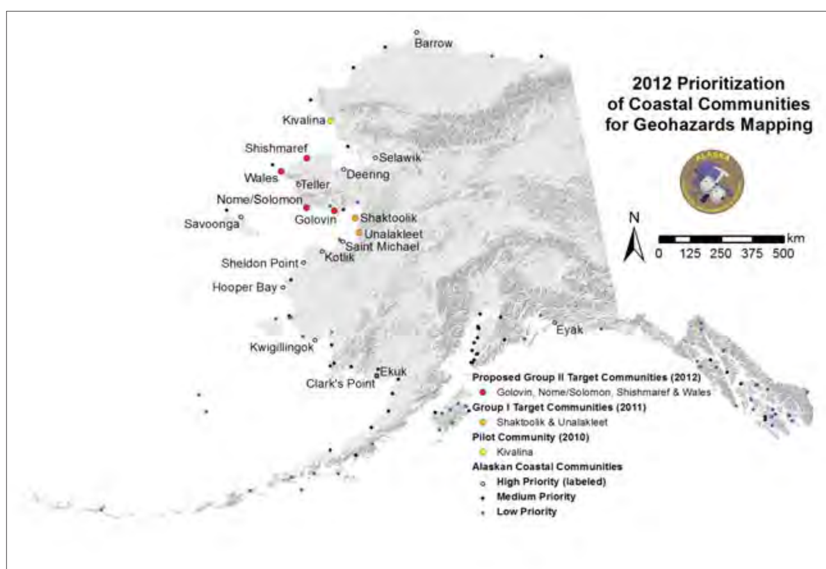


*Figure 2. Communities currently selected for inclusion in the DGGS CIAP mapping program. Prioritization is subject to revision based on direct dialogue with community leadership and the recommendations and activities of other state, federal, and local agencies.*

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## GEOLOGIC MAPPING AND HAZARDS EVALUATION IN AND NEAR KIVALINA, NORTHWEST ALASKA

Approximately 10,600 kilometers of Alaska's coastline and many low-lying areas along the state's rivers are subject to severe flooding and erosion. The United States General Accounting Office (GAO; now the U.S. Government Accountability Office) reported in 2004 that flooding and erosion affects 184 out of 213 (86 percent) of Alaska Native villages. These findings were reinforced by subsequent studies, conducted by the U.S Army Corps of Engineers and the Immediate Action Workgroup of the Alaska Governor's Subcabinet on Climate Change, which identified a number of communities as being in greatest peril due to anticipated climate change phenomena and therefore in most need of immediate actions to prevent loss of life and property.

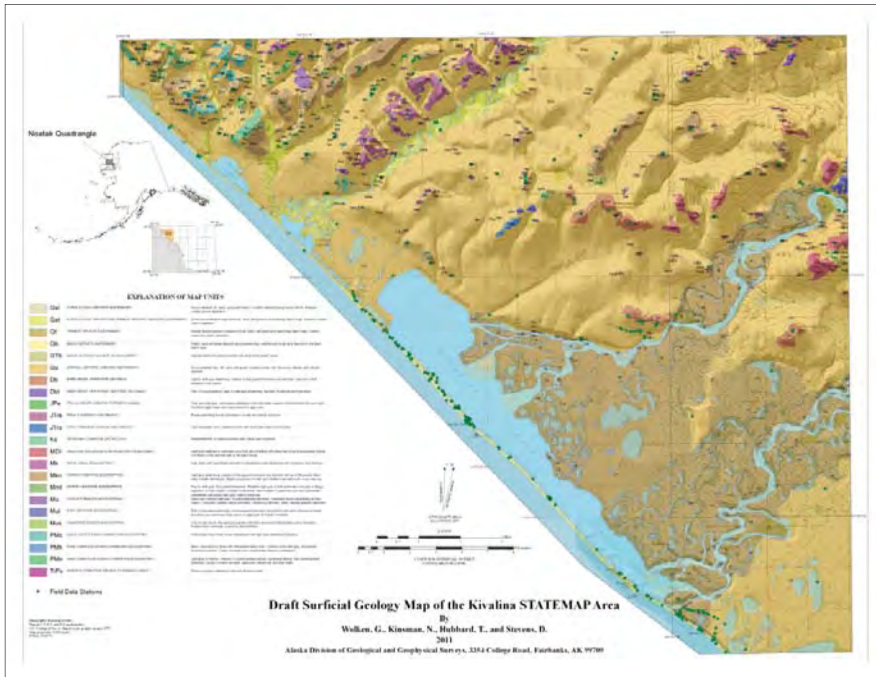


*Figure 1. Draft surficial-geologic map of Kivalina study area.*

The Alaska Division of Geological & Geophysical Surveys (DGGS) has statutory responsibility to perform the necessary science to identify high-risk areas where proactive mitigation efforts will be needed and useful. For FFY10, Alaska's Geologic Mapping Advisory Board (GMAB) endorsed DGGS's choice of the high-risk community of Kivalina (fig. 1) as a U.S. Geological Survey (USGS) STATEMAP-funded project in order to map surficial geology and assess geologic materials and natural hazards in support of informed community planning to deal with the severe flooding and erosion.

The objectives of the Kivalina STATEMAP project are: (1) Map the surficial geology in sufficient detail to develop comprehensive lithologic unit descriptions and a geomorphic framework that can be used to understand the active earth processes affecting the village of Kivalina and the surrounding area, and map the bedrock geology at a reconnaissance level sufficient to evaluate the lithologies for general engineering charac-teristics; (2) Develop information matrices and derive maps that describe the general engineering properties of bedrock and unconsolidated geologic units in the map area; and (3) Identify and map potential geologic hazards, including the coastal zone and areas of flooding, erosion, thawing permafrost, and slope instability (fig. 2).

*Figure 2. Thermokarst and drainage system development near Kivalina, Alaska.*

DGGS personnel have compiled field and remote-sensing data and have generated draft maps for the Kivalina STATEMAP project. Additionally, data from this project were presented at the fall 2010 American Geophysical Union and the 2011 American Society of Civil Engineers (ASCE) Solutions to Coastal Disasters Conference. These new data and products will be critical to community planners as they develop and administer their plans in the context of these major undertakings. We anticipate publishing the final maps and report in fall 2012.

