III.K.3 OVERVIEW OF ALASKA AND AIR QUALITY

A. Overview of Alaska

The size, scale, and diversity of Alaska have an influence on air quality and regional haze. This section discusses important features of the state and its air quality.

Alaska is a large state (572,000 square miles) with a small population (686,300). The largest population centers in Alaska are the Municipality of Anchorage (population 279,240), the City of Fairbanks (34,500), the Matanuska-Susitna Borough (76,006), and City & Borough of Juneau (30,700). There are no other communities with populations over 10,000. Several towns have populations between 1,000 and 10,000, and there are many communities with fewer than 1,000 people.

1. Geography

Alaska comprises one-sixth of the United States' landmass, spanning 20 degrees of latitude (51°N – 71°N). Alaska contains 65% of the U.S. continental shelf, more shoreline than the rest of the 49 states combined, 17,000 square mile of glaciers, 3,000,000 lakes that are over 20 acres in size, and receives 40 % of the U.S. fresh water runoff. Figure III.K.3-1 shows a map of Alaska and the diverse climate regions described below.

Figure III.K.3-1
Climate Regions of Alaska

Note: The majority of the Aleutian Islands (west) are omitted.

The Panhandle is a temperate rain forest in the southeastern part of Alaska that is mainly comprised of mountainous islands and protected marine waterways. Rainfall exceeds 100 inches per year in many areas. Most communities are small and have fewer than 5,000 year-round residents. Juneau, the State's capital, is the largest city in the region with a population of approximately 30,700.

The South Gulf Coast is one of the wettest regions in the world: Yakutat receives over 150 inches of non-thunderstorm rain per year and Thompson Pass averages over 700 inches of snow annually. The area is covered with rugged mountains and barren shoreline and is the target of many Gulf of Alaska storms. This coastline contains only a handful of small fishing communities.

South-central Alaska is fairly temperate in comparison to the rest of Alaska. Rainfall varies widely across the region, averaging between 15 inches per year in the Matanuska-Susitna (Mat-Su) Valley and 60 inches per year in Seward. This region contains 60% to 70% of the state's population, with Anchorage, the state's largest city, home to 279,240 people. Bounded by active volcanoes on the southwest and glacial river plains to the northeast, this sector of the state has experienced 24-hour dust levels in excess of 1,000 ug/m^3.

The Alaska Peninsula and its westward extension, the Aleutian Chain, form the southwestern extension of the mountainous Aleutian Range. This region is comprised of remote islands and small, isolated fishing villages. This area is one of the world's most economically important fishing areas, as well as a vital migratory route and nesting destination for birds.

Southwest Alaska encompasses the vast Yukon-Kuskokwim River Delta, a wide low-lying area formed by two of the state's major river systems and dotted with hundreds of small lakes and streams. This region is heavily impacted by storm systems which rotate northward into the Bering Sea. Communities in this region receive between 40 and 70 inches of precipitation each year. This portion of the state is quite windy, experiencing winds between 15–25 miles per hour throughout the year. These winds, coupled with fine delta silt, help to create dust problems for some southwestern communities. Rural villages normally contain fewer than 500 people and are located along the major rivers and coastline. Regional hub communities, such as Galena and Bethel, have up to 6,300 residents.

Interior Alaska describes the vast expanse of land north of the Alaska Range and south of the Brooks Range. This region contains Fairbanks, Alaska's second largest city, with a population of 32,000 people (84,000 in the borough). The climate varies greatly with clear, windless, -50°F winter weather giving way to summer days with 90°F temperatures and afternoon thunderstorms. Sectors of this region also experience blustery winds and high concentrations of re-entrained particulates from open riverbeds.

The Seward Peninsula is the section of Alaska that extends westward into the Bering Sea between Norton Sound and Kotzebue Sound. This hilly region is barren and windswept with 15-25 mile per hour winds common. Rainfall in this region averages between 15 and 24 inches per year. Villages in this region are small except for Nome, which has over 3,000 people.

The North Slope region, located north of the Brooks Range, is an arctic desert receiving less than ten inches of precipitation annually. Wind flow is bimodal, with the easterlies dominating the meteorological patterns. Winter wind speeds average 15-25 mile per hour, dropping off slightly during the summer. The North Slope is extremely flat and supports huge summertime populations of bears, caribou, and migratory birds.

2. Topography

Alaska is topographically varied. The state contains seven major mountain ranges, which influence the majority of all regional wind flow patterns. The mountains channel flow, create rotor winds, cause up slope and down slope flow, initiate drainage winds, produce wind shear and extreme mechanical turbulence. For air quality impact analyses, Alaska’s rugged mountains can only be described as complex; complex terrain makes most air quality models unsuited for use in the state. The complexity of most local meteorology renders the use of site specific meteorological data inadequate for control strategy development.

3. Economy

The oil and gas industry dominates the Alaskan economy, with more than 80% of the state's revenues derived from petroleum extraction. Alaska's main export product (excluding oil and natural gas) is seafood, primarily salmon, cod, pollock and crab. Agriculture represents only a fraction of the Alaskan economy. Agricultural production is primarily for consumption within the state and includes nursery stock, dairy products, vegetables, and livestock. Manufacturing is limited, with most foodstuffs and general goods imported from elsewhere. The state’s industrial outputs are crude petroleum, natural gas, coal, gold, precious metals, zinc and other mining, seafood processing, timber and wood products.

