Winter 2007 Air Quality Monitoring Report
Turnagain Pass, Alaska, Chugach National Forest

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September 2007

EXECUTIVE SUMMARY

An air quality monitoring pilot study was conducted on the Chugach National Forest during the winter of 2006-2007 to address concerns that winter motorized uses on the Forest are impacting air quality. This project addresses the Forest Service Chief's 2004 response to a Forest Plan appeal suggesting that the Chugach National Forest has not adequately quantified and assessed the impacts of winter motorized use on air quality. A pilot protocol for this monitoring effort was developed in 2007 as part of the development of the Chugach National Forest Monitoring Guide. Air quality personnel from the Alaska Department of Environmental Conservation (ADEC) provided technical assistance in developing the protocol and also provided some of the monitoring equipment.

Forest Service personnel from the Supervisor's Office and the Glacier Ranger District measured carbon monoxide and fine particulate concentrations at Turnagain Pass on a total of 8 days during the winter months of 2007. The west side of Turnagain Pass represents one of the most heavily used areas on the Chugach National Forest for winter motorized use. Weather and use parameters were also measured during these sample days.

These data show that motorized use at Turnagain Pass resulted in increased levels of carbon monoxide and fine particulates at sites measured near the western parking lot. However, the carbon monoxide and fine particulate data collected on the 8 sample days indicated no violations of the Alaska State air quality standards. Under the present motorized use trends at Turnagain Pass, the likelihood of exceeding the standards as a result of winter motorized use is relatively low. However, as shown on one of the sample days, a moderate potential exists for exceeding the standards when a high level of motorized use occurs on cold days with temperature inversions.

This study was limited in its temporal and spatial scope, but provides an adequate look at the potential that these uses are violating State air quality standards. It is recommended that this type of sampling is repeated every 3 to 5 years to determine future trends and whether violations of air quality standards are occurring.

AKNOWLEDGEMENTS

I would like to thank Barbara Trost and Bryan Evans of the Alaska Department of Environmental Conservation for their help in designing this project, providing equipment, and analyzing data. I would also like to thank Larry Taylor of the Municipality of Anchorage for his assistance with calibration of the Drager monitors. Finally, thanks to Sean Stash and Merlyn Schelske of the Glacier Ranger District for their assistance with the sampling.

TABLE OF CONTENTS

1 INTRODUCTION

A pilot study to monitor the effects of winter motorized use on air quality was conducted on the Chugach National Forest during the winter of 2006-2007. This monitoring pilot project qualitatively described air quality conditions and quantified levels of carbon monoxide (CO) and fine particulates (PM2.5). The study was conducted in and around the Turnagain Pass motorized parking area on the west side of the highway. This is one of the most heavily used areas on the Chugach National Forest for winter motorized recreation.

The protocol for this pilot study (MacFarlane, 2007) was developed as a part of this monitoring project and will be incorporated into the Chugach National Forest Monitoring Guide. This study evaluates the potential that these pollutants are exceeding Alaska State air quality standards as a result of winter motorized uses. Findings from this pilot study will help guide a long-range monitoring strategy for the effects of winter motorized use on air quality in the Chugach National Forest.

Turnagain Pass is located on the Glacier Ranger District of the Chugach National Forest, about 36 miles southeast of Anchorage, Alaska (**figure 1.1**). Only the west side of the highway at the Turnagain Pass area is designated for winter motorized use (USDA Forest Service, Chugach National Forest, 2002a), and the parking lot on the west side of the Seward Highway at Mile-69 is the most heavily used parking area in the area for winter motorized use.

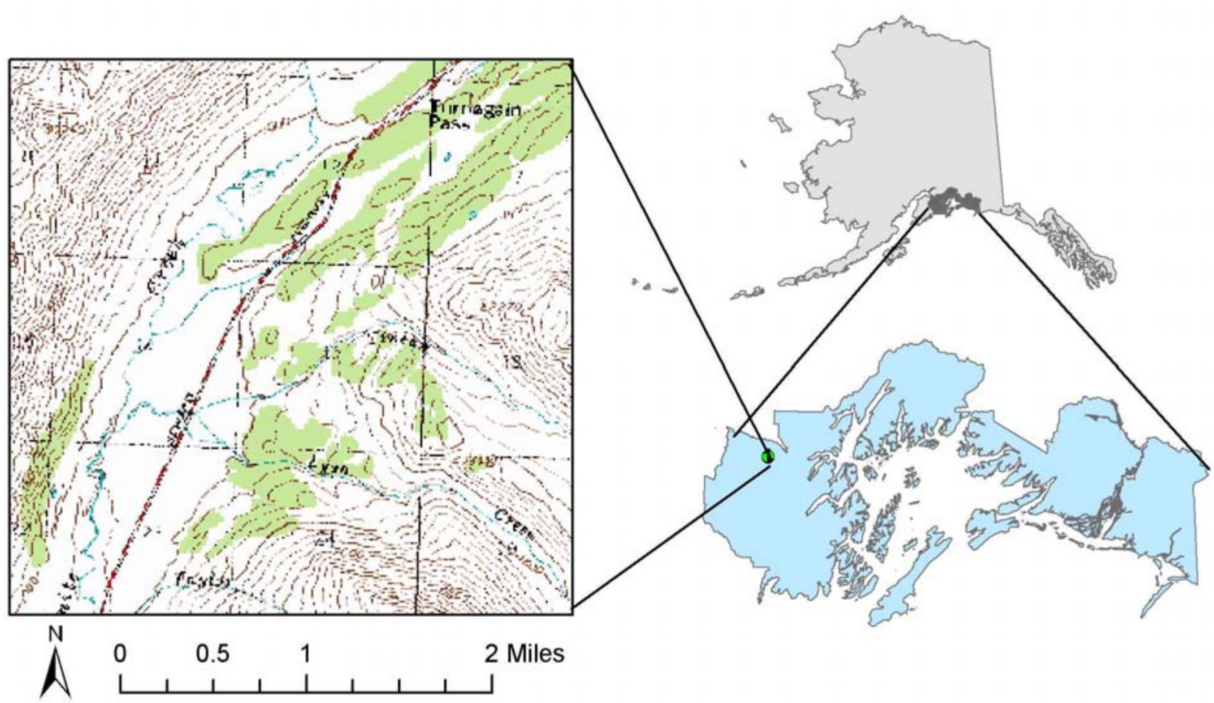


Figure 1.1: Location of the 2007 Turnagain Pass air quality monitoring study.

2 BACKGROUND

This pilot study addresses the following monitoring question dealing with the effects of Forest management on changes in air quality on the Forest. This pilot study will determine the appropriate approach to the Forest Service Chief's appeal response to the air quality issues addressed in the 2004 appeal of the 2002 Revised Chugach National Forest Plan (USDA Forest Service, 2004).

- What is the potential that winter snowmachine use and its associated activities are causing violations of Alaska State air quality standards in areas of the Chugach National Forest where winter motorized use is the highest?

Forest Plan Appeal: The Revised Chugach National Forest Land and Resource Management Plan (USDA Forest Service, Chugach National Forest, 2002a) (Forest Plan) does not include a monitoring question related to air resources. An appeal to the Forest Plan suggested that the Forest Service has not adequately quantified and assessed the impacts of winter motorized use on air quality. This pilot study will help to determine the appropriate level of monitoring to address the Forest Service Chief's response to this appeal (USDA Forest Service, 2004), in which the Chief agreed with the Regional Forester's decision in the Revised Forest Plan Record of Decision (USDA Forest Service, Chugach National Forest, 2002c) to conduct more detailed air quality analyses "so emissions can be more accurately quantified, reasonably forecasted, and local impacts assessed." In this response, the Chief determined the need to do the following:

- "Cooperate with the State to identify air quality changes over time and detect changes in air quality related to human activities on the Forest,"
- "Collect reliable qualitative air quality information to assure compliance with EPA's air quality standards," and
- Conduct monitoring to "conform to State air quality implementation plans."

The Forest Plan: The Forest Plan Final Environmental Impact Statement (FEIS) states that the largest source of air pollution on the Chugach National Forest is from airborne dust, particularly from natural sources (USDA Forest Service, Chugach National Forest, 2002b). Other sources of air pollutants include vehicle emissions, smoke from campfires, and smoke from wildfires and prescribed fires. The FEIS further states that snowmobile use on the Forest is dispersed and is not expected to have negative effects on air quality, although it does identify the fact that carbon monoxide and other pollutants may potentially increase in localized areas where high concentrations of snowmobiles assemble, such as Turnagain Pass and the Lost Lake area.

In the Revised Forest Plan Record of Decision (USDA Forest Service, Chugach National Forest, 2002c), the Regional Forester stated that the activities described in the Forest Plan are not likely to degrade air quality or violate state implementation plans. The Regional Forester also stated that more detailed analyses will be conducted at subsequent levels of planning to more accurately quantify and forecast emissions and assess the local impacts. No air quality studies quantifying levels of pollutants from snowmachine emissions have been previously conducted on the Chugach National Forest.

This pilot study will address the following Forest Plan air quality goals and objectives (USDA Forest Service, Chugach National Forest, 2002a) as they relate to winter motorized use:

- *Goal*: Conserve air quality related values over Chugach National Forest lands.
- *Objective*: Meet state standards for visible and particulate air quality.

The Clean Air Act: The Clean Air Act of 1990 sets the National Ambient Air Quality Standards (NAAQS) (US Environmental Protection Agency, 1990). These standards include six criteria pollutants: carbon monoxide, lead, nitrogen dioxide, suspended particulates, ozone, and sulfur oxides. Individual states are responsible for carrying out the regulations in the Clean Air Act, which includes enforcing state air quality standards and developing state implementation plans to clean up polluted areas. State standards must be no less stringent than the national EPA standards and are generally similar to the national standards. Air quality for the State of Alaska is regulated by the Alaska Department of Environmental Conservation (ADEC) air quality control standards (18 AAC 50) (Alaska Department of Environmental Conservation, 2005) (**table 2.1)**.

Table 2.1: Alaska State air quality standards (18 AAC 50).

Pollutant	**Primary Standard**	**Averaging Times**
Carbon Monoxide	9 ppm	8-hour average
	35 ppm	1-hour average
Lead	1.5 $\mu g/m^3$	Quarterly arithmetic mean
Nitrogen Dioxide	100 $\mu g/m^3$	Annual arithmetic mean
Particulate matter (PM10)	150 $\mu g/m^3$	24-hour average
Particulate matter (PM2.5) *(EPA standard)*	15.0 $\mu g/m^3$	Annual arithmetic mean
	35 $\mu g/m^3$	24-hour average
Ozone	0.12 ppm	1-hour average
Sulfur Oxides	0.03 ppm	Annual arithmetic mean
	0.14 ppm	24-hour average
	0.50 ppm	3-hour average

Motorized use and air quality: The winter motorized season on the Chugach National Forest begins on December 1 and ends on April 30, as snow conditions allow. Motorized use at Turnagain Pass can be permitted as early as the Wednesday before Thanksgiving if snow conditions allow (USDA Forest Service, Chugach National Forest, 2002a). The Turnagain Pass area is one of the most popular areas for winter motorized recreation on the Forest because of its high elevation, abundant snow, and proximity to Anchorage.

Snowmachine emissions have been shown to cause increased levels of carbon monoxide, nitrogen oxide, and particulates in the air (Ray, 2005; Bishop et al., 2006). The types and amounts of these pollutants can vary with factors such as the manufacturer, type of engine, temperature, and elevation. Four-stroke engines have been shown to have lower emissions than 2-stroke engines (Bishop et al., 2006). These emissions can be sources of concern for public health and safety, and clean air is an important part of the experience for visitors to the Forest in terms of visual clarity as well as health.