This project is funded by the State of Alaska through DGGS's Climate Change Hazards program and by the federal STATEMAP program through USGS. Additional federal funding for this project was provided by the Coastal Impact Assistance Program (CIAP) through the Bureau of Ocean Energy Management as part of the DGGS Coastal Hazards program.

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## GEOLOGY, GEOHAZARDS, AND RESOURCES ALONG THE PROPOSED NATURAL GAS PIPELINE CORRIDOR, ALASKA HIGHWAY, FROM DELTA JUNCTION TO THE CANADA BORDER

In preparation for the proposed Alaska natural gas pipeline, the Alaska Division of Geological & Geophysical Surveys (DGGS) has continued work on a multi-year project to evaluate the geology, geohazards, and material resources between Delta Junction and the Canada border along a 12-mile-wide corridor centered along the Alaska Highway. This work is now being enhanced with recently acquired high-resolution lidar (light detection and ranging) data along an approximately 1-mile-wide corridor centered along the Alaska Highway (fig. 1).

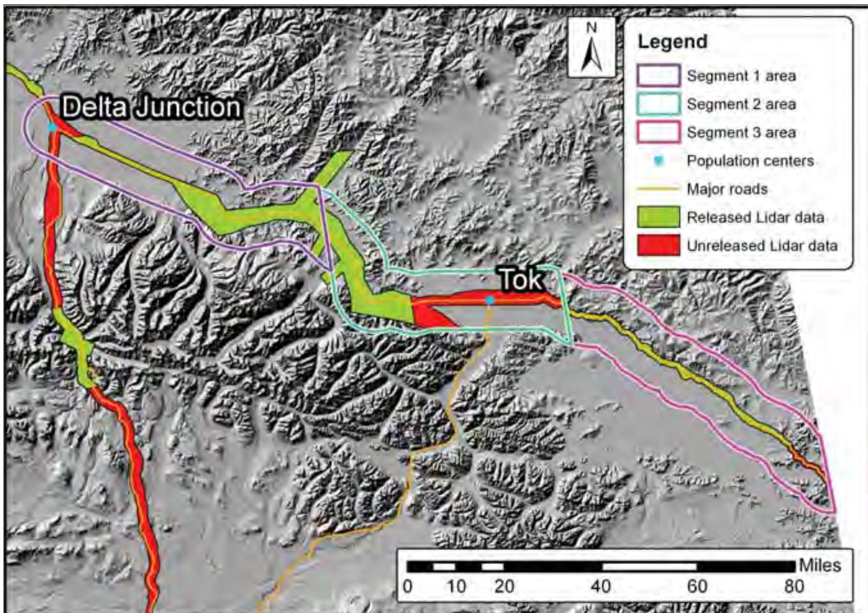



*Figure 1. Map showing the three segments of the Alaska Highway Corridor study and areas where lidar was collected. All lidar data will be available to the public.*

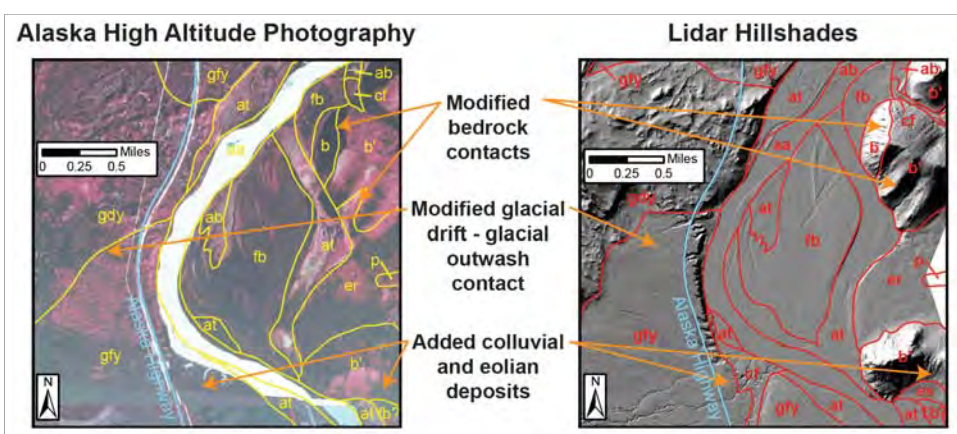
Published materials from each of three segments along this route include reports describing surficial geology, permafrost, bedrock geology, and potentially active faults. Each report, with the exception of one describing potentially active faults, will be accompanied by 1:63,360-scale reconnaissance maps and digital GIS data. An engineering-geologic map and associated descriptive table will also be published as a derivative product from each surficial-geologic map.

During 2011, DGGS published the surficial geology report and accompanying maps for the second segment between Dot Lake and Tetlin Junction. With the exception of bedrock geology, this completes publication of maps and reports for the first two segments. Maps and reports for the third segment of the corridor between Tetlin Junction and the Canada Border are in the advanced stages of editing and we anticipate publication in 2012.

Fieldwork was conducted during the summer of 2011 to refine geologic mapping and use lidar to evaluate potential geologic hazards (fig. 2). DGGS plans to complete fieldwork and lidar evaluation in 2012, and anticipates completing for review a draft comprehensive report describing the geology and geologic hazards for the entire corridor route, including results from lidar evaluations, in fall 2012. DGGS will publish a set of final comprehensive geologic maps in 2013, accompanied by seamless GIS layers of all geologic mapping.

The Gas Pipeline Corridor project is funded by the State of Alaska as a Capital Improvement Project (CIP).