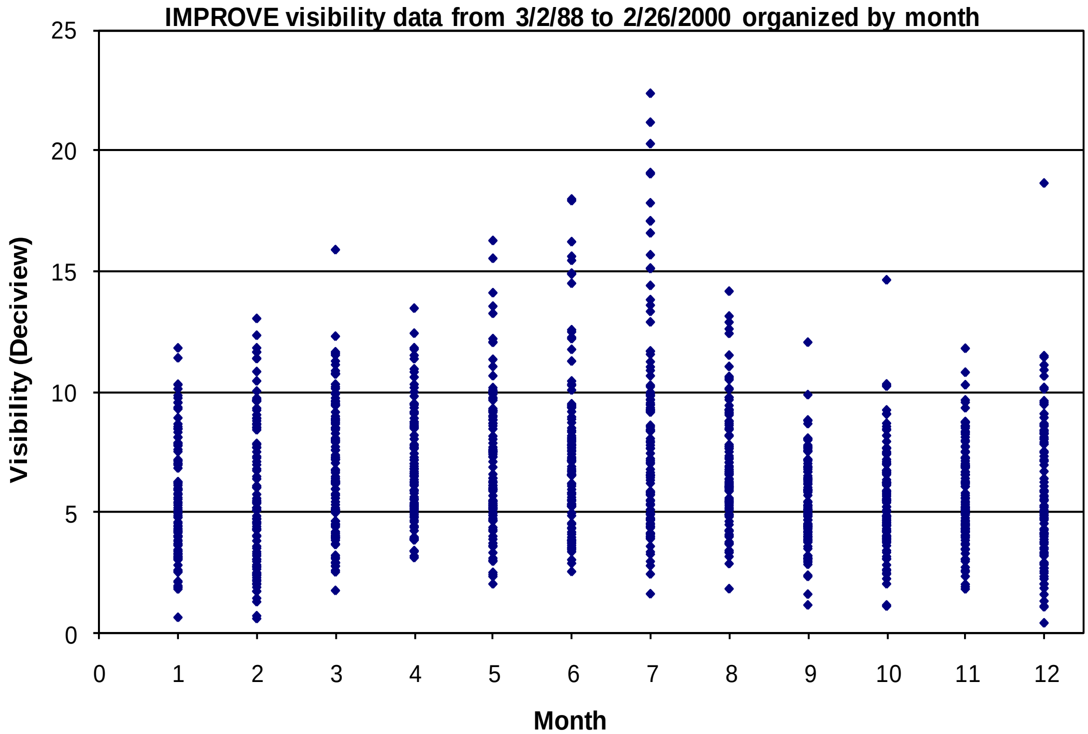
Employment is primarily in government and industries such as natural resource extraction, shipping, and transportation. Military bases are a significant component of the economy in both Fairbanks and Anchorage. Federal subsidies are also an important part of the economy, allowing the state to keep taxes low. There is also a growing service and tourism sector. Tourism via cruise ships and air travel has expanded considerably in recent years, providing additional support to the economy.

B. Sources of Pollution

The primary sources of visibility degradation in Alaska’s Class I areas are dust and anthropogenic emissions originating in Asia (referred to as “Asian dust”) and blowing across the Pacific Ocean from March to May; the “Arctic haze,” which occurs from October to March; and regional wildfires, which typically start when the snow melts, usually in April, and continue until mid-August.

The seasonal nature of long-range transport and regional pollution leads to a bimodal trend of low visibility that peaks once in summer and once in winter; this can be seen in Figure III.K.3-2, which shows the IMPROVE visibility data collected at the headquarters of the Denali National Park from March 1988 to February 2000.

Figure III.K.3-2
Improve Visibility Data for Denali National Park



1. International Long-Range Transport of Aerosols to Alaska

A primary issue that has been identified is the international transport of air pollutants into the state.[1] Unlike the states in the contiguous United States, Alaska borders no other state. Instead, Alaska has direct impacts from Russia, China, other parts of Asia, Europe, and Canada. Alaska is particularly affected by transport from Asia and Russia/Eastern Europe. Due to the winter conditions at high latitudes (like at Denali National Park), namely a lack of sunlight and liquid water, expected atmospheric chemical reactions do not occur. This can cause emissions that have been transported hundreds or thousands of miles to appear in analyses as though from a local source. International transport of pollutants into Alaska has been documented through a variety of research studies. In particular, the research has focused on Arctic haze and Asian dust events.

The Alaskan airshed contains a complex array of aerosols that vary seasonally and geographically. Forest fires are the largest source of aerosols in central ("Interior") Alaska,[2] followed by "Arctic haze," anthropogenic aerosols from Northern Europe and Russia that reach Alaska in the winter and early spring. Asian deserts and cities are the source of some of the aerosols, collectively known as Asian dust, that arrive in spring and summer. Oceans are another, generally less significant, source of aerosol.

The two major international aerosol transport phenomena that affect Alaska are Arctic haze and Asian dust.[3] Arctic haze refers to pollution transported to Alaska over the Pole during the winter and early spring from Europe and Russia; Asian dust refers to wind-blown dust originating primarily from the arid deserts of Mongolia and China and transported across the Pacific and into Alaska during late spring. A brief summary of each of these phenomena is provided below; further details are provided in Appendix III.K.3.

a. Arctic Haze

During the winter, the Arctic atmosphere becomes contaminated with anthropogenic pollution transported primarily from sources in Europe and Russia.[4] This unusual form of regional air pollution is commonly referred to as "Arctic haze". Sulfur oxides and soot are its main ingredients, although many metal and organic compounds can be found in Arctic haze samples.[5] Arctic haze is absent during summer, but begins to appear in the early winter. Photochemical oxidation of sulfur dioxide into sulfate aerosols after polar sunrise and seasonal meteorological conditions cause Arctic haze to reach its peak intensity in March, after which levels sharply decline.

The haze is composed of particles no larger than 2 μm because these particles have low settling velocities and are capable of remaining suspended in the atmosphere for weeks. This allows the particles to travel into the Arctic, which has few local aerosol sources.[6] The size of the Arctic haze aerosols is approximately the same as the wavelength of visible light (0.39-0.76 μm), allowing the aerosol to scatter light and therefore diminish visibility very effectively.