Air pollution as a result of snowmachine use has been monitored in Yellowstone National Park since 1998 (Ray, 2005). At the West Yellowstone entrance between 1998 and 2002, the maximum 8-hour carbon monoxide levels averaged between 5ppm and 9ppm. These levels nearly exceeded the 8-hour NAAQS standard (9ppm), with roughly 400 snowmachines entering the park each day and a high percentage of 2-stroke engines. Air quality impairment can be worse on days with stagnant air conditions and temperature inversions. As a result of adaptive management leading to decreased numbers of snowmachines and clean engine technology requirements, levels of carbon monoxide and particulates have decreased considerably over the last four years. During the 2004-2005 season, between 130 and 190 snowmachines used the West Yellowstone entrance each day, and the maximum 8-hour carbon monoxide levels reached only 1ppm (Ray, 2005).

Past snowmachine use at Turnagain Pass has averaged around 50 users per day on weekends and 10 users per day on weekdays (Skustad, 2001). Furthermore, weather conditions at Turnagain Pass are often such that the air is not stagnant. Based on these use levels and climatic factors, levels of air pollutants on the Chugach National Forest as a result of winter motorized use are likely to be minor and below the federal air quality standards (USDA Forest Service, Chugach National Forest, 2002b).

3 METHODS

The following methods are taken from the Chugach National Forest Monitoring Guide protocol for Air Resources (MacFarlane, 2007).

This protocol is a pilot protocol. No nationally established Forest Service air quality monitoring protocols currently exist for quantifying the air quality effects of winter motorized recreation. This pilot protocol was designed by the Chugach National Forest to meet the needs of this monitoring question, with assistance from the Alaska Department of Environmental Conservation.

3.1 Objective Statement

This pilot air quality monitoring project has the following objectives:

1) Quantifiably determine the potential that Alaska State air quality standards for carbon monoxide and fine particulates are being exceeded as a result of winter motorized use on the Chugach National Forest. Because of the remote nature and the unknown air quality conditions for these sites, this study will quantify levels and determine the sources of these pollutants during a number of days during the winter motorized season when the use is the highest. Air quality data will be analyzed in relation to climatic observations and motorized use levels observed during the day in order to account for natural and human-related variations in the air quality conditions.

2) Provide information leading to the future development of an adaptive, long range air quality monitoring program on the Chugach National Forest to investigate the influence of winter motorized use on air quality.

This type of monitoring will not meet the stringent requirements of the State Implementation Plan for air quality monitoring. However, it will allow a determination of the level of need, which will drive the development of an appropriate monitoring program. In order to meet the Chief’s objectives stated in the 2004 Forest Plan appeal response (USDA Forest Service, 2004), this pilot study will involve the State of Alaska Department of Environmental Conservation to obtain monitoring equipment and assistance with sampling procedures, and collect sufficient data to accurately quantify air pollution as identified in the objective statement.

Legal requirements: The Chugach National Forest is required to ensure that management activities do not contribute to violations of the air quality standards regulated by the Alaska Department of Environmental Conservation (Alaska Department of Environmental Conservation, 2005), as specified by the US Environmental Protection Agency and the Clean Air Act (US Environmental Protection Agency, 1990).

Statistical Rigor Rationale: This pilot is designed to determine the potential for winter motorized use on the Forest to cause air quality standards to be exceeded, and not to make statistical inferences about air quality across the Forest. Therefore, a non-statistical approach

is employed. The determination of this potential will be based on quantitative data and professional judgment.

Data precision and reliability: The data will be Class A quantitative data that is repeatable, using instrumentation that will be calibrated to known concentrations of pollutants.

Confidence: Confidence levels of this monitoring are dependent upon the standard errors associated with the equipment used to measure air quality parameters (see *Quality Control and Assurance*).

Thresholds: Threshold levels of carbon monoxide and fine particulates that would trigger changes in the monitoring approach and a management review were established for this pilot study as shown in **table 3.1**. The threshold that defines the high potential to exceed the State standard is based on the air quality standards established by the State of Alaska (Alaska Department of Environmental Conservation, 2005).

Table 3.1: Action thresholds for carbon monoxide (CO) and fine particulates (PM2.5).

Potential for exceeding State air quality standards / Description of conditions	1-Hour Average CO Concen-tration	8-Hour Average CO Concen-tration	24-Hour Average PM2.5 Concen-tration *	Action Needed
LOW: Background or low levels of pollutants	0-25 ppm	0-6 ppm	0-25 μg/m^3	Continue monitoring the same sites with remeasurement occurring every 3 to 5 years.
MODERATE: Some impairment of air quality, levels at or below State standards	25-35 ppm	6-9 ppm	25-35 μg/m^3	Consider remeasurement of same sites on an annual basis.
HIGH: Levels of air pollutants exceed State standards	>35ppm	>9 ppm	>35 μg/m^3	Consider increasing the frequency of monitoring and the number of sites monitored. Review of monitoring results by management to determine need for change in policy.

** The 24-hour average PM2.5 concentration is inferred based on data from an 8-hour sampling period.*

Scope of inference: This pilot study will quantify air quality conditions during the “worst case scenario” that occurs during the peak of motorized use in one of the most heavily used areas on the Forest (Turnagain Pass). It is likely, but not certain, that the air quality as a result of winter motorized uses throughout the rest of the Forest will be as impaired or less impaired than at this site. The temporal scope of reference is the winter months corresponding to the winter motorized use season (December 1 to April 30).

3.2 Indicators and Units of Measure

Primary indicators and units of measure: This pilot study will monitor carbon monoxide (CO) and fine particulates (PM2.5) in relation to winter motorized use. At the Turnagain Pass area, snowmachine use is likely to cause some degree of increase in the levels of carbon monoxide, nitrogen oxides, and particulates in the air. Because the only standard for nitrogen oxide is an annual arithmetic mean, winter seasonal snowmachine use is less likely to violate this standard. Carbon monoxide, with an 8-hour standard, and fine particulates, with a 24-hour standard, are likely the best indicators to assess whether winter motorized uses are causing a violation of air quality standards.

- 1-hour average CO concentration ppm
- 8-hour average CO concentration ppm
- 24-hour average PM2.5 concentration $\mu g/m^3$

Climatic indicators and units of measure: The variable climatic conditions at Turnagain Pass can affect the air quality conditions. The Turnagain Pass area has characteristics of the maritime climate of Prince William Sound and the interior climate of the Kenai Peninsula. This area has peak snowpacks averaging over 100 inches at the 1800-foot elevation (USDA Natural Resources Conservation Service, 2007), occasional winter rains, and winds generally from the northeast or southwest, parallel to the direction of the valley. The following weather variables will be collected as secondary indicators:

- Air Temperature degrees F
- Relative Humidity percent
- Wind Speed mph
- Wind Direction direction
- Barometric Pressure mm Hg
- Weather conditions description

Human use indicators and units of measure: This pilot study will compare air quality conditions to the amount of winter motorized use in these areas. Motorized activities associated with snowmachine use include vehicle use. The following secondary indicators are used to quantify the amount of human use on each day of sampling:

- Snowmachines visible number
- Trucks in parking lot number
- Cars/SUVs/Vans in parking lot number
- Trailers in parking lot number
- RVs and semi-trucks in parking lot number
- Traffic rate on Seward Highway vehicles/minute

3.3 Sampling Design

Air quality monitoring will be conducted at the times of the heaviest winter motorized use, over a range of climatic conditions. The intent is to collect data that represent the maximum air quality impairment related to winter motorized uses.

Target Population: The target population is the air quality conditions of carbon monoxide and fine particulates at peak times of winter motorized use at Turnagain Pass.

Sampling Frame: Four sites at Turnagain Pass will be sampled for carbon monoxide, including one control site. One site at Turnagain Pass will be sampled for fine particulates (PM2.5). Each of these sites will be sampled on 8 different days over the course of the winter season. The 4 carbon monoxide sampling sites represent the range of conditions around the Turnagain Pass western parking lot. The 1 particulate sampling site represents impaired air quality conditions at the Turnagain Pass western parking lot.

Sample Selection Methods: The method of site selection was not probabilistic. The Turnagain Pass area represents the highest degree of air quality impairment on the Forest resulting from winter motorized uses. The parking lot is where the most concentrated winter motorized uses occur, including emissions resulting from "cold-starts," idling snowmachines, and idling vehicles. The four monitoring sites at Turnagain Pass were chosen to adequately quantify variability in air quality conditions around the site that may be the result of the following factors:

- *Elevation*: During inversions, pollutants can be trapped in low-lying areas.
- *Weather*: Wind can cause pollutants to drift in various directions.
- *Distance from the source*: Air pollutants will diminish with distance from the area of most concentrated use.

Sample Unit Description: The Turnagain Pass area, near Mile-70 of the Seward Highway can be used as an indicator of maximum carbon monoxide and particulates concentrations resulting from winter motorized activities on the Forest. Its 1000-foot elevation allows for a long winter motorized season. The Forest Service allows winter motorized use only on the west side of the Seward Highway. The topography consists of a terrace on which the highway and parking lot lay, a flat valley floor to the west of the parking lot, and steep hills and mountain slopes rising to the west of the valley.

In order to show local variability in levels of air pollution at the Turnagain Pass area, several sites will be sampled at three locations on the west side of the highway (where motorized use is allowed) and one site on the east side of the highway (designated non-motorized area) (**figure 3.1**). Because the objective of this study is not to sample the individual sources of pollutants, such as an idling truck or a running snowmachine, samples will not be taken in the parking lot, but in the general vicinity of where these activities are taking place. These samples will be representative of the air quality in the area, and the locations will provide a representative sample of air quality conditions during a variety of weather and wind conditions. The sensors are set up to sample the air about 6 feet above the snow surface, or the general air that users would encounter at the site. Air quality will be sampled at the following sites:

1. **SITE #1**: Turnagain Pass west-side (motorized) parking area. This site is about 10 feet west of the plowed edge of the parking lot, on the snow berm a few feet above the parking lot level and between the two restrooms. Both carbon monoxide and particulates will be sampled at this site. Because only one particulate sensor is available, particulates will

always be measured only at this site because it is in a central location and it is the closest site to the most concentrated motorized uses.

2. **SITE #2**: Turnagain Pass west-side (motorized), northwest of the parking area. This site is in the valley floor approximately 200 feet west of the northwest corner of the parking lot, on a small terrace just south of the creek. The sensor is about 20 feet below the level of the parking lot. Carbon monoxide will be sampled at this site.
3. **SITE #3**: Turnagain Pass west-side (motorized), southwest of the parking area. This site is on a terrace bench approximately 150 feet west of the southwest corner of the parking lot. The site is on the edge of the bench so that it is visible from above and below. The sensor is about 10 feet below the level of the parking lot. Carbon monoxide will be sampled at this site.
4. **SITE #4**: Turnagain Pass east-side (non-motorized) parking area. This site is next to the 'Avalanche Danger' sign located along the trail, about 500 feet east of the east end of the parking lot. Carbon monoxide will be sampled at this site.