*Figure 2. Examples from the Tanacross B-6 Quadrangle illustrating how lidar is being used to refine geologic contacts originally mapped using airphoto interpretations. Original mapping on left, revised mapping on right.*

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# AIRBORNE LIDAR ACQUISITION FOR GEOLOGIC HAZARD EVALUATION OF PROPOSED NATURAL GAS PIPELINE CORRIDORS

In advance of design, permitting, and construction of potential pipelines to deliver North Slope natural gas to out-of-state and Alaska customers, the Division of Geological & Geophysical Surveys (DGGS) has acquired and is making publicly available high-resolution airborne lidar (light detection and ranging) data for an area of approximately 3,000 square miles along proposed pipeline routes (fig. 1). Financial support for the project comes from the Alaska Gas Pipeline Project Office, the Office of the Federal Coordinator, and the Alaska Gasline Development Corporation (AGDC). These data serve multiple purposes, but were primarily collected to (1) evaluate geologic hazards, including active faulting, slope instability, thaw settlement, erosion, and other engineering considerations along the proposed pipeline routes, and (2) provide a base layer for the State–Federal GIS database that will be used to evaluate permit applications and construction plans.

Lidar data for this project include: (1) Continuous, 1-mile-wide coverage over existing infrastructure along the lengths of the various proposed natural gas pipeline corridors from Prudhoe Bay to Valdez following the route of the Trans-Alaska Pipeline System (TAPS), the Alaska Highway from Delta Junction to the Canada border, and Livengood to the Anchorage area along the George Parks Highway; (2) approximately 1-mile-wide corridors over routes the State believes gas pipeline applicants are considering, where departing from existing infrastructure; (3) half-mile-wide coverage of existing primary pipeline-support roads where outside the main corridor; and (4) expanded areas of coverage along these corridors where data are needed for evaluation of known or suspected active faults, slope instability, and other hazards.

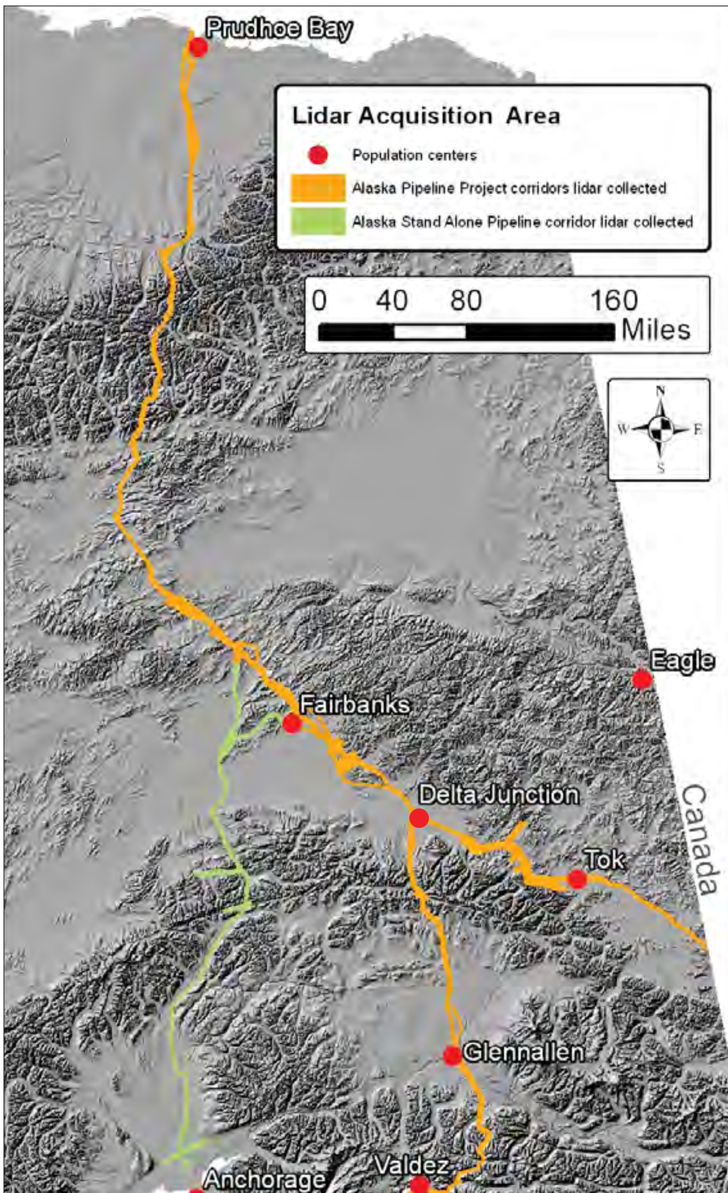


*Figure 1. Lidar acquisition areas.*

The quality-controlled lidar data and products, grouped by USGS quadrangle, are being made available to the public on the DGGS website (http://dggs.alaska.gov/pubs/id/22722) soon after delivery from the contractor. The initial DGGS lidar data release includes bare-earth digital elevation models (DEMs), lidar intensity images, bare-earth hillshade images, and water-body polygons. Other lidar products, including point cloud data, vegetation metrics, and digital surface models will be made available at a later time. In addition to making the data publicly available, DGGS is using lidar data for ongoing projects to evaluate active faults and geologic hazards. For example, the lidar products have enabled the Proposed Natural Gas Pipeline Corridor Geohazards Project (described separately, p. 53) to refine geologic contacts from earlier work and to identify areas of previously unrecognized slope instability. All lidar data and products from this project will be available to the public online by spring 2012.

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## SURFICIAL-GEOLOGIC MAP OF THE LIVENGOOD AREA, TOLOVANA MINING DISTRICT, ALASKA

During the summer of 2003 DGGS geologists mapped the northern 124 square miles of the 229-square-mile Livengood airborne geophysical survey tract (fig. 1). These geophysical and geological projects are part of the Alaska Airborne Geophysical/Geological Mineral Inventory Program, a multi-year investment by the State of Alaska to expand Alaska's geologic and mineral resources knowledge base, catalyze future private-sector mineral exploration and development, and guide State planning. The Livengood area, located about 75 miles northwest of Fairbanks in the northern part of the Tintina gold belt, contains the most productive portion of the Tolovana mining district. Approximately 500,000 ounces of placer gold have been mined from the Livengood subdistrict. The Elliott Highway, numerous mine roads, and the Trans-Alaska Pipeline System (TAPS) corridor provide excellent accessibility to the mineralized zones.