Arctic haze is often layered, a consequence of the small thermal lapse rate of the Arctic atmosphere in the winter. The shallow lapse rate dampens vertical mixing and therefore allows pollution to spread horizontally much faster than vertically.[7] Arctic haze occurs throughout the height of the Arctic troposphere as a result of the tendency of air parcels to move along surfaces of constant potential temperature causing pollution from lower latitudes to enter the Arctic at higher altitudes.[8]

Episodes of high concentrations of aerosol pollution are not always coincident with high concentrations of gaseous pollution. In fact, the two have a slightly offset seasonality, with the gases tending to reach their highest concentrations in January-February due to decreased photochemistry and mixing in the Arctic, while aerosol pollution reaches its maximum in March-April due to increased airflow from central Eurasia and increased gas-to-particle conversion.

In the absence of Arctic haze, visibility in the Arctic is quite high. Barrow averages 271 km visual range in June. The average value for March is reduced to 143 km, and episodes of Arctic haze drive the range much lower.[9] Arctic haze often reduces visibility to approximately 30 km in the high Arctic.[10] Barrie also notes that suspended ice crystals frequently accompanied the haze, which further reduces visibility to about 10 km. These ice crystals are probably formed by the nucleation of ice onto acidic aerosols at temperatures below –25° C.

b. Asian Dust

Generally, long-range transport must occur at high altitudes (above 5 km) over an ocean in order to avoid scavenging.[11] Therefore, while the Pacific Ocean usually serves as a barrier to pollution transport, pollution can undergo long-range transport over it if lofted high enough. The transport of desert dust from the Orient is a well-documented phenomenon,[12] and so, increasingly, is the transport of pollution.

One of the first attempts to characterize the origin of Arctic haze found that a large haze incident in early May 1976 was caused by desert dust.[13] This conclusion was based on the morphology of the aerosols and their chemical composition, along with consideration of the meteorological situation preceding the appearance of the haze. The dust was almost certainly transported from the Gobi and Taklimakan deserts in Mongolia and northern China. Nearly every spring, high winds loft so much dust that it falls on Japan and Korea like yellow snow. The Japanese refer to the massive dust fall as the "kosa", the Koreans call it the "whangsa". Spring is not only the most active period for dust storms in the Gobi and Taklimakan, but also the period of most active atmospheric transport between the Orient and the Arctic.[12]

Geological evidence suggests that global scale transport of Asian dust has been a long-running natural phenomenon.[14] Chemical analysis of Greenlandic ice cores[15] and Hawaiian soil studies[16,17,18,19] have shown that the chemical and radiological fingerprints of deposited dust were consistent with the composition of the Asian dust sources.

Rahn et al. [1977] detected little pollution in the 1976 dust plume, but Chinese sulfur dioxide emissions have since tripled. Unsurprisingly, more recent studies have shown an increase in anthropogenic pollution concurrent with the transport of Asian air during the spring over the Pacific Ocean[20,21,22] and North America.[23] The concentration of sulfate, nitrate, soot, and heavy metal aerosols accompanying these dust plumes will almost certainly increase as China's coal-fired economy rapidly expands over the coming decades.

Since human activities have been contributing to the expansion of the Gobi Desert, it is likely that the amount of Asian dust transported over to the Arctic will increase over time. Chinese records indicate an increase in the severity of dust storms impacting Beijing, which lies directly in the path of storms coming off the desert.

2. Biogenic Aerosols

Alaska's landscape is dominated by natural ecosystems rather than human dominated systems. Consequently, air quality in the state is strongly affected by natural biogenic emissions as well as human activities. Biogenic emissions, or emissions from (non-human) living things, are produced by the organisms of forests, tundra, wetlands, and sea. The effects of biogenics on air quality are determined by vegetation, animal and microbial species composition, climate and meteorology, soil and permafrost processes, and secondary atmospheric reactions.

Forest and tundra ecosystems produce a wide variety of volatile organic hydrocarbons, with common groups being isoprenes and monoterpenes. Production of biogenic volatile organic compounds (VOCs) varies by latitude, plant species, diurnal cycles, temperatures, meteorology, and even browsing pressure. Under the right conditions, biogenic VOCs act as nucleation centers, forming nanoparticles which impair visibility and alter climate.[24,25,26,27,28]

Wetland and lake ecosystems release VOCs from microbial activity in inundated and seasonally inundated soils. These ecosystems release VOCs as perennially frozen soils thaw, releasing to decomposition organic matter produced and trapped long ago by freezing. Common emissions from lakes and wetlands are methane and methane hydrates.[29,30]

The term "biogenic" is used inconsistently in the scientific literature, sometimes including emissions from wildfire, sometimes not. In this document wildfire emissions are treated separately. Recent research on biogenic emissions has focused on sources, transport, vertical stratification, chemical composition, modeling from meteorology, variation in emissions factors, and specific processes producing ozone, NO_x, black carbon, CO, and VOCs. Most of the research is aimed at understanding formation of climatically relevant, or climate altering, particles. Included here within the category of biogenic emissions are sea salt and volcanic emissions.

a. Formation of Biogenic Aerosols

Under some conditions biogenic VOCs become nucleation centers, resulting in the formation of nanoparticles up to 80 nm.[31] Much current research examines the conditions under which this happens. Relevant conditions include concentrations of condensable vapor[32] and concentrations of other atmospheric constituents such as H_2SO_4 and ammonia.[33] Some researchers have noted, based on correlations, the likely importance of sulfuric acid, sulfur dioxide, and ammonia concentrations to particle formation.[32, ,34,35] Increasing probabilities of nucleation mode aerosols have been seen with increasing heat flux, temperature variability, and vertical wind speed variance.[36]

Biogenic emissions vary seasonally, both qualitatively and quantitatively, even at a single location. Local meteorology influences secondary particle formation as well. In the Canadian high Arctic, variation in the composition of primary biogenic emissions has been reported, with monoterpenes and B-caryophyllene making major contributions to secondary OC in late winter to early summer, and isoprenes making major contributions to secondary OC in early June.[37]