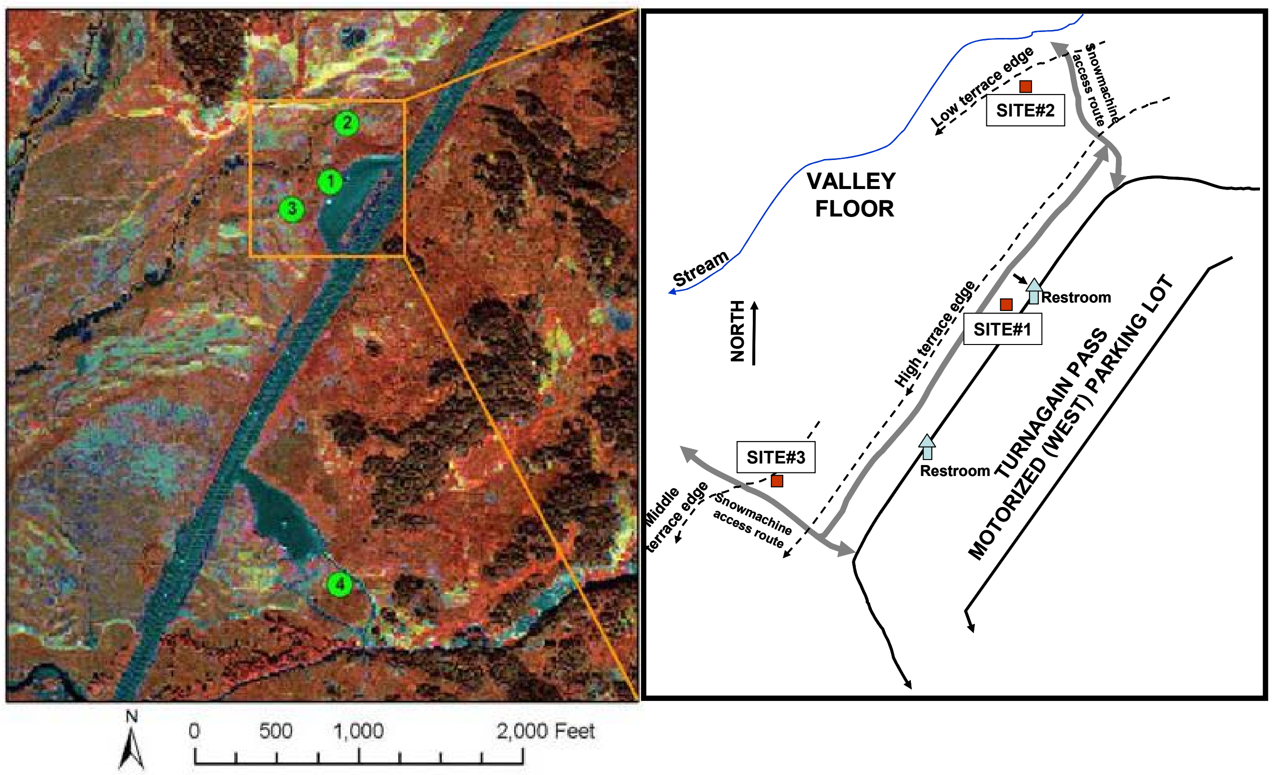


Figure 3.1: Turnagain Pass parking area sampling sites (left) and west Turnagain Pass detail drawing (right).

Sample Size Estimate and Estimation Methods: Air quality monitoring at Turnagain Pass will occur on a total of 8 sample days over the course of the winter season in order to characterize the air quality conditions during a variety of weather conditions and motorized use levels. These eight sample days will characterize high-use conditions and low-use conditions, including a control sample to characterize the background conditions.

Temporal Details of Sampling: The 8 sample days, occurring between December 1 and April 30, will measure air quality during high-use days to show the highest potential for carbon monoxide and fine particulates pollution at these locations. The following schedule, dependent on motorized access closures, weather conditions, and other factors, will be used for sampling:

- 6 days during moderate or heavy use (weekend days or weekdays during holiday times) between December 1 and April 30
- 1 day during low use (weekdays or low-use weekend days) between December 1 and April 30
- 1 day during no motorized use (non-motorized season, weekday, or night)

Sampling will occur during approximately 8-hour periods spanning the time of most concentrated motorized use on each sample day. This will be generally 9:00am to 5:00pm. The monitors will be set up by about 9:00am each sampling day.

3.4 Data Collection

Carbon Monoxide

Carbon monoxide concentrations will be measured using Drager PACIII hand-held monitors equipped with carbon monoxide (XS CO) sensors. These lightweight, portable samplers with data-logging capabilities allow continuous sampling to occur at multiple locations, allowing sampling personnel to measure the spatial and temporal variations in carbon monoxide levels over the course of the sampling period. Drager PACIII monitors have been used to successfully characterize carbon monoxide levels in other studies, including a winter carbon monoxide saturation study in Anchorage, Alaska (Morris and Taylor, 1998). The PACIII monitors used for this pilot study are property of Alaska Department of Environmental Conservation. The CO sensors that are used in the PACIII monitors were purchased by the US Forest Service. The PACIII monitors continuously detect carbon monoxide levels at concentrations between 0 and 2000ppm at temperatures of minus 40 degrees F to 120 degrees F. Sample resolution is 1ppm. The monitors use 9-Volt lithium batteries.

These monitors will be left at the sample sites from approximately 9:00am to 5:00pm, providing 8 hours of continuous data. These monitors will be configured to record an average carbon monoxide concentration every 15 minutes in the datalogger.

One monitor will be placed at each of the four sample sites. One additional monitor will be placed at one of the sites as a duplicate for quality control. The sample site that is duplicated will rotate to a different site on each sample day. One monitor will be kept as a spare and used as necessary. For consistency, the monitors are assigned to each site as shown below:

Drager ID #	Turnagain Pass
DEC 1	Site #1
DEC 2	Site #2
DEC 4	Site #3
DEC 6	Duplicate
DEC 7	Spare
DEC 8	Site #4

The PACIII monitors will be placed in insulating cases. The insulators will not cover the air inlet area and will be placed on posts so that the monitors are about 6 feet above the snow surface, at the level at which a user would breathe. The mounting posts will include a cover held several inches above the sampler to keep snow and rain off the air inlet area but still allow air saturation of the monitors from all directions. The monitors will be surrounded by orange snow fence, and a small informational sign will be posted at each site.

The time at which sampling at the site begins and ends will be recorded for each site. The battery voltage at the beginning and end of the sampling period will also be recorded. Battery voltage for the monitors must be greater than 7.0 volts to ensure valid data. Any visible sources of carbon monoxide at or near the site will be recorded.

Particulates

Fine particulates (PM2.5) will be sampled during this pilot study using a portable Met-One EBAM particulate sampler, configured to sample fine particulates. The EBAM sampler used for the pilot study is property of Alaska Department of Environmental Conservation. Only one sampler is available for this pilot study.

The EBAM sampler uses a rechargeable battery. The battery will be kept in a cooler with a lamp to keep it warm. The sampler will continuously record PM2.5 concentration and temperature. The sampler will be calibrated prior to use for this project. The sampler will be configured to take measurements continuously and calculate 15-minute and 1-hour averages.

Each sample day, the sampler will be set up by about 9:00am and taken down at about 5:00pm. The EBAM sampler may take 30 minutes to 1 hour to set up. A leak test, temperature check, pressure check, and flow check must be conducted at the beginning and end of each sample day in order to ensure valid data. The instrument must be calibrated prior to use if needed, and these check and calibration data will be recorded. The sampler will be surrounded by orange snow fence, and a small informational sign will be posted at the monitoring location. Any visible sources of particulates at or near the site will be recorded.

Secondary Indicators

On each sample day, weather conditions and motorized use levels will be recorded during a morning observation period (between 9:00am and 10:00am), a mid-day observation period (between 12:00pm and 2:00pm), and an afternoon observation period (between 4:00pm and 5:00pm). This will characterize the general weather and use conditions for each of the two main parking lots at Turnagain Pass (west side motorized and east side non-motorized) over the course of the day. Measurements and observations will include the following:

- **Weather**: Air temperature, relative humidity, wind speed, and wind direction will be recorded using a hand-held Kestrel 4000 weather instrument held 6 feet above the ground. Qualitative weather descriptions include precipitation, sky conditions, and description of any visible haze layers from natural or human sources. Barometric pressure will be recorded by the EBAM sampler. If available, realtime weather information can also be

downloaded from the Road Weather Information System (RWIS) *Seward Highway at Turnagain Pass MP 69.9* weather site at http://www.dot.state.ak.us/iways/roadweather/forms/IndexForm.html and realtime weather and snow information for the Turnagain Pass SNOTEL site can be downloaded at http://www.ambcs.org/.

- **Quantitative use parameters**: The amount of motorized use will be quantified, including the number of snowmachines visible at the time of sampling, the number of snowmachine trailers in the parking lot, and the number of each type of vehicle in the parking lot during each observation period. These values will be used as indicators of the amount of motorized use at each location. The estimated average traffic rate, in vehicles per minute going both directions on the Seward Highway, will be measured as an additional indicator of motorized use in the area.

- **Photographs**: Photographs will be taken on each sampling day showing the air conditions at the site. In particular, any visible air pollution should be photo-documented. These should be in digital format, with the photo numbers recorded.

- **General observations**: This will include observations on any specific human sources of air pollution, natural sources of air pollution, or any other factors that could influence the measured parameters.

3.5 Quality Control and Assurance

Air quality monitoring will be conducted by the Forest air quality specialist or hydrologist. Oversight and training on use of the carbon monoxide and particulate samplers will be provided by the Alaska Department of Environmental Conservation (ADEC). Additional Forest Service monitoring personnel will be trained in the operation of the sampling equipment by ADEC personnel or the Forest air quality specialist.

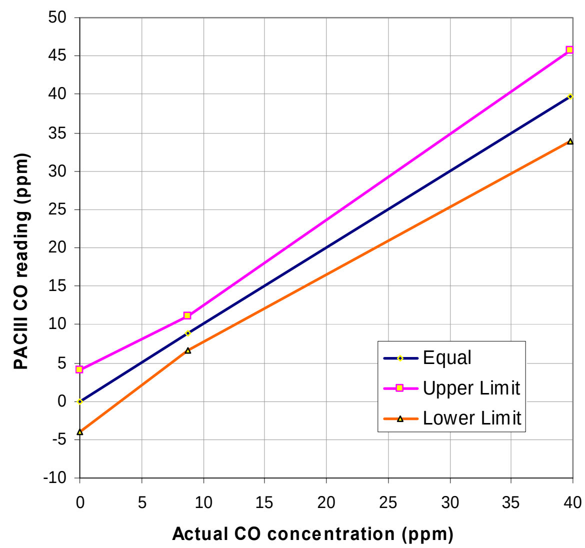
Carbon Monoxide monitors

The PACIII carbon monoxide monitors will be calibrated prior to the first day of monitoring and will undergo a post-sampling quality control check and calibration and after every two sample days. Calibration can be conducted in cooperation with Alaska Department of Environmental Conservation and the Municipality of Anchorage using calibration gases. Batteries will be replaced so that voltage readings are always greater than 7.0 volts. New CO sensors will be used in these monitors, as the sensors expire after 30 months of being opened.

Carbon monoxide error limits for post-sampling quality control and calibration were established for the PACIII monitors during past carbon monoxide monitoring conducted by the Municipality of Anchorage (Morris and Taylor, 1998). These limits, established for three concentrations of carbon monoxide and extrapolated as shown in **figure 3.2**, include the following:

- ***Zero***: Readings must be within 4 ppm of the known concentration (0ppm)
- ***Span***: Readings must be within 15% of the known span concentration. The span concentration used during this study is 39.8ppm.
- ***Precision***: Readings must be within 25% of the known precision concentration. The precision concentration used during this study is 8.81ppm.

Figure 3.2: Quality control limits for PACIII carbon monoxide monitors.



The 8-hour average carbon monoxide concentrations from the duplicated carbon monoxide monitors during each monitoring day should be within these established quality control limits. Each monitor will be assigned to the same site for consistency, and the duplicate monitor will rotate between sites.

In a carbon monoxide study in Anchorage, Alaska, the Municipality of Anchorage Environmental Services Division correlated the PACIII monitors with EPA-compliant reference method TECO 48 carbon monoxide monitors of the Anchorage air quality network (Morris and Taylor, 1998). Data show that the PACIII monitors reported slightly higher carbon monoxide readings than the reference monitors, and at carbon monoxide concentrations below 2ppm, the PACIII monitors sometimes read zero or below. Morris and Taylor (1998) applied a correction factor using the regression equation developed in this correlation. After this correction, 95% of the PACIII data fell within 2ppm of the reference concentration. This regression equation will also be applied to the data obtained in this air quality pilot study in order to compare carbon monoxide data to the State standards.