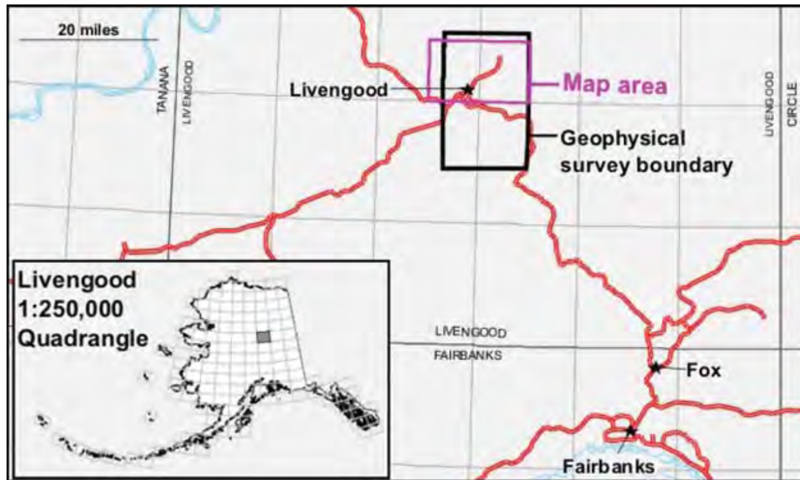


*Figure 1. Livengood study area.*

DGGS published a 1:50,000-scale bedrock geologic map and supporting geochemical and geochronologic data in 2004, but the surficial-geologic map was not completed at that time. In response to current high commodity prices and renewed interest in Livengood-area geology and mineral resources, DGGS is working to revise and update the draft map and publish it in hard copy and GIS formats (fig. 2). In support of this effort, DGGS contractors engaged in field work in summer 2011 to acquire the data necessary to complete the mapping project. We anticipate publication of the 1:50,000-scale surficial-geologic map in fall 2012.

New surficial-geologic interpretations in the map area will lead to better understanding of the geologic framework for placer deposits in the Livengood area, stimulate increased mineral exploration investment, and provide construction-materials resource information useful for planning and construction of future infrastructure in this developing region. The Livengood geologic mapping project was funded by the State of Alaska, with additional support by the U.S. Geological Survey STATEMAP program.

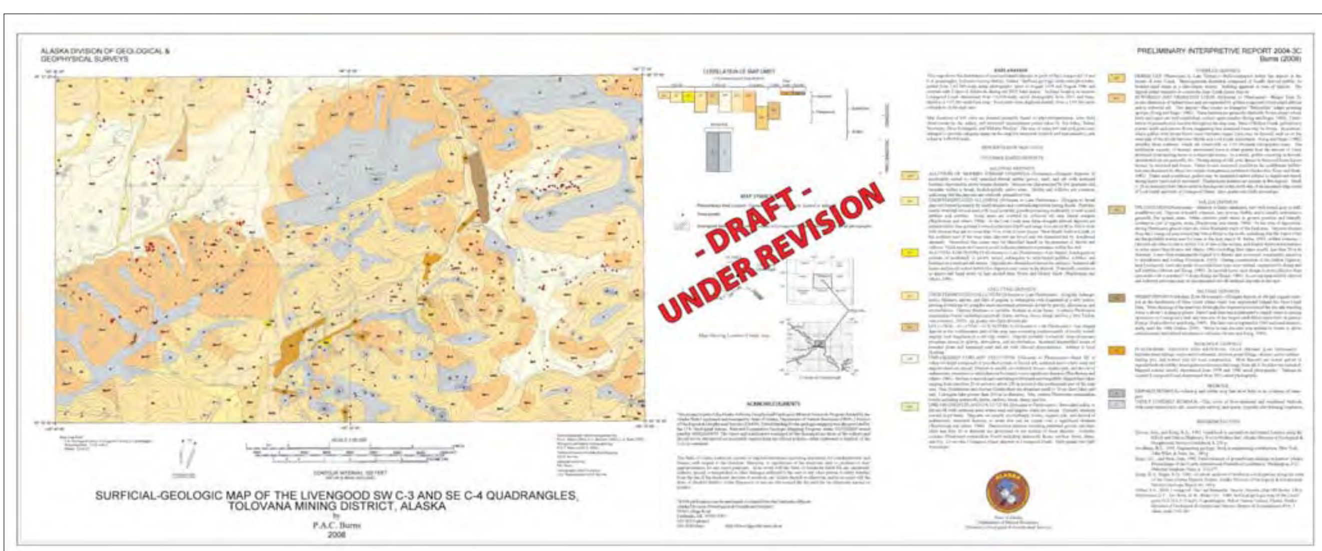


*Figure 2. Draft surficial-geologic map of the Livengood area based on 2003 fieldwork and air photo interpretation. The map is undergoing extensive revision in response to additional field data collected in 2011.*


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## MapTEACH

Alaska's Division of Geological & Geophysical Surveys (DGGS) continues to participate in MapTEACH (Mapping Technology Experiences with Alaska's Community Heritage), an education–outreach program that targets geospatial technology skills for rural Alaska students (fig. 1). This program is a continuation of what was originally a multi-year NSF-funded collaborative project led by DGGS and is now an important part of the University of Alaska Integrated Geography Program. MapTEACH emphasizes hands-on experience with spatial technology (GPS, GIS, Google Earth, and remote-sensing imagery in a local landscape–landform context) in conjunction with traditional activities. Working directly with geologists and local landscape experts, participants are presented with a chance to authentically emulate scientific data collection and mapping activities at a novice level, using real data in a real-world setting.


*Figure 1. The MapTEACH website (http://www.mapteach.org) offers curriculum resources and other helpful information about the program to teachers wishing to explore place-based education in Alaska.*

MapTEACH is founded on the integration of three focus areas: Geoscience, geospatial technology, and local landscape knowledge. Program materials are built on a menu-based model in which users (teachers) can select those portions of the curriculum that are most useful for their classroom objectives. When implementing the full range of MapTEACH curriculum, students and teachers interact in field settings with Native Elders, traditions-based community leaders, and professional geologists from DGGS and the University of Alaska. Introducing students to geoscience and geospatial technology in culturally responsive and stimulating classroom and field settings will enhance community understanding of landscape processes and natural hazards in rural Alaska. It will also foster appreciation of state-of-the-art technology tools and datasets that can be applied to informed community planning and decision making.