One comprehensive study in Scandinavia concludes that boreal forest is a major source of climate-relevant aerosols, most likely at levels capable of competing with the anthropogenic aerosol releases.[34] It demonstrates that conversion of terpenes to secondary organic aerosols does take place over boreal forests, with the highest concentrations of very small particles formed when emissions are low. As terpene emissions increased, particle mass increased, with the consequence that nucleation quenches itself. Boreal forest typically sustains 1K-2K/cm^3 particles in 40-100 nm size range, and these concentrations are established rapidly across marine-terrestrial boundaries. Across boreal and arctic regions, particle formation varies seasonally, latitudinally, and with temperature.[38]

b. Sea Salt

Sea salt, a major component of marine aerosols, is formed by the evaporation of water ejected from wind whipped whitecaps and breaking waves. The production of sea salt aerosol and its size distribution is very sensitive to wind speed and surface conditions. Although most of the sea salt aerosol mass is in the size fraction above 1 μm diameter, a small but significant fraction of the sea salt aerosol is in the submicrometre fraction.[39] The large particles have high settling velocities, resulting in relatively short residence times. The remaining particles are smaller, have a longer residence time, transport over longer distances and impact visibility. Sea salt has been identified as a significant contributor to visibility impairment at all of the Class I sites in Alaska.

c. Geogenic Emissions

Alaska is home to many active and dormant volcanoes. Volcanoes located on the Aleutian Islands, the Alaska Peninsula, and in the Wrangell Mountains are part of the "Ring of Fire" that surrounds the Pacific Ocean basin. The state contains 52 historically active volcanoes, 14 of which have had at least one major eruptive event since 1990. During the 50-year period between 1945 and 1995, 90 eruptions have been reported from 23 volcanoes, for a frequency of about 2 (1.8) eruptions per year. Additional volcanic sources impacting Alaska are located across the Bering Sea on Russia's Kamchatka Peninsula. The 29 active volcanoes in Kamchatka typically have three or four explosive eruptions per year that emit volcanic ash and gases high enough into the atmosphere to impact air travel between Asia and North America.

The most abundant gas typically released into the atmosphere from volcanic systems is water vapor, followed by carbon dioxide and sulfur dioxide. Volcanoes also release smaller amounts of others gases, including hydrogen sulfide, hydrogen, carbon monoxide, hydrogen chloride, hydrogen fluoride, and helium. Large explosive eruptions inject a tremendous volume of sulfur aerosols into the stratosphere, which depending on wind speed and direction can significantly impact any of the Class I sites located in Alaska.

3. Sources of Visibility Impairment Summary

The initial mischaracterization of arctic haze as dust from Asian dust storms rather than industrial activity foreshadowed the more complex picture of Arctic haze seen today. International transport of pollutants into Alaska is indeed crucial to the impairment of visibility in the sparsely populated, less-industrialized Alaska, but the pollutants seen today derive from a variety of sources, not solely industrial.

International transport of pollutants affecting visibility in Alaska is associated with human activities in many places and at multiple scales. Carbon particulates arise from both local human activities and regional phenomena. Important long-distance sources of atmospheric carbon include land clearing fires, wildfires, and coal burning for power generation. Dust particulates are affected by local land use and management, local weather systems, and intercontinental air masses. Biogenic emissions from vegetation, soils, and oceanic plankton also affect visibility, and are of increasing interest to researchers. Biogenic emissions can arise locally or can be transported long distances before entering Alaska. Geogenic emissions from volcanoes and river geomorphic processes contribute to degradation of visibility within Alaska. Geogenic sources also may be local or international.

C. Monitoring Strategy and Air Quality Data

1. Statewide Pollutant Monitoring

ADEC operates or oversees a network of ambient air monitors in a variety of locations throughout Alaska. The purpose of the state ambient air-monitoring network has been to determine whether levels of pollutants are exceeding the national ambient air quality standards. For this reason, sites have typically been located to evaluate impacts from local emission sources, such as motor vehicles, wood-burning stoves, unpaved roads, windblown dust, and industrial facilities. Air quality data are easily available for the major population centers but data are sparse for the vast majority of the state. It is not possible to monitor the air quality in every community, so ADEC has taken a three-pronged approach to the monitoring network design:

- Monitoring larger communities to cover the largest possible population exposure.
- Monitoring designated smaller towns that are representative of multiple communities in a region.
- Monitoring in response to air quality complaints.
- Additional monitoring data are available when industries applying for air quality permits conduct background monitoring.

Alaska's air monitoring program focuses on five of the seven criteria pollutants regulated through the National Ambient Air Quality Standards (NAAQS): carbon monoxide (CO), coarse particulate matter (PM_{10}), fine particulate matter ($PM_{2.5}$), ozone (O3) and lead (Pb). There are eight separate and distinct monitoring objectives associated with these pollutants:

1. CO – seasonal monitoring in Anchorage and Fairbanks (October through March);
2. PM_{10} – monitoring in the major communities of Juneau, Anchorage and the central Matanuska-Susitna Valley (Mat-Su);
3. $PM_{2.5}$ – monitoring in Juneau, Fairbanks, Anchorage and the Mat-Su Valley;
4. Wildland Fire ($PM_{2.5}$) - statewide monitoring during the summer fire season (May – September);
5. Slash Burning ($PM_{2.5}$) for agricultural and beetle kill (August – May);
6. Rural Community/Tribal Village Dust Monitoring (May-September), Residential Wood Smoke (September-March) – selected communities statewide;
7. Ozone – Denali National Park (operated by NPS) and Anchorage; and
8. Source oriented lead monitoring.

The state's primary air monitoring network evaluates the level of these criteria air pollutants, following guidance provided in EPA's National Monitoring Strategy, and focuses Alaska's monitoring on our largest communities. Citizen complaints from rural villages have been addressed on an "as available" basis in the past.

In addition to the primary network of criteria pollutant monitors, there are several mercury deposition monitoring sites in Alaska. Two state-sponsored sites for collecting ambient mercury in precipitation are located in Kodiak and Unalaska. The sites are part of the mercury deposition network (MDN). Additionally there is a site established in Bettles and a short term site in Glacier Bay in southeast Alaska both managed by the National Park Service.