Particulate sampler

The Met-One EBAM sampler is reported to meet the EPA requirements for Class III PM2.5 designation, with an accuracy of 2.5μg in a 24-hour period. The flow accuracy is reported to be within 3% of the reading. Trent (2006) found that the EBAM sampler accurately estimated smoke particulate concentrations within 1% of the concentrations measured with the federal reference method sampler.

The EBAM particulate sensor will be calibrated for temperature, pressure, and flow rate before and after each use. If the unit is repeatedly used at the same location, re-calibration may not be required. Calibration must occur if the unit is moved to another sample location. The temperature, pressure, and flow values on the EBAM unit should be recorded and compared to the values on the DeltaCal calibration unit before and after each sample day. The battery voltage must read greater than 10.6 volts.

3.6 Data Analysis

This pilot project will analyze the following:

1. ***Carbon monoxide***: The carbon monoxide monitors record an average value every 15 minutes. These values will be averaged over the course of the 8-hour sampling period to derive 1-hour averages and an 8-hour average that will be compared to the State standards and the action levels shown in **table 2.1** and **table 3.1**.

2. ***Particulates***: The EBAM particulate sampler records an average value every 15 minutes. These values will be averaged over the course of the 8-hour sampling period. It is assumed that the 24-hour average PM2.5 concentration would be less than the measured 8-hour average PM2.5 concentration sampled during the daytime hours when motorized use is present at the site. The PM2.5 concentration during the overnight hours could be approximated by extrapolating data from the morning or other periods when motorized use levels are the lowest. The inferred 24-hour average PM2.5 concentration will be compared to the State standards and the action levels shown in **table 2.1** and **table 3.1**.

3. ***Standards***: The measured air quality parameters will be compared to the State air quality standards (**table 2.1**) and the thresholds for *low*, *moderate*, and *high* potentials for exceeding these standards (**table 3.1**). Data analysis will show the number of sample days that achieve the low, moderate, or high potentials for carbon monoxide and particulates to exceed the State standards.

4. ***Motorized use correlation***: Quantitative trends between measured air quality parameters and the number of motorized users will be analyzed.

5. ***Effects of weather***: The relationships between measured air quality parameters and temperature, wind speed, wind direction, and barometric pressure will be qualitatively analyzed to determine under what conditions air quality is likely to be the most impaired given a known level of motorized use.

6. ***Actions needed***: Management actions will be suggested based on the action levels shown in **table 3.1**. If a *low* potential for exceeding State air quality standards is found, then additional monitoring similar to this pilot protocol may need to be implemented every 3 to 5 years. If a *moderate* potential for exceeding State air quality standards is found, then additional monitoring may be required on an annual basis. If a *high* potential for exceeding State air quality standards is found, then a new monitoring strategy may need to

be developed, including additional monitoring sites and more frequent monitoring. In this case, results will be presented to management to determine the need for a change in policy.

3.7 Assumptions and Limitations

The following assumptions and limitation exist for this air quality monitoring protocol:

Sampling equipment: This monitoring protocol assumes that the instruments used to measure air quality parameters will accurately quantify the levels of the measured pollutants. In order to meet the requirements for air quality monitoring under the Alaska State air quality implementation plan, EPA-approved Federal Reference Method (FRM) or Equivalent Method Monitors (FEM) must be used under a strict quality control/quality assurance protocol. Any data that are not collected in this way cannot be used to determine attainment or non-attainment of air quality standards. However, data from non-EPA approved instruments may be used to analyze the *potential* for attainment/non-attainment of these standards. This is a suitable approach when the magnitude of air quality impairment is unknown, such as in this pilot study.

Time: This pilot study does not conduct continuous monitoring beyond an 8-hour period on each sample day. This protocol assumes that the greatest period of air quality impairment associated with winter motorized uses occurs during the daytime hours when motorized uses are the highest, and that overnight levels of particulates will be less than those during the day.

Sample sites: This protocol assumes that the selected sample sites are representative of the general air conditions at the monitoring location. Only four sites are sampled at Turnagain Pass, providing a limited glimpse of the distribution of air pollutants. The locations in which sampling will occur have particular characteristics of environmental, climatic, and topographic conditions. Therefore, air quality conditions at these locations cannot necessarily be extrapolated to other locations given the same amount of motorized use.

Weather: Although monitoring will sample a range of weather conditions, it will not represent the air quality conditions that may occur during all weather conditions. In particular, wind speed and direction can have a large effect on air pollutant concentrations.

4 RESULTS

4.1 Sampling Days

Sample days were chosen to represent high motorized use days at the western parking lot at Turnagain Pass throughout the winter motorized use season. The site was sampled on 7 days during the motorized season, and 1 day was sampled after the end of the motorized season to represent a control sample (**table 4.1**). These sample days represent a wide range of climatic and human use conditions.

Table 4.1: Sample days for the 2007 winter air quality monitoring at Turnagain Pass.

Date	Day of week	Season
5-Jan	Fri	Motorized
13-Jan	Sat	Motorized
27-Jan	Sat	Motorized
10-Feb	Sat	Motorized
3-Mar	Sat	Motorized
31-Mar	Sat	Motorized
28-Apr	Sat	Motorized
9-May	Wed	Non-Motorized

4.2 Climatic Indicators

Weather on each of the sample days varied. Some scheduled sampling days had to be rescheduled because of heavy snow and winds which could have potentially damaged the sampling equipment. The 8 sample days represent a wide range of weather conditions (**table 4.2**).

Table 4.2: Climatic variables for each sample day at Turnagain Pass.

Date	Sky conditions	Precipi-tation	Daytime Air Temp (deg F)			Average wind speed (mph)	Notes
			Minimum	Average	Maximum		
5-Jan	Clear	None	-4.2	-1.8	1.2	3.0	Cold, patchy fog
13-Jan	Partly Cloudy	None	19.2	22.0	27.0	2.0	Temperature inversion, fog in morning
27-Jan	Mostly Cloudy	Snow	29.3	31.2	31.8	8.5	Snow increased during the day
10-Feb	Foggy	None	21.4	23.0	24.1	2.2	Patchy fog
3-Mar	Clear	None	0.3	10.2	16.7	1.6	Light haze
31-Mar	Clear	None	16.9	34.0	42.6	1.4	Clear and sunny
28-Apr	Clear	None	36.7	43.8	47.1	1.3	Nice warm day
9-May	Mostly Cloudy	None	39.0	41.0	43.3	5.4	Clouds, breezy, a few rain drops

4.3 Human Use Indicators

Two large parking lots are used in the winter at Turnagain Pass. The western parking lot is the primary parking lot for winter motorized use in this area. Some motorized users park in the eastern parking lot as an overflow parking lot during times of peak use, but the eastern parking lot is primarily used by non-motorized recreational users. The peak motorized use levels generally occurred in the afternoon. The time of peak use shifted to later in the afternoon toward the end of the season when the days became longer.

Because of variability in the conditions on the sample days associated with weather, snow conditions, and availability of open terrain for motorized use, the sampled days varied greatly from low to high use (**table 4.3**). Of the sample days, three were considered *high use,* with a maximum of more than 50 vehicles at the western parking lot. Two days were considered *moderate use* (maximum of 25 to 50 vehicles), two days were considered *low use* (maximum of 5 to 25 vehicles), and the non-motorized season control sample was considered *very low use* (maximum of less than 5 vehicles). These use level categories are subjective, based on the range of conditions observed during the 2006-2007 winter season.

Table 4.3: Human use variables measured for each sample day at Turnagain Pass.

Date	Motorized Use Level	West side maximum vehicle count	East side maximum vehicle count	West side maximum snowmachine count	East side maximum snowmachine count
5-Jan	Moderate	32	2	14	0
13-Jan	High	61	6	60	2
27-Jan	Moderate	34	6	9	0
10-Feb	Low	12	2	12	0
3-Mar	Low	16	2	10	0
31-Mar	High	62	17	29	0
28-Apr	High	69	8	24	0
9-May	Very Low	2	3	0	0

4.4 Carbon Monoxide concentrations

Carbon monoxide was sampled at four sites on each sample day (**table 4.4**). The carbon monoxide sensors were placed at each site for up to about 8 hours in order to determine an 8-hour average. On some days at some sites, 8 hours of continuous data were not achieved because of constraints caused by weather or equipment issues. The carbon monoxide sensors recorded 15-minute averages. One-hour averages and sample period averages were calculated from these data. Negative values recorded by the sensors were adjusted to 0 ppm prior to averaging. Following the January 27 sample day, the sensors gave unreliable data. This may be the result of problems associated with the temperature compensation of the sensors, humidity, and cold.

Table 4.4: Carbon monoxide concentrations for each sample day at each site.

	Site #1			Site #2			Site #3			Site #4		
Date	Hours sampled	Max 1-hour avg (ppm)	Sample period average (ppm)	Hours sampled	Max 1-hour avg (ppm)	Sample period average (ppm)	Hours sampled	Max 1-hour avg (ppm)	Sample period average (ppm)	Hours sampled	Max 1-hour avg (ppm)	Sample period average (ppm)
5-Jan	6.5	1.25	0.36	5.5	2.75	0.73	5.25	0.75	0.14	4.5	0.00	0.00
13-Jan	7.75	2	0.90	7.75	1.75	0.48	7.75	1.25	0.32	7	0.00	0.00
27-Jan	8.5	0.00	0.00	8.0	0.00	0.00	8.0	0.00	0.00	8.0	0.00	0.00
10-Feb	Sensors not functioning			Sensors not functioning			Sensors not functioning			Sensors not functioning		
3-Mar												
31-Mar												
28-Apr												
9-May												

4.5 Fine Particulate concentrations (PM2.5)

Fine particulates (PM2.5) were measured for 6 to 8 hours each sample day with an EBAM sampler. Hourly averages were recorded. All data less than the detection limit of 2.5 µg/m^3 were manually adjusted to one half the detection limit (1.25 µg/m^3) prior to calculation of averages. From these data, the sample period averages were calculated (**table 4.5**).

In order to approximate a 24-hour PM2.5 concentration for each day using the 6 to 8 hours of available data, the average PM2.5 concentrations for the overnight hours (generally between 5pm and 9am) were estimated by averaging the first and last hour of data during the sampling period. The first and last hours of the sampling period are assumed to be those with the least use, and are assumed to be similar to the conditions during the overnight hours. The 24-hour average was estimated by averaging the collected hourly data and the estimated hourly data from the overnight hours. This is likely to be a conservative estimate, as the PM2.5 concentrations during the overnight hours may be lower than the estimated overnight concentrations.

Table 4.5: Fine particulate data for each sample day.

Date	Number of Hours Sampled	Maximum hourly average (µg/m^3)	Sample Period Average (µg/m^3)	Average of first and last hours of sample period * (µg/m^3)	Estimated 24-hour average ** (µg/m^3)
5-Jan	5.75	33.0	18.0	10.7	12.5
13-Jan	6	78.0	36.5	23.1	26.4
27-Jan	6.75	40.0	9.4	3.6	5.2
10-Feb	6.75	13.0	5.1	2.8	3.4
3-Mar	6.75	16.0	5.9	6.8	6.5
31-Mar	8	26.0	11.8	14.3	13.5
28-Apr	8	23.0	8.1	5.7	6.5
9-May	6.75	4.0	1.8	1.7	1.7

** Approximates the average for the overnight hours*

*** Calculated using weighted average of sample period average and estimated overnight average*

4.6 Daily Air Quality data

The following are the quantitative and qualitative results of the data collected for each air quality sample day in 2007 at Turnagain Pass.