*Figure 2. The 2011 MapTEACH Capstone Field Experience provided an intensive field-based integration of the program's focus areas of geoscience, geospatial technology, and local knowledge. Students and teachers collaborated with Elders, local knowledge experts, and scientists to understand, document, and map the history and landscape of the Tanana River between Manley Hot Springs and Old Minto using GPS units and GIS.*

The MapTEACH training model includes multiple workshops and on-site training and classroom visits with participating teachers. In 2011, MapTEACH conducted a 6-day field camp for students, teachers, Elders, and scientists in Manley Hot Springs and Old Minto (fig. 2). MapTEACH is currently working primarily with the Yukon–Koyukuk and Yukon Flats school districts to train science and geography teachers in the use of the MapTEACH curriculum, but the program has attracted the attention of other school districts and resulted in additional teacher-participants in Sleetmute, Hoonah, and Metlakatla.

MapTEACH is funded by the Alaska Department of Education and Early Development (EED) through an Alaska Native Education Program (ANEP) grant to the University of Alaska Fairbanks. Additional EED support is provided through Alaska Title II-A SEP Competitive grants to the Yukon–Koyukuk and Yukon Flats school districts.

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# ALASKA DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS
# FY12 Project Description

## QUATERNARY FAULT AND FOLD DATABASE

The Alaska Division of Geological & Geophysical Surveys (DGGS) has designed a Quaternary fault and fold database for Alaska in conformance with standards defined by the U.S. Geological Survey (USGS) for the National Quaternary fault and fold database (fig. 1). Alaska is the most seismically active region of the United States; however, little information exists on the location, style of deformation, and slip rates of Quaternary faults. Thus, to provide an accurate, user-friendly, reference-based fault inventory to the public, we have produced a digital GIS shapefile of Quaternary fault traces. This database will be of great utility to the earthquake engineering community, the insurance industry, scientific researchers, policy planners, and the general public, and will contribute to the established database of active faults for the nation. The release of the database is timely for the assessment of seismic hazards associated with several proposed natural gas pipelines presently under consideration within the State.

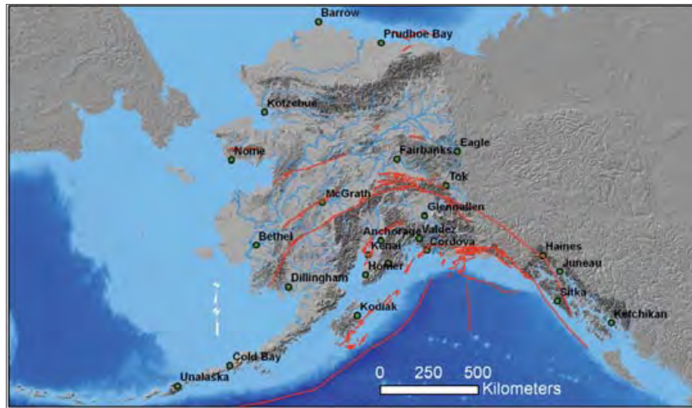


*Figure 1. Hillshade image of the State of Alaska and surrounding areas showing fault traces from the Alaska Quaternary fault and fold database.*

Fault parameters in our GIS fault attribute tables are in accordance with national guidelines and include fault name, age, slip rate, slip sense, dip direction, location confidence (i.e., well constrained, moderately constrained, or inferred), and mapped scale. Our initial effort will serve as a platform to append additional information as new faults are discovered and future detailed studies are implemented.

To host the database, we are developing an interactive web-map application that will present the database through a variable scale range, with each fault displayed at the resolution of the original map. Application functionality includes search by name or location, identification of fault by manual selection, and choice of base map. Base map options include topographic, satellite imagery, and digital elevation maps available from ArcGIS on-line (fig. 2). We anticipate that the database will be publicly accessible from a portal embedded on the DGGS website by early 2012 and will provide a comprehensive resource for seismic hazard assessment and regional policy planning.

Initial funding was provided by the USGS; funding to support the GIS digitizing efforts was provided by the Federal Emergency Management Agency (FEMA) through the Alaska Division of Homeland Security & Emergency Management. Pending additional funding, DGGS plans to develop text-based descriptions about individual structures. Pertinent data summarized in these descriptions will include geographic information, geomorphic expression, length, average strike, sense of movement, age of faulted surficial deposits, existing paleoseismological studies, and a list of references.

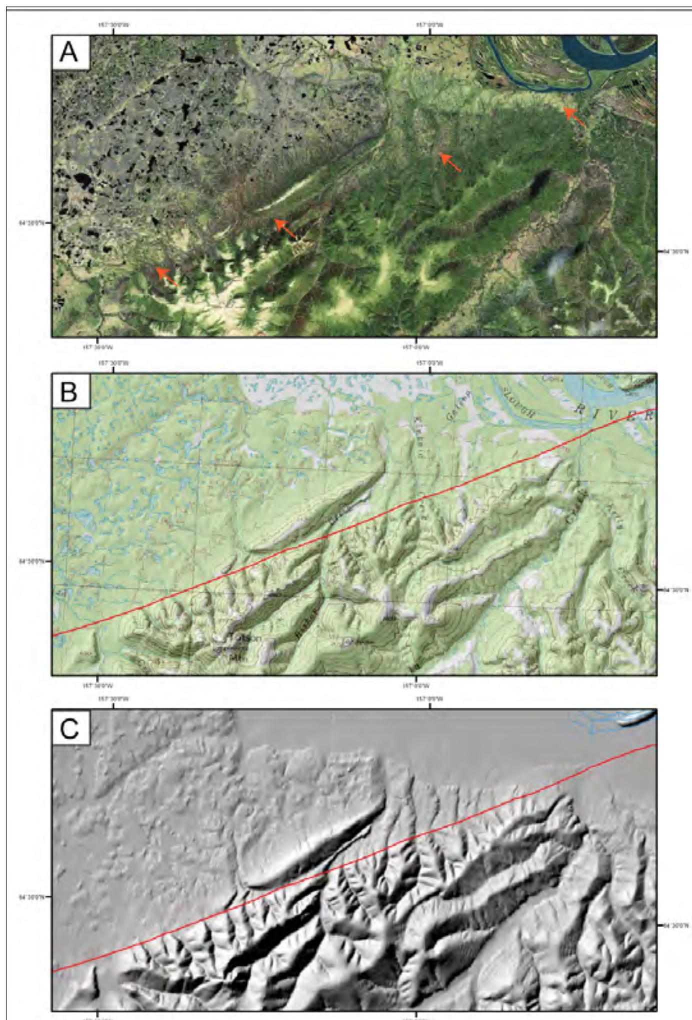


*Figure 2. Examples of the digital base maps available for viewing Quaternary faults and folds in the web-map application. (A) Satellite image, (B) 1:250,000-scale topographic map, and (C) hillshade image. Shown is the Kaltag fault in central Alaska.*