Atmospheric wet deposition monitoring was initiated in 1980 at Denali National Park in Denali Borough, Alaska, as part of the National Atmospheric Deposition Program (NADP)/National Trends Network. Monitoring at the Poker Creek site northeast of Fairbanks began in 1992. Monitoring in Juneau began in 2004. Ambler was an NADP site from 1994-1995. Precipitation at National Trends Network sites is measured for pH, specific conductance, then analyzed for the following chemical species: Ca, Mg, K, Na, NH_4, NO_3, Cl, SO_4, and PO_4.

Because ADEC's core ambient air monitoring network has been concentrated on urban areas, which are far from Alaska's Class I areas, the ambient air monitoring data are not representative of impacts within Alaska's Class I areas and are of limited usefulness for analysis of regional haze pollutants around Alaska's Class I areas.

2. Regional Haze Monitoring

EPA's regional haze rule has several monitoring requirements. This plan must include a monitoring strategy for measuring, characterizing, and reporting regional haze visibility impairment that is representative of all Class I areas within the State. Alaska complies with this requirement through participation in the IMPROVE network.

Alaska is working with EPA and the FLMs to ensure that monitoring networks provide data that are representative of visibility conditions in each affected Class I area within the State. Along with monitoring strategies for the Class I areas, the SIP must include a determination of whether additional monitoring sites or equipment are needed to establish if progress goals are being achieved. The State of Alaska needs to address many issues in its comprehensive regional haze monitoring strategy.

A description of Alaska's Class I areas and the monitoring network within each is provided below. This is followed by a brief discussion of monitoring considerations particularly relevant to Alaska's Class I areas and conditions.

a. Description of Class I Areas and Monitoring Network

Alaska has four Class I areas subject to the Regional Haze Rule: Denali National Park, Tuxedni National Wildlife Refuge, Simeonof Wilderness Area, and Bering Sea Wilderness Area. They were designated Class I areas in August 1977. Figure III.K.1-2 shows their locations, with Denali National Park in the Interior, Tuxedni and Simeonof Wilderness Areas as coastal, and the Bering Sea Wilderness Area.

Denali National Park and Preserve

Denali National Park and Preserve is a large park in the interior of Alaska. It has kept its integrity as an ecosystem because it was set aside for protection fairly early in Alaska's history. Denali National Park headquarters lies 240 miles north of Anchorage and 125 miles southwest of Fairbanks, in the center of the Alaska Range. The park area totals more than 6 million acres. Denali, at elevation 20,320-feet the highest mountain in North America, is a prominent feature in the park and throughout Alaska. Denali National Park and Preserve accommodates a wide variety of visitor uses. The Alaska Range divides the park into two geographic zones by blocking the warm moist air from the Gulf of Alaska from getting to the interior inland side of the park. The park has many vegetation types associated with the variety of aspects and elevations within the park; elevations range from 2000 feet to over 20,000 feet above sea level. The park contains numerous glaciers, permafrost and high mountains. Treeline in Denali is typically around 3,000' above sea level. Much of the 92 mile Park Road is near or above treeline, making for many spectacular views. Denali is the only Class I site in Alaska that is easily accessible and connected to the road system. Denali has the most extensive air monitoring of Alaska's Class I areas, so more detailed examinations of long-term and seasonal air quality trends are possible for this site.

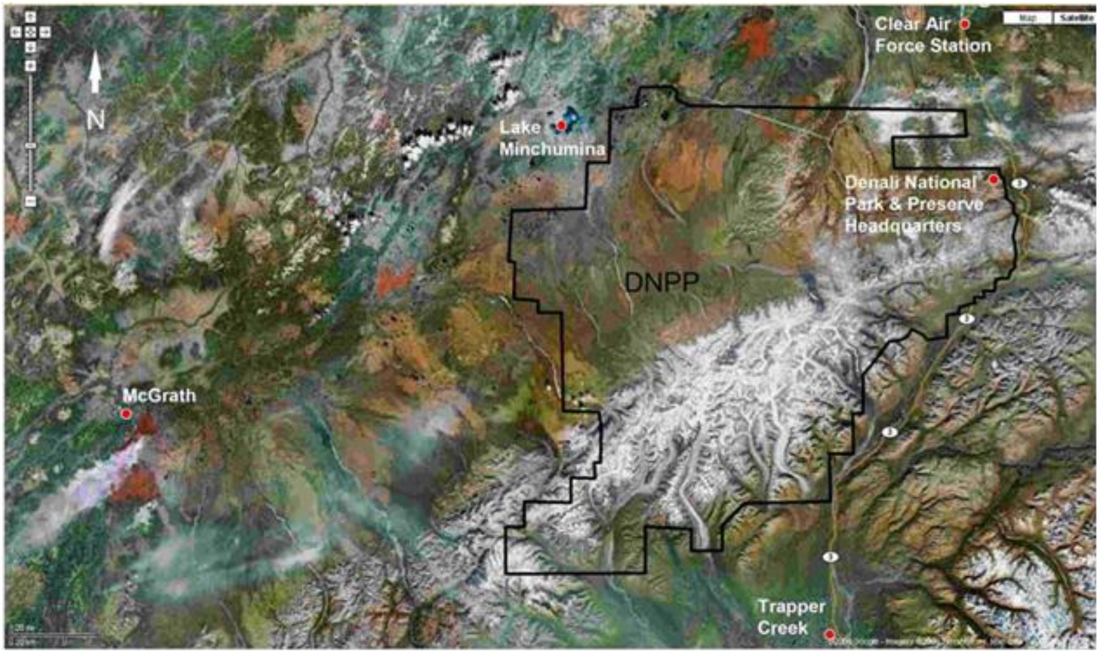
IMPROVE monitoring data are available from the Denali site from March 1988 to the present. Air quality at Denali National Park is monitored as part of several other national air and visibility monitoring networks, described below, as well as many stand-alone atmospheric science research projects.