Friday, January 5, 2007

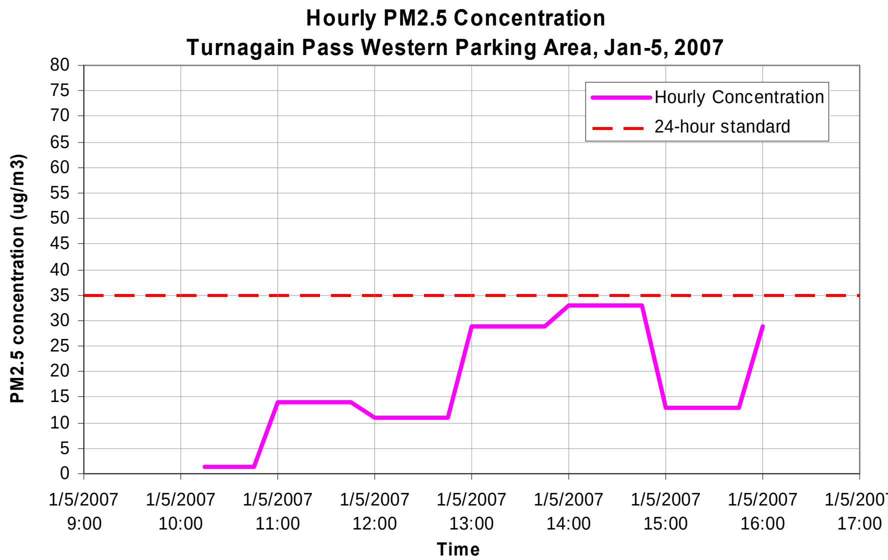
January 5 was the first sample day for this project. The weather was clear and very cold, and the motorized use level was moderate (**figure 4.1**). This sample day represents early season conditions with a shallow snowpack. Because of difficulties setting up the EBAM sampler, only 5.75 hours were sampled. Because of the short days during this part of the year, most of the motorized use occurred between 10am and 5pm. Cold weather resulted in numerous idling vehicles in the parking lot throughout the day, and vehicle and/or snowmachine exhaust could be seen and smelled. The smell of exhaust was greatest in the low valley west of the parking lot, where much of the exhaust settled.


Figure 4.1: Air quality samplers (left) and the western parking lot at Turnagain Pass (right), January 5, 2007.

Hourly PM2.5 concentrations ranged up to 33 µg/m^3, with the highest concentrations occurring in the mid-afternoon (**figure 4.2**). The average PM2.5 concentration during the sample period was 18 µg/m^3, and the estimated 24-hour average was 12.5 µg/m^3.

Carbon monoxide concentrations ranged from 0 to 4 ppm at the four sample sites (**figure 4.2**). The highest sample period average CO concentration of 0.73 ppm was measured at Site #2. Over the sample period, site #1 averaged 0.36 ppm, and Site #3 averaged 0.14 ppm. The highest 1-hour average CO concentration was 2.75 ppm at site #2. The control site on the non-motorized side of Turnagain Pass averaged 0.00 ppm, with no carbon monoxide detected.

Friday, January 05, 2007	
Season	Motorized
Average Temperature	-1.8 deg F
Average Wind Speed	3 mph
Max vehicle count	32
Max snowmachine count	14



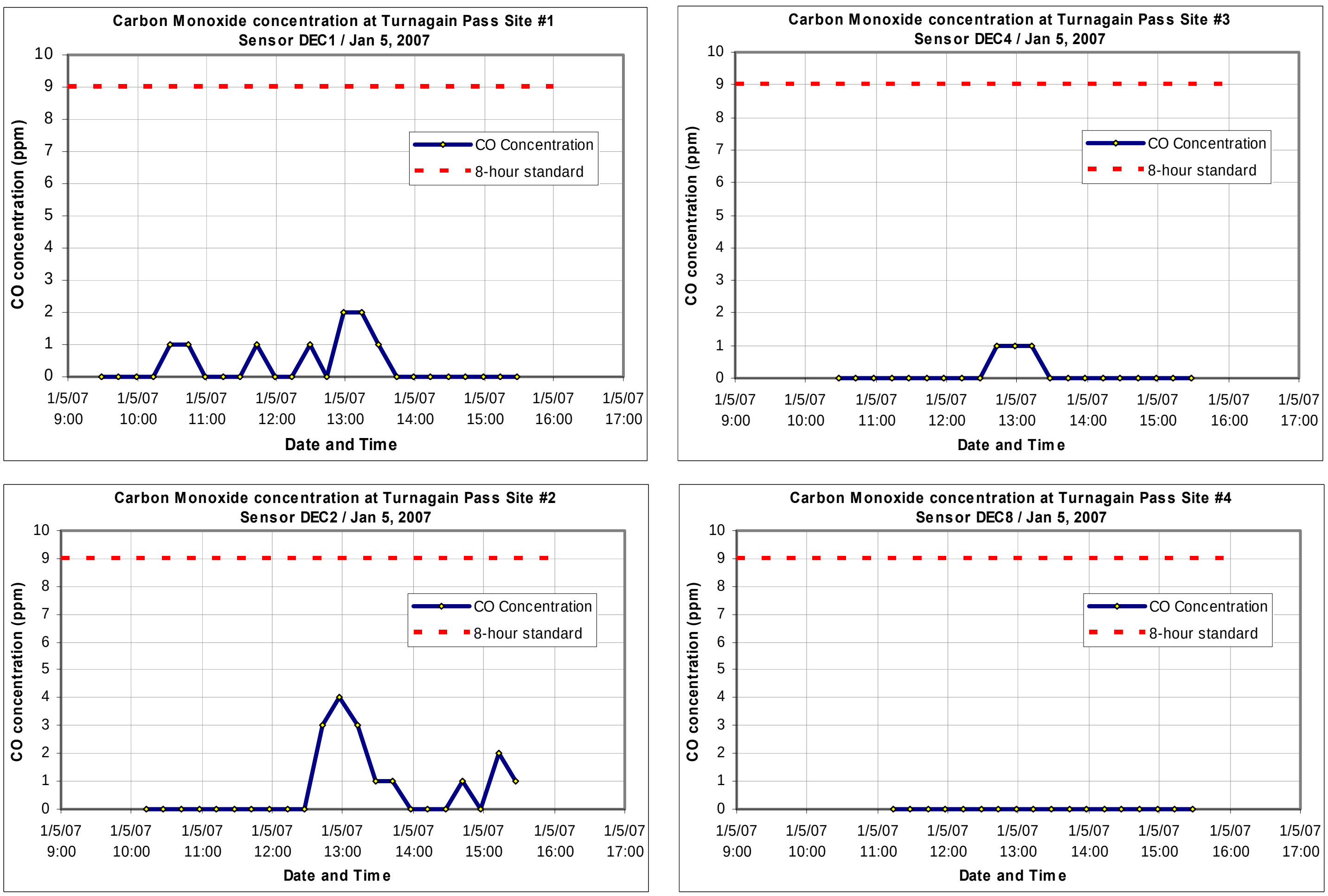


Figure 4.2: Fine particulate (PM2.5) and carbon monoxide concentrations at Turnagain Pass, January 5, 2007.

Saturday, January 13, 2007

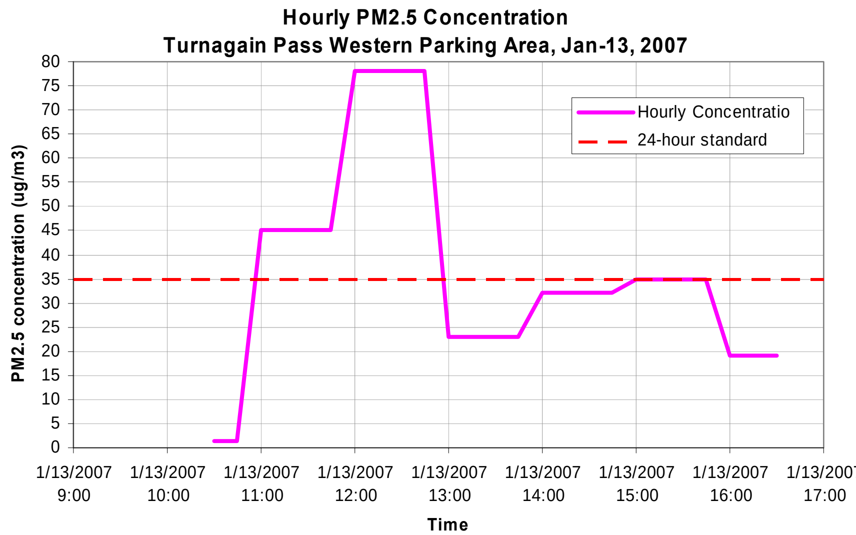
January 13 was characterized by high levels of motorized use, and moderately cold temperatures with a temperature inversion on Turnagain Pass (**figure 4.3**). Snow fell during the early morning, followed by clearing in the morning and development of fog settling on the pass most of the day. Motorized use was concentrated between about 10am and about 5pm. Numerous idling vehicles were observed during the mid-day observation period, and much of the snowmachine use appeared to be occurring close to the parking area.

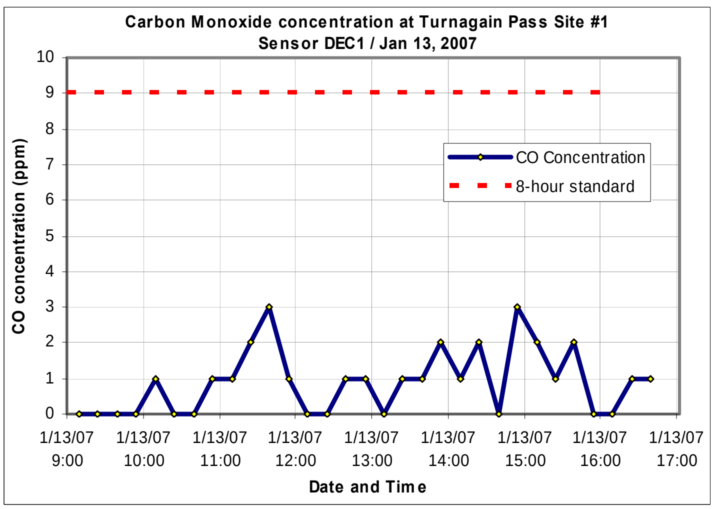
Figure 4.3: Conditions at the western Turnagain Pass parking lot, January 13, 2007.

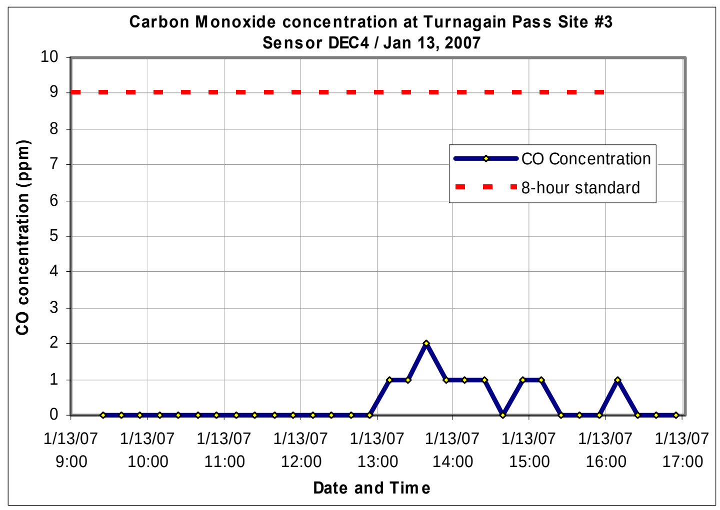
The hourly PM2.5 concentration reached as high as 78 $\mu g/m^3$, with a 6-hour sample period average of 36.5 $\mu g/m^3$ (**figure 4.4**). Peak levels of particulates were measured between 12pm and 1pm, with moderately high levels persisting the rest of the afternoon. Using the average of the first and last hours (23.1 $\mu g/m^3$) to estimate the PM2.5 concentrations during the overnight hours resulted in an estimated 24-hour average of 26.4 $\mu g/m^3$. This is likely a conservative estimate, as the PM2.5 concentrations during the overnight hours probably dropped below 23.1 $\mu g/m^3$ as a result of little or no motorized use.