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# SURFICIAL-GEOLOGIC MAP OF THE SAGAVANIRKTOK AREA, NORTH SLOPE ALASKA

The Alaska Division of Geological & Geophysical Surveys (DGGS) continues work begun in 2008 to publish a new 1:63,360-scale surficial-geologic map covering approximately 1,200 square miles of the northern Brooks Range foothills in the Sagavanirktok B-3, B-4, B-5, A-3, A-4, and A-5 quadrangles (fig. 1). The Trans-Alaska Pipeline System (TAPS) and Dalton Highway run through the central portion of the study area; detailed geologic mapping will provide important information about construction materials resources and potential geologic hazards such as thawing permafrost, slope failure, and flooding, which are important for highway and pipeline maintenance, as well as for planning for future infrastructure development.

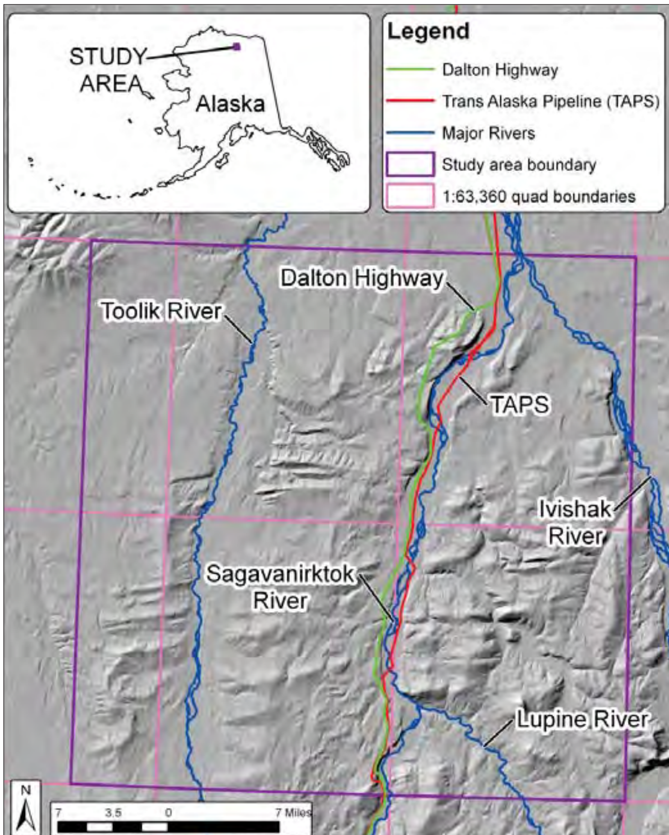


*Figure 1. Sagavanirktok study area.*

The surficial geology of the study area is dominated by glacial deposits, often highly modified by slope processes (fig. 2) and containing extensive ice-rich permafrost. Middle to upper Pleistocene glacial deposits in the southern and eastern parts of the map typically retain primary glacial morphology, whereas Tertiary to lower Pleistocene glacial deposits farther to the north and west are characterized by more gentle gradients and extensive solifluction. Polygonal ground and thermokarst are common in silt-rich, low-lying areas and in unglaciated terrain in the northern- and westernmost portions of the map area.

Surficial-geologic mapping in this area will provide baseline data necessary for future development such as resource exploration and construction of a proposed natural gas pipeline. This kind of detailed baseline geologic information is generally very limited in arctic regions of Alaska. The mapping will additionally provide information useful for assessing the nature and rate of landscape change over time.

We anticipate that the map will be submitted for publication in 2012, with final release expected by 2013. This project has been conducted in conjunction with the DGGS Energy Resources section as part of its continuing work assessing and mapping the geology of the northern foothills of the Brooks Range. The Sagavanirktok mapping project is funded by the State of Alaska, with additional funding provided by the federal STATEMAP program through the U.S. Geological Survey.

*Figure 2. Anaktuvuk River drift of early Pleistocene age is characterized by broad, gently sloping surfaces extensively modified by colluvial and periglacial processes.*

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## SURFICIAL-GEOLOGIC MAP OF THE TYONEK AREA, WEST COOK INLET, ALASKA

In conjunction with the 2010 Tyonek STATEMAP project (see p. 33), the Division of Geological & Geophysical Surveys (DGGS) is undertaking surficial-geologic mapping on the west side of Cook Inlet (fig. 1). The 875-square-mile map area in the northwestern Cook Inlet trough is rich in petroleum, coal, geothermal, aggregate, and timber resources, but the detailed geologic mapping necessary for planning future resource development exists only in part of the area. The purpose of our surficial-geologic mapping is to provide important detailed information for the entire STATEMAP area to supplement cooperative bedrock investigations there by DGGS, the U.S. Geological Survey (USGS), and University of Alaska geologists.