Aside from visitor services concentrated around park headquarters, there is a single park road, extending 92 miles into the park from the northeastern boundary. The road is paved for its first 15 miles. One air monitoring site is located near the eastern end of the park road. A second, newer site, known as "Trapper Creek", is located to the south of the Park at another site with reliable year-round access and electrical power (see Figure III.K.3-3).

The Denali Headquarters monitoring site, an IMPROVE protocol site (DENA1), is across the Park Road from park headquarters, approximately 250 yards from headquarters area buildings. The site (elevation of 2,125 feet) sits above the main road (elevation 2,088 feet). The side road to the monitoring site winds uphill for 130 yards, providing access to the monitoring site and a water treatment facility. The hill is moderately wooded, but the monitoring site sits in a half-acre clearing.

During the park season, mid-May to mid-September, 70 buses and approximately 560 private vehicles per day traverse the road loaded with park visitors. During the off season, approximately100 passenger and maintenance vehicles pass within 0.3 miles of the monitoring site. Private vehicles are only allowed on the first 14.8 miles of the Park Road.

Figure III.K.3-3
Map of Denali National Park and Preserve



The monitoring site is 2 miles west of the Nenana River and 3.2 miles south of the Healy Ridge, which rises to 6,000 feet at its highest point. It is located in an east-west valley, between the Healy Ridge and the main Alaska Range, which is about two miles wide at the monitoring station and gets wider to the west towards the Sanctuary and Savage Rivers.

The Trapper Creek IMPROVE monitoring site (TRCR1) is located 100 yards east of the Trapper Creek Elementary School. It is the official IMPROVE site for the Denali Class I area. The site is located west of Trapper Creek, Alaska and a quarter mile south of Petersville Road. The site is the official IMPROVE site for Denali National Park and Preserve and was established in September 2001 to evaluate the long-range transport of pollution into the Park from the south. The elementary school experiences relatively little traffic during the day, about 4 buses and 50 automobiles. The school is closed June through August. This site was selected because it has year-round access to power, is relatively open and is not directly impacted by local sources.

IMPROVE monitoring data have been recorded at the Denali Headquarters IMPROVE site from March of 1988 to present. The IMPROVE monitor near the park's headquarters was originally the IMPROVE site. Due to topographical barriers, such as the Alaska Range, it was determined that the headquarters site was not adequately representative of the entire Class I area. Therefore, Trapper Creek, just outside of the park's southern boundary, was chosen as a second site for an IMPROVE monitor and is the official Denali IMPROVE site as of September 10, 2001. The headquarters site is now the protocol site. A CASTNet (Clean Air Status and Trends Network) monitor is located near the Denali Headquarters IMPROVE site.

A DELTA-DRUM sampler was installed at the Denali National Park headquarters site for the period July 30 –September 7, 2001. (A Poker Flat research range site north of Fairbanks also had a DELTA-DRUM sampler September 1 – 29, 2000, March 25 – April 22, 2001, and July 26 – September 7, 2001.) DRUM samplers were installed for both the Denali and Trapper Creek sites in February 2008. They ran through April of 2009.

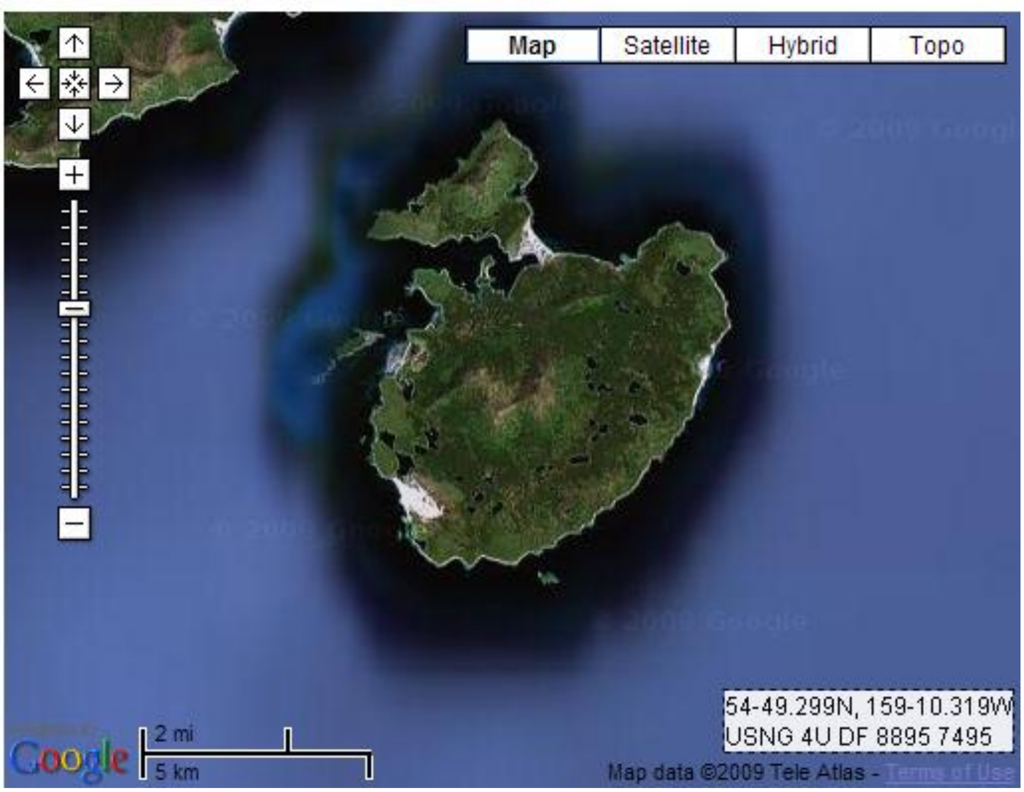
A CASTNet (Clean Air Status and Trends Network) style monitor was located near the Trapper Creek IMPROVE site. Another CASTNet style monitor is co-located with the Denali National Park headquarters IMPROVE monitor. A third was located at Poker Flat Research Range.