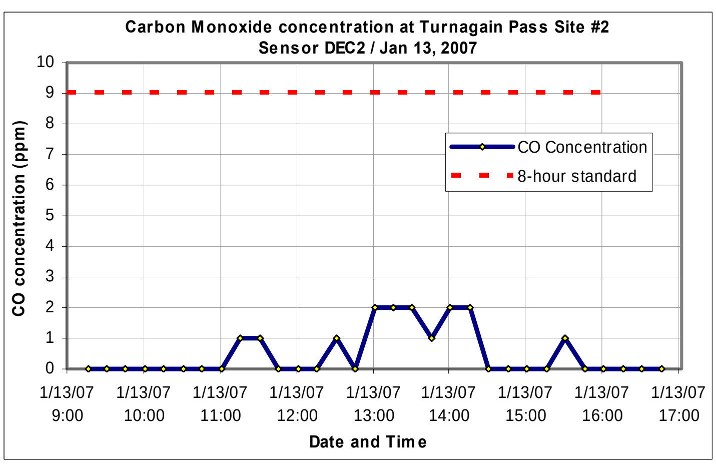
Carbon monoxide concentrations ranged from 0 to 3 ppm at the three sites at the western Turnagain Pass parking lot (**figure 4.4**). Over the sample period, CO concentrations averaged 0.90 ppm at site #1, 0.48 ppm at site #2, and 0.32 ppm at site #3. The highest concentrations at these sites were detected between 11am and 3pm, with a maximum 1-hour CO concentration of 2.0 ppm at site #1. The site at the eastern parking lot (non-motorized side) detected no carbon monoxide.

Saturday, January 13, 2007	
Season	Motorized
Average Temperature	22.0 deg F
Average Wind Speed	2 mph
Max vehicle count	61
Max snowmachine count	60









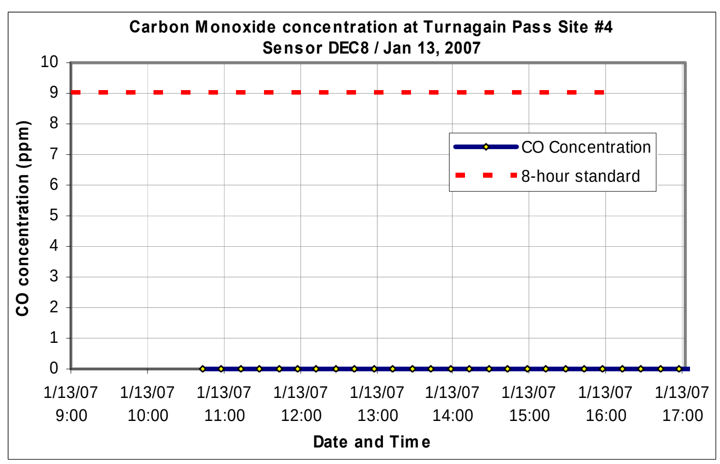


Figure 4.4: Fine particulate (PM2.5) and carbon monoxide concentrations at Turnagain Pass, January 13, 2007.

Saturday, January 27, 2007

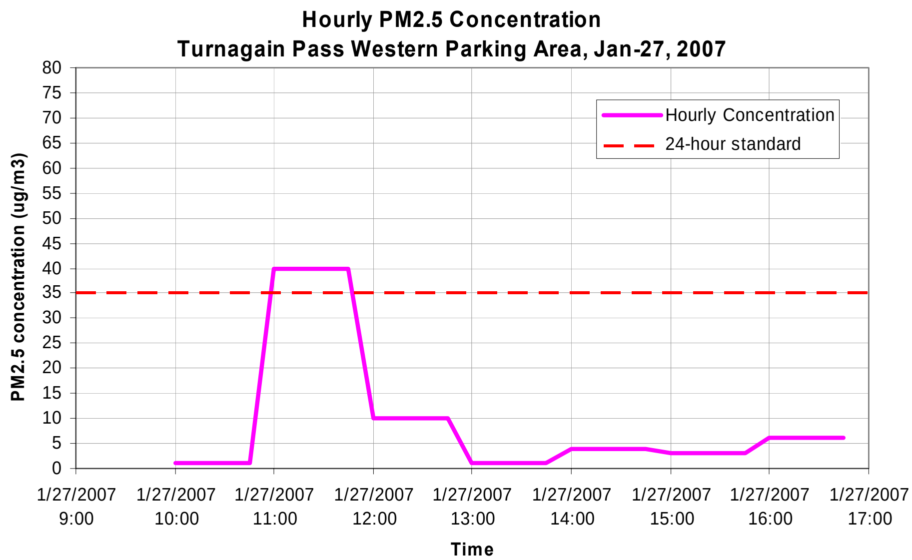
January 27 was characterized by clouds, snowfall, a light breeze, and a moderate level of motorized use (**figure 4.5**). Over a foot of snow fell the night before. Clearing occurred in the morning, but snowfall and winds increased throughout the day. Most of the motorized use occurred between 8:30am and 5pm.

Figure 4.5: Conditions at the Turnagain Pass western parking lot, January 27, 2007.

The hourly PM2.5 concentration reached as high as 40 µg/m^3, with a 6.75-hour average of 9.4 µg/m^3 (**figure 4.6**). Peak levels of particulates were measured between 11am and 12pm, with low levels detected the remainder of the day. Low levels during the afternoon are likely the result of increased wind velocities. The estimated 24-hour average PM2.5 concentration was 5.2 µg/m^3.

Carbon monoxide was not detected at any of the four sites on this day (**figure 4.6**).

Saturday, January 27, 2007	
Season	Motorized
Average Temperature	31.2 deg F
Average Wind Speed	8 mph
Max vehicle count	34
Max snowmachine count	9



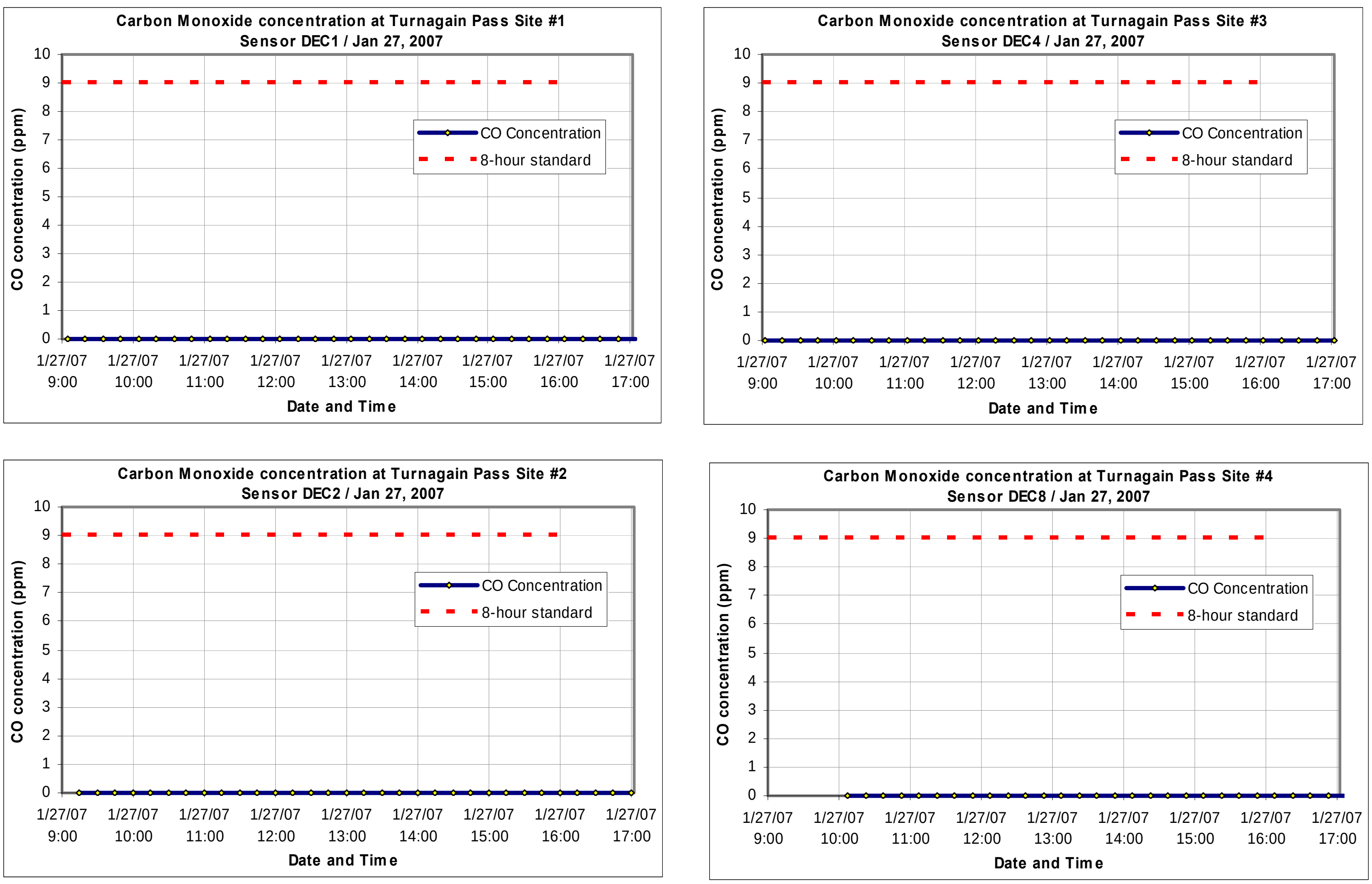


Figure 4.6: Fine particulate (PM2.5) and carbon monoxide concentrations at Turnagain Pass, January 27, 2007.

Saturday, February 10, 2007

February 10 had low levels of motorized use, likely the result of a very firm snowpack that may have limited snowmachine use. This was the lowest motorized use day of all days sampled during the motorized season. Also, fewer users may have been present at the Turnagain Pass site because of increased availability for snowmachine use in other areas such as the Placer River. Weather on this day was moderately cold with some sun, high fog, and periodic light snow.

The hourly PM2.5 concentration reached as high as 13.0 µg/m^3, and the 6.75-hour average was 5.1 µg/m^3 (**figure 4.7**). Peak levels of fine particulates were measured between 12pm and 1pm, and between 3pm and 4pm. Using the average of the first and last hours to estimate the PM2.5 concentrations during the overnight hours resulted in an estimated 24-hour average of 3.4 µg/m^3. Carbon monoxide data are not available for this sample day because the carbon monoxide sensors were not functioning properly.

Saturday, February 10, 2007	
Season	Motorized
Average Temperature	23.0 deg F
Average Wind Speed	2 mph
Max vehicle count	12
Max snowmachine count	12

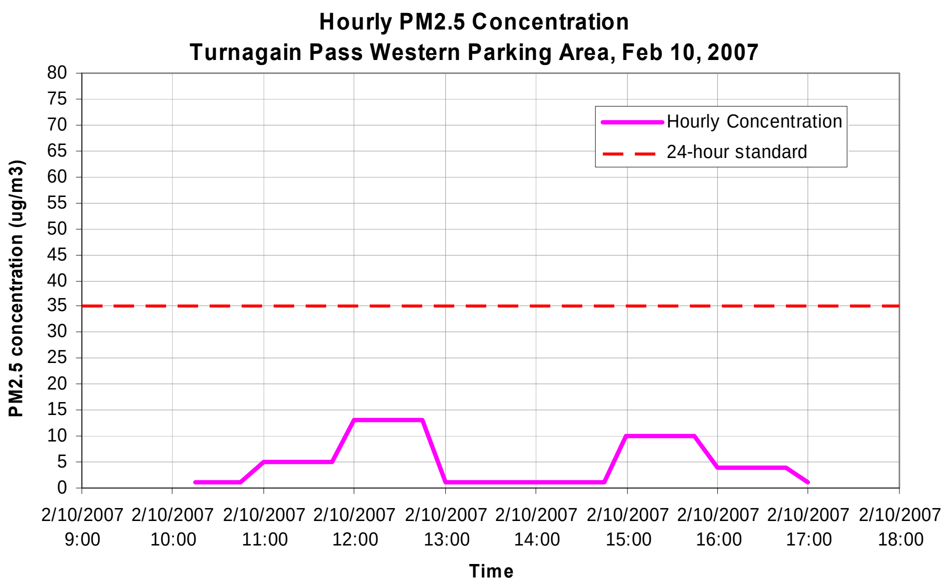


Figure 4.7: Fine particulate (PM2.5) concentrations at Turnagain Pass, February 10, 2007.