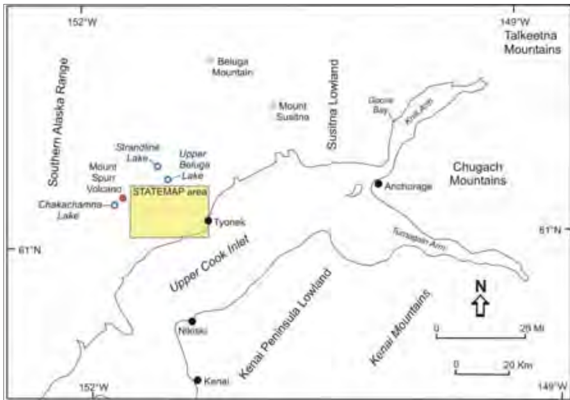


*Figure 1. Location map of Tyonek area.*

Glacial, volcanic, and mass-movement deposits dominate the Tyonek landscape (fig. 2). During the last major glaciation, the map area was invaded by the massive Cordilleran Ice Sheet, which spread eastward into the Cook Inlet trough from sources in the southern Alaska Range to the west and north. Following the maximum ice extent about 23,000 years ago, the glacier complex thinned and ice from individual lobes fluctuated as it deposited glacial and glacioestuarine sediment that is now preserved in the coastal lowland area of northwestern Cook Inlet. Volcanism centered on the Mt. Spurr complex temporarily dammed the valley of Chakachatna River, producing extensive flooding in the southwestern part of the map area. Massive landslides have displaced bedrock and Quaternary sediments in the uplands and valley walls of incised streams, and the volcanic plateau in the northwestern map area is being actively dismantled by complex landslides along the eastern and western margins.

New geologic mapping will lead to a better understanding of the region's geologic framework and provide geologic-resource and -hazards data critical to sound land management decisions. Final products of the Tyonek surficial mapping project will be a report and 1:63,360-scale surficial-geologic map, which are anticipated to be published in summer 2012. Bedrock geologic mapping performed in conjunction with this project is described separately. This project is funded by the State of Alaska and by the federal STATEMAP program through the USGS.

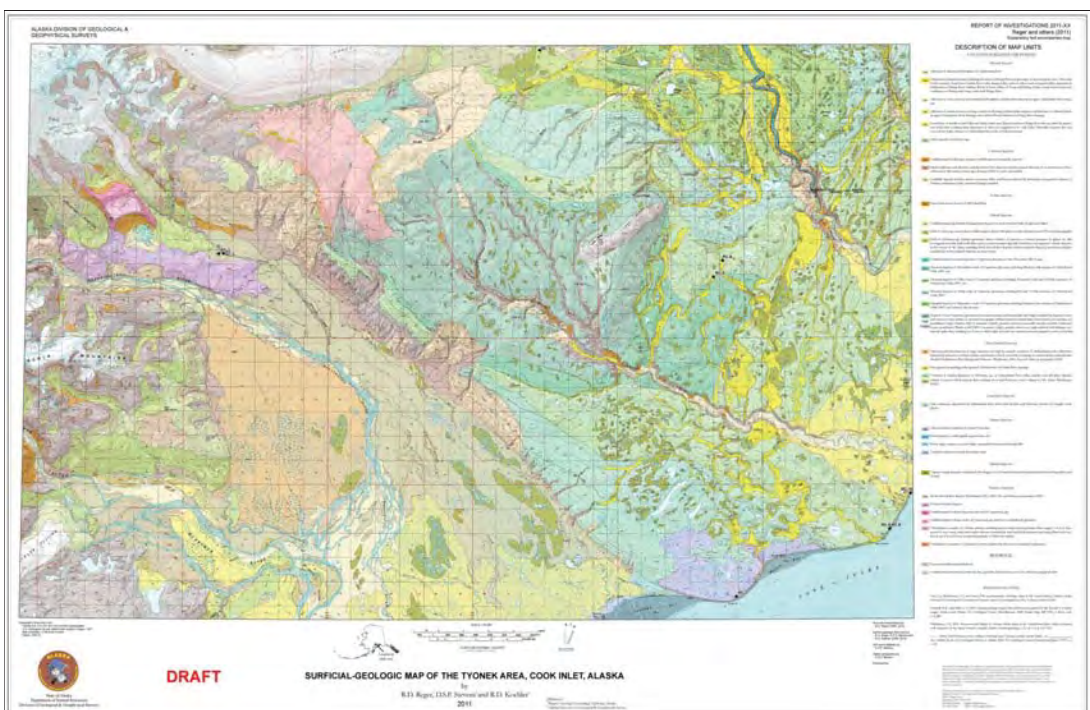


*Figure 2. Draft surficial-geologic map of the Tyonek area. Green=glacial deposits, yellow=alluvial deposits, blue=glacioestuarine deposits, salmon=landslides, orange=flood deposits, and pink–purple=volcanic deposits.*

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## GEOLOGIC CONTRIBUTIONS TO THE PROPOSED SUSITNA–WATANA HYDROELECTRIC PROJECT, ALASKA

The Alaska Energy Authority (AEA) has been authorized by the State of Alaska to develop the Susitna–Watana Hydroelectric Project on the Susitna River, Alaska (fig. 1). The purpose of the project is to help meet the future electrical needs of Alaska's Railbelt Region by providing clean, renewable energy at the lowest possible long-term cost. Located approximately halfway between Anchorage and Fairbanks on the upper Susitna River, the 700-foot-high Susitna–Watana dam is expected to have a reservoir 39 miles long and up to 2 miles wide, with an average annual power generation of 2,600 GWhrs (AEA). The powerhouse, dam, and related facilities would be linked by a transmission line to the Railbelt Intertie, as well as to road or railroad access from the Parks or Denali highways.


*Figure 1. The Susitna–Watana Hydroelectric Project will provide power to meet the electrical needs of Alaska's Railbelt Region. Map by the Alaska Energy Authority,* http://www.susitna-watanahydro.org.

An accurate assessment of the site geology and potential for seismic and other geologic hazards is essential for dam location, design, and construction. The Alaska Division of Geological & Geophysical Surveys (DGGS) has therefore initiated a project at the request of AEA to evaluate seismic-hazard issues and produce GIS-based geologic and derivative construction-materials resources maps in support of the hydroelectric project. Planned work includes map and data compilation and assessment of existing geologic and seismic hazards data. Information developed in the course of this project will be disseminated through publicly available maps and reports published by DGGS.