In addition to the IMPROVE network, many other monitoring networks have sites at the Denali headquarters monitoring site , including the National Atmospheric Deposition Program, NPS's meteorological monitoring equipment, and several research projects from the University of Alaska, Fairbanks.

Simeonof Wilderness Area

Simeonof Wilderness Area consists of 25,141 acres located in the Aleutian Chain 58 miles from the mainland (see Figure III.K.3-4). It is one of 30 islands that make up the Shumagin Group on the western edge of the Gulf of Alaska. Access to Simeonof is difficult due to its remoteness and

Figure III.K.3-4
Map of Simeonof Wilderness Area



the unpredictable weather. It is home to greater than 55 species of birds as well as sea otters, hair seals, walruses, Arctic foxes, ground squirrels and at least 17 species of whales. The vegetation is naturally treeless with wetlands mixed in with coastal cliff, meadow and dune environments. There are 188 taxa of lichens in the park. Winds are mostly from the north and northwest as part of the midlatitude westerlies. Occasionally winds from Asia blow in from the west.

The island is isolated and the closest air pollution sources are from marine traffic in the Gulf of Alaska and the community of Sand Point.

The Fish and Wildlife Service has placed an IMPROVE air monitor in the community of Sand Point to represent the wilderness area. The community is on a nearby more accessible island approximately 60 miles north west of the Simeonof Wilderness Area. The monitor has been on line since September 2001. The location was selected to provide representative data for regional haze conditions at the wilderness area.

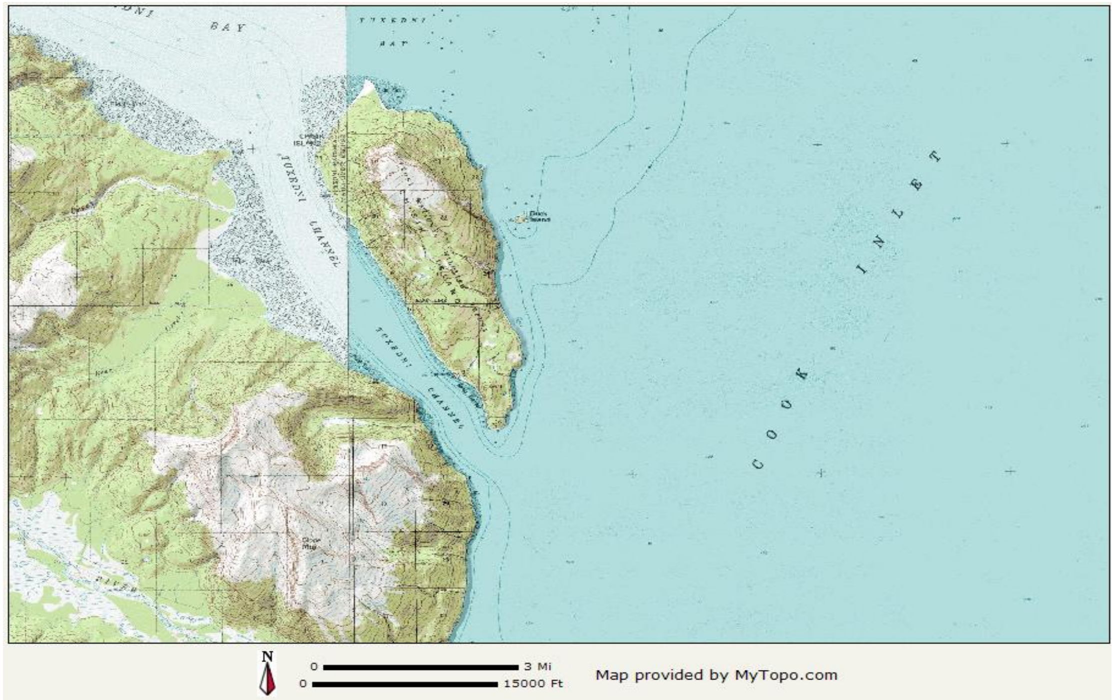
Tuxedni National Wildlife Refuge

Tuxedni National Wildlife Refuge is located on a fairly isolated pair of islands in Tuxedni Bay off of Cook Inlet in Southcentral Alaska. There is little human use of Tuxedni except for a few kayakers and some backpackers. There is an old cannery built near Snug Harbor on Chisik Island which is not part of the wilderness area; however it is a jumping off point for ecotourists staying at Snug Harbor arriving by boat or plane. The owners of the land have a commercial fishing permit as do many Cook Inlet fishermen. Set nets are installed around the perimeter of the island and in Tuxedni Bay during fishing season.

Along with commercial fishing, Cook Inlet has reserves of gas and oil that are currently under development. Gas fields are located at the Kenai area and farther north. The inlet produces 30,000 barrels of oil a day and 485 million cubic feet of gas per day. Pipelines run from Kenai to the northeast and northeast along the western shore of Cook Inlet starting in Redoubt Bay. The offshore drilling is located north of Nikiski and the West McArthur River. All of the oil is refined at the Nikiski refinery and the Kenai Tesoro refinery for use in Alaska and overseas.

The Fish and Wildlife Service has installed an IMPROVE monitor near Lake Clark National Park to represent conditions at Tuxedni Wilderness Area. This site is on the west side of Cook Inlet, approximately 5 miles from the Tuxedni Wilderness Area. The site was operational as of December 18, 2001, and represents regional haze conditions for the wilderness area. Figure III.K.3-5 shows a map of Tuxedni and the surrounding area.