Saturday, March 3, 2007

March 3 had low levels of motorized use, likely the result of a very cold, firm snowpack and lack of recent new snow that may have limited snowmachine use. Also, fewer users may have been present at the Turnagain Pass site because of increased availability for snowmachine use in other areas such as the Placer River. Weather on this day was very cold, still, and clear.

The hourly PM2.5 concentration reached as high as 16.0 µg/m^3, and the 6.75-hour average was 5.9 µg/m^3 (**figure 4.8**). Peak levels of fine particulates were measured near the end of the day between 3pm and 4pm, with low levels measured the remainder of the day. Using the average of the first and last hours to estimate the PM2.5 concentrations during the overnight hours resulted in an estimated 24-hour average of 6.5 µg/m^3. Because the highest concentrations occurred during the last hour of the sample period, this estimate may over-represent the 24-hour average. It is likely that the PM2.5 concentrations during the overnight hours were more similar to the concentrations measured during the first half of the sample period. Carbon monoxide data are not available for this sample day because the carbon monoxide sensors were not functioning properly.

Saturday, March 03, 2007	
Season	Motorized
Average Temperature	10.2 deg F
Average Wind Speed	2 mph
Max vehicle count	16
Max snowmachine count	10

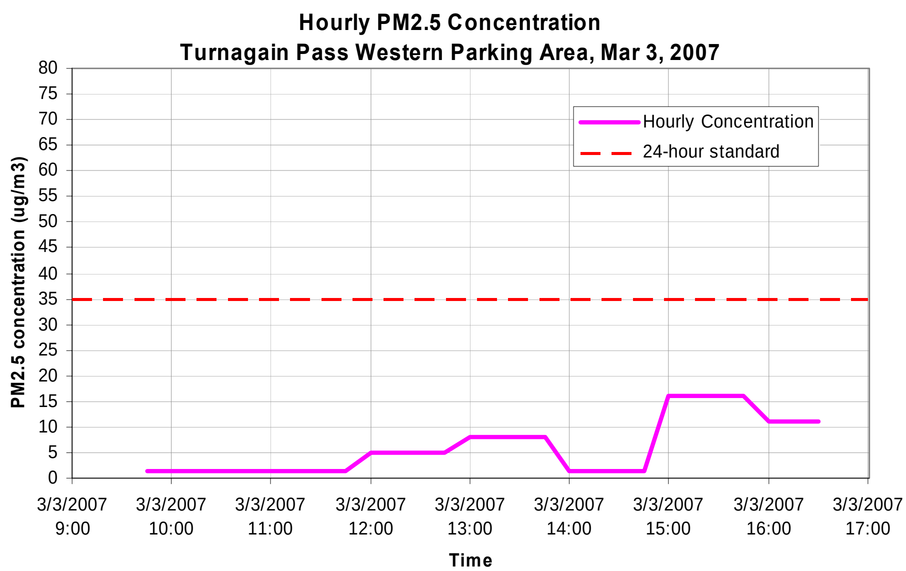


Figure 4.8: Fine particulate (PM2.5) concentrations at Turnagain Pass, March 3, 2007.

Saturday, March 31, 2007

March 31 was characterized by a high level of motorized use, and a clear, sunny day (**figure 4.9**). Morning temperatures were cold, warming to well above freezing by afternoon, and virtually no breeze was present. This was one of the highest use days of the season. Motorized use occurred from 8am to well after 5pm, and some users camped overnight in RVs. With the warmer weather, evening activity was high, with numerous vehicles, snowmachines, and barbeques. Numerous idling trucks were observed in the western parking lot, but most of the snowmachine use was dispersed throughout the Turnagain Pass valley and the Seattle Creek Valley to the west. With the adequate snowfall this year, this was a popular time for snowmachining. It should be noted that at about 1pm, about 115 vehicles were also parked at the various parking lots along the Placer River area at the base of Turnagain Pass. Most of these vehicles were probably associated with winter motorized backcountry use in the Placer River Watershed.

Figure 4.9: Conditions at the western Turnagain Pass parking lot, March 31, 2007.

The hourly PM2.5 concentration reached as high as 26.0 $\mu g/m^3$, and the 8-hour average was 11.8 $\mu g/m^3$ (**figure 4.10**). Peak levels of fine particulates were measured at the end of the day after about 4pm, with low levels measured the remainder of the day. Using the average of the first and last hours to estimate the PM2.5 concentrations during the overnight hours resulted in an estimated 24-hour average of 13.5 $\mu g/m^3$. Because the highest concentrations occurred during the last hour of the sample period, this estimate may over-represent the 24-hour average. It is likely that the PM2.5 concentrations during the overnight hours were more similar to the concentrations measured during the first half of the sample period. Carbon monoxide data are not available for this sample day because the carbon monoxide sensors were not functioning properly.

Saturday, March 31, 2007	
Season	Motorized
Average Temperature	34.0 deg F
Average Wind Speed	1 mph
Max vehicle count	62
Max snowmachine count	29

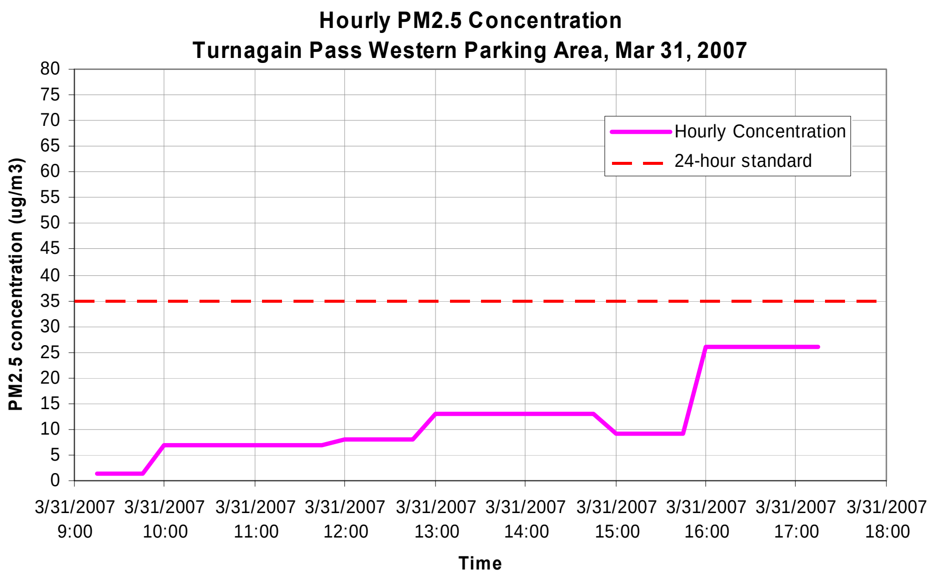


Figure 4.10: Fine particulate (PM2.5) concentrations at Turnagain Pass, March 31, 2007.

Saturday, April 28, 2007

April 28 was characterized by high motorized use and warm, sunny weather (**figure 4.11**). This was one of the highest motorized use days of the season. Most of the motorized use occurred during the afternoon and evening. Because of the long, warm days, motorized use likely occurred at high levels in the evening until about 8pm. Numerous motorists from the Seward Highway stopped at the western parking lot to use the restrooms. Most of the snowmachine use was dispersed throughout the Turnagain Pass valley and Seattle Creek Valley to the west. This was one of the last days of the season open to snowmachine use at Turnagain Pass. Motorized use was high at this site because the Placer River and Twentymile River areas were closed to motorized use. The weather was well above freezing, with very little breeze and clear skies.

Figure 4.11: Conditions at the western Turnagain Pass parking lot, April 28, 2007.

The hourly PM2.5 concentration reached as high as 23.0 µg/m^3, and the 8-hour average was 8.1 µg/m^3 (**figure 4.12**). Peak levels of fine particulates were measured between about 12pm and 1pm, and again between 4pm and 5pm, with the lowest levels measured in the morning. Using the average of the first and last hours to estimate the PM2.5 concentrations during the overnight hours resulted in an estimated 24-hour average of 6.5 µg/m^3. Sampling stopped at about 5:30pm, but motorized use at the site likely continued until about 8pm. Carbon monoxide data are not available for this sample day because the carbon monoxide sensors were not functioning properly.

Saturday, April 28, 2007	
Season	Motorized
Average Temperature	43.8 deg F
Average Wind Speed	1 mph
Max vehicle count	69
Max snowmachine count	24

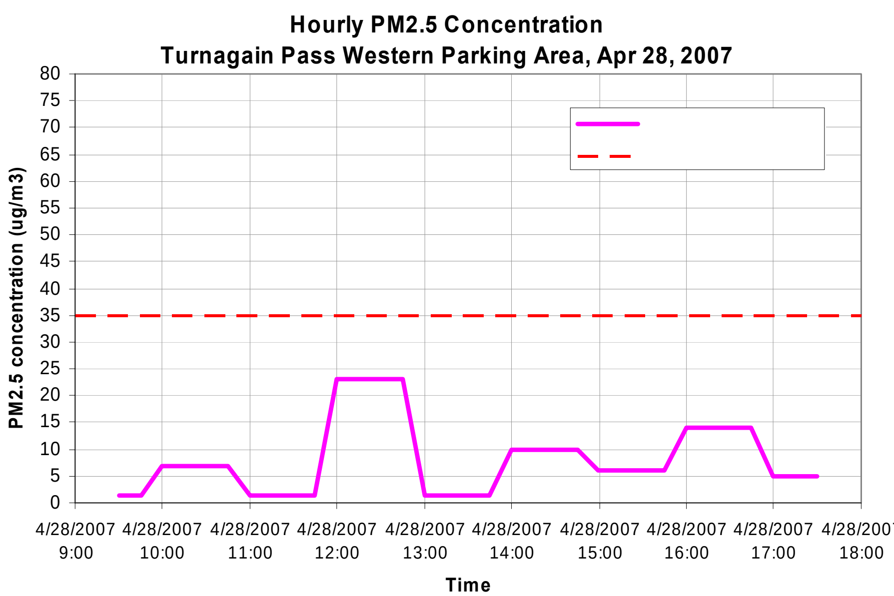


Figure 4.12: Fine particulate (PM2.5) concentrations at Turnagain Pass, April 28, 2007.

Wednesday, May 9, 2007

The May 9 sample day represents a control sample during the non-motorized season. The motorized season ended on April 30, and no snowmachine use occurred on May 9. Some vehicles were present, primarily highway traffic stopping briefly at the restrooms, but motorized use was characterized as very low. Dust from road sand on the highway and in the parking lots was a visible source of air pollution (**figure 4.13**). The weather was warm, cloudy, and a little breezy, with a few rain drops falling.

Figure 4.13: Western Turnagain Pass parking lot with dust along Seward Highway, May 9, 2007.

The hourly PM2.5 concentration reached as high as 4.0 µg/m^3, and the 6.75-hour average was 1.8 µg/m^3 (**figure 4.14**). Peak levels of fine particulates were measured between about 11am and 12pm, with low levels measured the remainder of the time. Using the average of the first and last hours to estimate the PM2.5 concentrations during the overnight hours resulted in an estimated 24-hour average of 1.7 µg/m^3. Carbon monoxide data are not available for this sample day because the carbon monoxide sensors were not functioning properly.