DGGS's overall project plan reflects a phased approach to evaluating selected geologic aspects of the proposed Susitna–Watana Hydroelectric Project. Phase 1 is currently underway and consists of (1) a review of existing and new AEA-contractor-developed seismic hazards reports, (2) a review of existing contractor-developed geologic maps of the Susitna–Watana Hydroelectric Project area, and (3) conversion of the existing hardcopy geologic maps into digital GIS format. Phase 1 preliminary maps and geologic assessments are anticipated to be completed in 2012. Future work is dependent on additional funding but may include Phase 2 field-based verification to improve and expand the body of geologic data needed to fully meet the requirements of this major hydroelectric project, and a Phase 3 wrap-up of the geologic evaluation with final field checks, additional data analysis, and report writing.

This project is funded by the Alaska Energy Authority.

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# ALASKA DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS
# FY12 Project Description

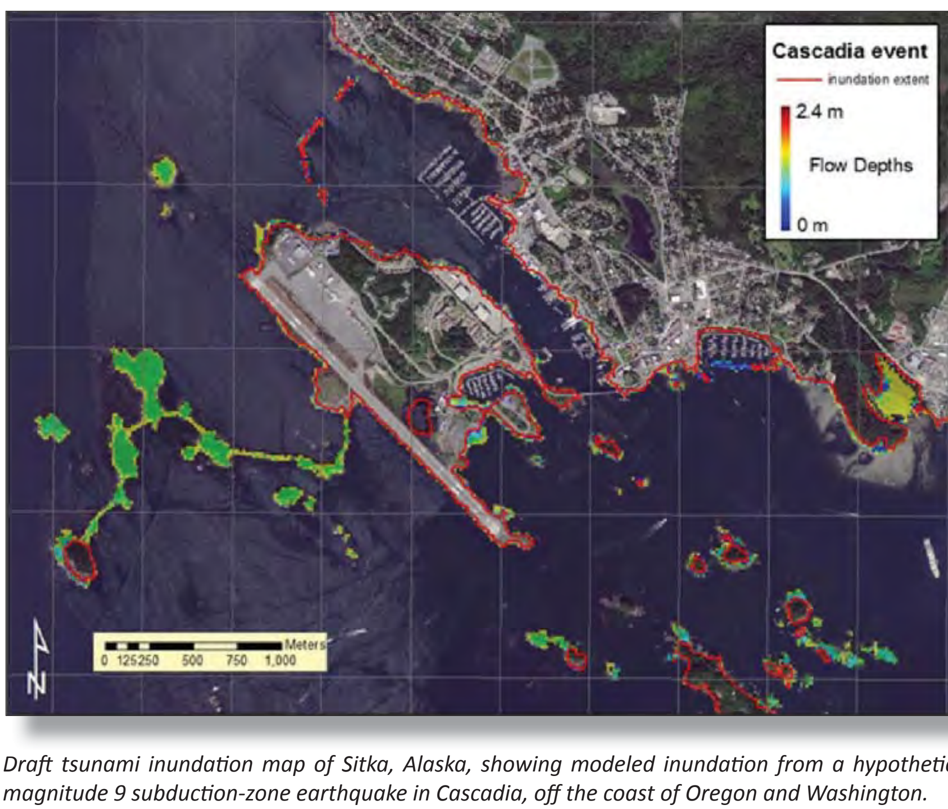
## TSUNAMI INUNDATION MAPPING FOR ALASKA COASTAL COMMUNITIES

With funding from Congress, the National Oceanic & Atmospheric Administration (NOAA) initiated the National Tsunami Hazard Mitigation Program in 1997 to assist Pacific states in reducing losses and casualties from tsunamis. The program included funding for five states (Alaska, Hawaii, Washington, Oregon, and California) to address four primary issues of concern: (1) Quickly confirm potentially destructive tsunamis and reduce false alarms, (2) address local tsunami mitigation and the needs of coastal residents, (3) improve coordination and exchange of information to better utilize existing resources, and (4) sustain support at state and local level for long-term tsunami hazard mitigation. In 2005, following the catastrophic Sumatra earthquake and tsunami, the U.S. program was expanded to include Atlantic and Gulf of Mexico states and territories.

As part of this program, the Division of Geological & Geophysical surveys (DGGS) participates in a cooperative project with the Alaska Division of Homeland Security & Emergency Management (DHSEM) and the University of Alaska Geophysical Institute (UAGI) to prepare tsunami inundation maps of selected coastal communities. Communities are chosen and prioritized on the basis of tsunami risk, infrastructure, availability of bathymetric and topographic data, and willingness of a community to use results for emergency preparedness. For each community, DGGS and UAGI develop multiple hypothetical tsunami scenarios that are based on the parameters of potential underwater earthquakes and landslides. We have completed and published tsunami inundation maps for the Kodiak area, Homer, Seldovia, Seward, and Whittier. Source scenarios are being developed and wave modeling performed for Sitka and Valdez, for which draft maps and reports will be submitted in 2012.

To develop inundation maps, we use complex numerical modeling of tsunami waves as they move across the ocean and interact with the seafloor and shoreline configuration in shallower nearshore water. UAGI conducts the wave modeling using facilities at the Arctic Region Supercomputing Center. DGGS, UAGI, and DHSEM meet with community leaders to communicate progress and results of the project, discuss format of resulting maps, and obtain community input regarding past tsunami effects and extent. DGGS publishes the final maps along with explanatory text, which are available in both hardcopy and digital formats. DGGS also makes the GIS files of inundation limit lines available to the local communities for use in preparing their own tsunami evacuation maps.

Team members have presented results of this program at international tsunami symposia in Seattle; Honolulu; Istanbul; Vienna; Melbourne; Hania, Greece; and Perugia, Italy; and at American Geophysical Union annual meetings in San Francisco. Locally, we have given presentations in the affected communities, in Dutch Harbor, and at the Association of Environmental & Engineering Geologists 2011 national meeting in Anchorage. In addition, this project has been the subject of articles in *Geotimes* and *TsuInfo Alert Newsletter.*




*Draft tsunami inundation map of Sitka, Alaska, showing modeled inundation from a hypothetical magnitude 9 subduction-zone earthquake in Cascadia, off the coast of Oregon and Washington.*

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