Figure III.K.3-5
Map of Tuxedni National Wildlife Refuge and Surrounding Area

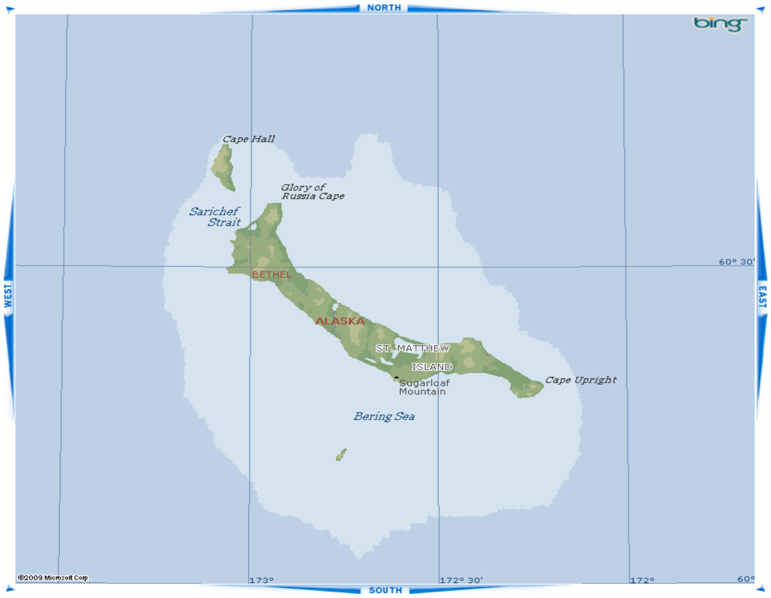


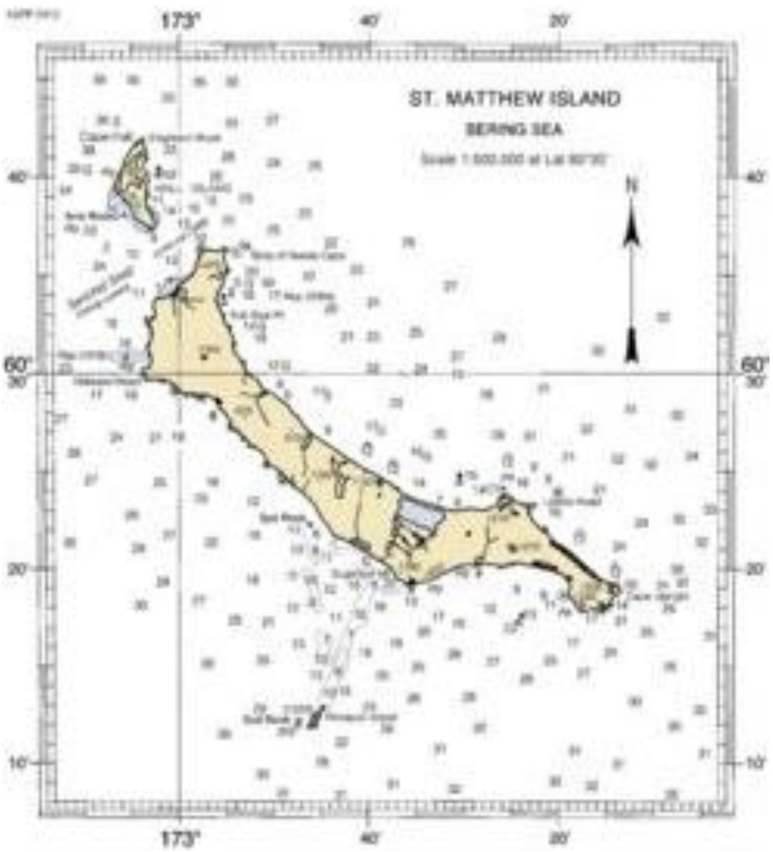
Bering Sea Wilderness Area

The Bering Sea Wilderness is located off the coast of Alaska about 350 miles southwest of Nome. Hall Island is at the northern tip of the larger St Matthew Island. St Matthew Island is remote with arctic foxes and insular voles joined by the occasional polar bear that comes in off the pack ice. Ringed seals and stellar sea lions haul themselves up on the shore. 125 species of birds are present on the tundra and rock covered island. There is trawling for king crab offshore. Lichen species were heavily overgrazed when the Coast Guard introduced reindeer to the island in 1944; mosses, forbs and shrubs took over leaving about 10% of the lichen cover. The reindeer are gone, but 22 years later the lichens are only very slowly growing back. Figure III.K.3-6 shows a map of the Bering Sea Wilderness Area.

The Bering Sea Wilderness Area had a DELTA-DRUM sampler placed on it during a field visit in 2002**.** However, difficulties were encountered with the power supply for the sampler and no viable data is available from that effort. No IMPROVE monitoring is currently planned for Bering Sea Wilderness Area because of its inaccessibility.

Figure III.K.3-6
Map of Bering Sea Wilderness Area





b. Additional Monitoring Considerations

One of the monitoring issues that Alaska has identified is the logistical difficulty of monitoring at remote locations. Remote locations make it challenging to provide power for instrumentation. If a monitor is located at the nearest power source, such as a town, it is also near local sources of emissions, and therefore less likely to be representative of the Class I area. Remote sampling in Class I areas may be needed to verify that data from an off-site IMPROVE monitor are representative. DRUM aerosol impactor sampling may provide an opportunity to verify impacts at remote Class I areas like Simeonof and Tuxedni. The challenges for ongoing air and visibility monitoring in Alaska are transportation and site maintenance. Sites are remote, access may be only by air or water, and electrical power may be lacking. In many places winter temperatures are extreme, often dipping well below zero Fahrenheit for weeks at a time.

DELTA-DRUM Samplers have been used at several sites in Alaska for relatively short periods. Researchers have unsuccessfully modified these samplers for remote winter use in Denali Park. Drum samplers were set up at the Denali and Trapper Creek sites as well as in McGrath and Lake Minchumina in February and March 2008. They proved to be quite problematic with mechanical and pump issues in winter conditions. They ran intermittently between February/March 2006 and April 2009.

Alaska will continue to evaluate as resources allow their portable sampling platforms for use in remote environments.