Wednesday, May 09, 2007	
Season	Non-Motor
Average Temperature	41.0 deg F
Average Wind Speed	5 mph
Max vehicle count	2
Max snowmachine count	0

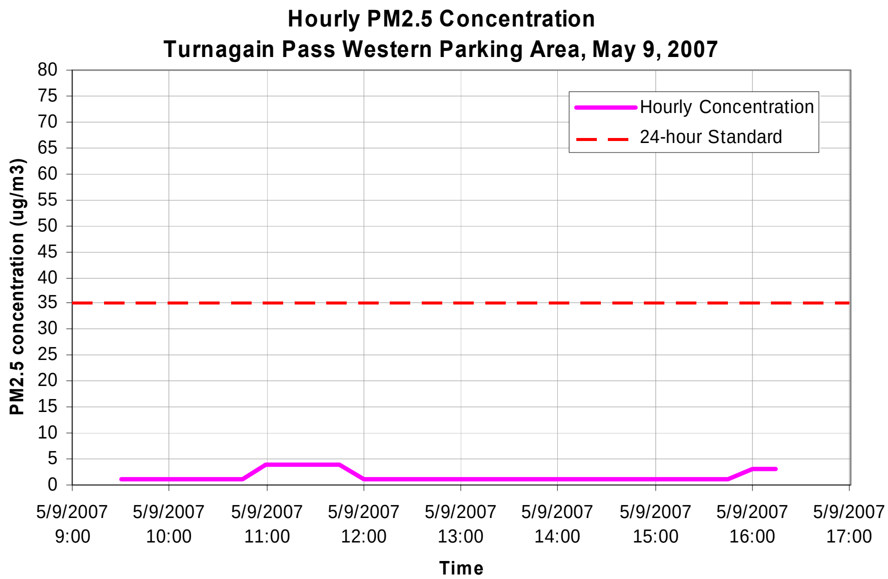


Figure 4.14: Fine particulate (PM2.5) concentrations at Turnagain Pass, May 9, 2007.

5 ANALYSIS

A summary of the air quality data collected at Turnagain Pass in 2007 is shown in **table 5.1**.

Table 5.1: Summary of 2007 air quality data at Turnagain Pass.

			CO concentrations			PM2.5 concentrations	
Date	**Use level**	**Weather**	**Highest 1-hour average (ppm)**	**Highest 8-hour average (ppm)**	**Potential for exceeding standards**	**Estimated 24-hour average (μg/m³)**	**Potential for exceeding standard**
5-Jan	Moderate	Clear, very cold, patchy fog	2.75	0.73	LOW	12.5	LOW
13-Jan	High	Temperature inversion, fog	2.0	0.9	LOW	26.4	MODERATE
27-Jan	Moderate	Cloudy, snow	0.0	0.00	LOW	5.2	LOW
10-Feb	Low	Cold, patchy fog	*n/a*	*n/a*	*n/a*	3.4	LOW
3-Mar	Low	Clear, cold, light haze	*n/a*	*n/a*	*n/a*	6.5	LOW
31-Mar	High	Clear, sunny, warm	*n/a*	*n/a*	*n/a*	13.5	LOW
28-Apr	High	Clear, sunny, warm	*n/a*	*n/a*	*n/a*	6.5	LOW
9-May	Very Low	Cloudy, breezy, warm	*n/a*	*n/a*	*n/a*	1.7	LOW

Fine Particulates

On the 8 sample days, the estimated 24-hour average PM2.5 concentrations ranged from 1.7 to 26.4 μg/m³. These estimates indicated no violations of the State air quality standard for fine particulates (35 μg/m³). Using the action level categories shown in **table 3.1**, only the January 13 sample day showed a *moderate* potential to exceed the State standards. The remainder of the days showed a *low* potential to exceed the State standards.

The highest PM2.5 concentrations were observed during the days of highest motorized use levels, with peak levels of PM2.5 occurring during the time of day with the most motorized activity. A positive correlation exists between the 24-hour average PM2.5 concentration and the total number of vehicles and snowmachines counted during the 3 observation periods each day (**figure 5.1**).

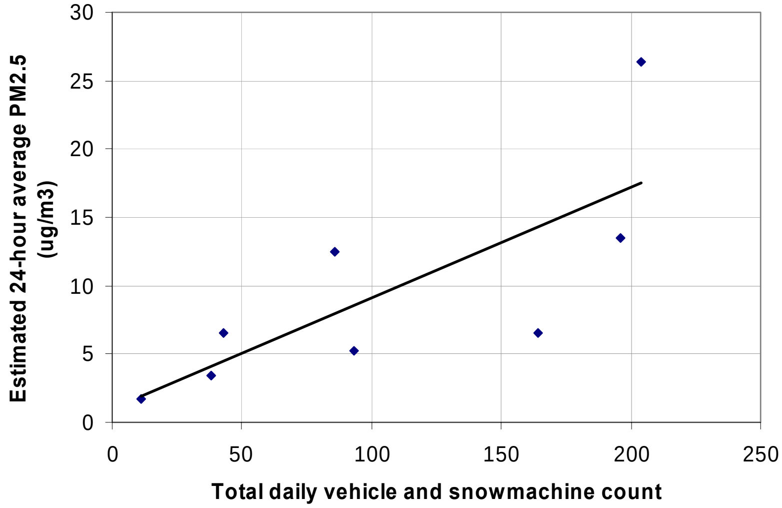


Figure 5.1: Positive correlation between total daily snowmachine and vehicle count and the estimated 24-hour average PM2.5 concentration.

Weather also can affect PM2.5 concentrations. The 2007 data show that the highest PM2.5 concentrations occurred on clear, cold days with temperature inversions. Of the 3 days characterized by high motorized use, the cold temperatures and inversion on the January 13 sample day resulted in 24-hour average PM2.5 levels 2 to 4 times higher than the March 31 and April 28 sample days, when temperatures were warmer and an inversion did not occur. Temperature inversions cause any pollutants to stay near the ground level, or even settle into the valley. This weather conditions is also often associated with light or nonexistent winds.

The high PM2.5 concentrations measured on the January 13 sample day are the result of a combination of high motorized use levels and cold temperatures with an inversion. These are the conditions that will generally lead to the highest levels of air quality impairment at Turnagain Pass. With cold temperatures, numerous vehicles are idling in the parking lot. Also, cold starts of snowmachines can contribute to increased emissions, and the lack of wind or warm air convection will prevent these pollutants from dissipating quickly. In concentrated areas such as the western parking lot at Turnagain Pass, these levels of pollutants can increase dramatically during times of peak motorized use. These pollutants can spread into the valley below the parking lot, but it is likely that they dissipate substantially with distance from the parking lot.

Carbon Monoxide

For the 3 days in which carbon monoxide concentrations were measured at the Turnagain Pass site, the 8-hour average carbon monoxide concentrations ranged from 0 to 0.90 ppm and the 1-hour averages ranged from 0 to 2.75 ppm. These average concentrations all fell well below the Alaska State air quality standards for carbon monoxide. Using the action level categories shown in **table 3.1**, the carbon monoxide concentrations at each site on each sample day fell within the "low potential" for exceeding the State standards.

The 3 days in which carbon monoxide concentrations were measured had moderate and high levels of motorized use. The daily trends in the carbon monoxide concentrations are similar to

those of the fine particulates, although not enough data points are available to show a correlation. January 13 showed the highest concentrations of carbon monoxide as well as fine particulates.

Carbon monoxide was measured at 4 different sites at Turnagain Pass. The nonexistent levels of carbon monoxide measured at the control site on the east side of the highway suggest that the increased carbon monoxide concentrations on the west side are the result of motorized uses. Carbon monoxide levels generally peaked during the middle of the day, during times of highest motorized use.

Carbon monoxide can settle in areas of tow topography, especially on days with temperature inversions. The highest carbon monoxide concentrations were not always measured at the site closest to the parking lot. On January 5, site #2 in the valley below the parking lot showed the highest concentrations.

Carbon monoxide is easily dissipated by light winds. No carbon monoxide was detected on the January 27 sample day, although fine particulates were measured. The highest carbon monoxide concentrations are likely to occur on cold days with temperature inversions and high levels of motorized use. With cold temperatures, numerous vehicles and snowmachines generally idle in the parking lot. Also, cold starts of vehicles and snowmachines can contribute to increased emissions, and the lack of wind or warm air convection will prevent these pollutants from dissipating quickly. In concentrated areas such as the western parking lot at Turnagain Pass, these levels of pollutants can increase dramatically during times of peak motorized use.

6 DISCUSSION

These data show that motorized use at Turnagain Pass results in increased levels of carbon monoxide and fine particulates. However, the carbon monoxide and fine particulate data collected on the 8 sample days at Turnagain Pass in 2007 indicated no violations of the Alaska State air quality standards. Based on the action levels shown in **table 3.1**, the carbon monoxide and fine particulate concentrations measured have a *low* potential of exceeding the State standards on all of the sample days except January 13, which showed a *moderate* potential for exceeding the 24-hour fine particulate standard.

Increased winter air pollution at Turnagain Pass as a result of motorized uses is likely to be the most severe under the following conditions:

1) ***High levels of motorized use:*** During the motorized use season, use can be concentrated at the western Turnagain Pass parking lot. High levels of use in 2007 were characterized by greater than 50 vehicles in the parking lot. High use levels generally occur early in the season, when other areas are still closed to motorized use, and later in the season when weather conditions and longer days are more favorable for outdoor recreation. However, use levels are highly dependent on weather and snowpack conditions.

2) ***High concentrations of motorized uses, in area and time:*** At times, snowmachine use is concentrated near the parking lot at Turnagain Pass, whereas at other times it is dispersed into the backcountry. Also, on shorter winter days, motorized use is concentrated during the middle of the day as a result of limited daylight.

3) ***Cold winter days with temperature inversions:*** These weather conditions are characterized by little wind and little warm air convection, causing air and pollutants to settle near the ground. This generally occurs between December and February. When motorized use occurs on these days, the greater number of idling vehicles and cold starts can lead to increased levels of air pollutants.

4) ***Percentage of 2-stroke snowmachine engines:*** Some newer snowmachines have 4-stroke engines, which emit lower levels of pollutants than 2-stroke engines.

A combination of these factors occurred on January 13, 2007, leading to higher than typical levels of air pollutants, but levels still below the State standards. The frequency of these conditions occurring is not predictable, as it depends on weather conditions, snowpack, and other use patterns. On most days during the winter season, there is little risk of motorized uses causing violations of State air quality standards. This risk can be moderate on days with high levels of use on cold days with temperature inversions.

Limitations of this study

This study is adequate for showing the potential that motorized uses are causing violations of State air quality standards at Turnagain Pass. However, this study has numerous limitations, as listed in section 3.7. The 8 sample days were intended to represent the range of conditions at Turnagain Pass, including the days with the highest factors for degrading air quality. The equipment used is assumed to adequately measure carbon monoxide and fine particulate concentrations, and quality control was conducted to ensure accuracy. Problems with the carbon monoxide detectors half way through the study limited the amount of data collected. The limited lengths of the sampling periods provide greater ambiguity when comparing to the 8-hour and 24-hour State air quality standards, and air quality conditions during the overnight hours were only estimated.

Recommendations

Based on the results of this study, it is recommended that air quality is sampled every 3 to 5 years during a number of days over the winter season at areas on the Chugach National Forest with high levels of winter motorized use. Fine particulates should be measured, as they are the largest concern for violations of the State standards from winter motorized use. The EBAM sampler with a battery system performed well for this type of sampling. Carbon monoxide may also be measured. However, the PACIII samplers did not perform well in this environment. If carbon monoxide is measured, alternate sampling equipment may need to be acquired and tested. Chugach National Forest personnel should work with the Alaska Department of Environmental Conservation to conduct this sampling. Sampling should be conducted in high-use areas such as Turnagain Pass, the Lost Lake trailhead, or the Placer River parking areas. Because of the remote nature of these sites and the low potential for exceeding the State air quality standards at this time, it is not feasible to install permanent air quality monitoring equipment. Sampling should focus on cold days with temperature inversions and high levels of use in order to measure the maximum levels of air pollutants that might occur under these conditions.

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