Research Studies Related to Snowmobiling Impacts

WATER QUALITY (Including Snowpack and Snowmelt)

Winter recreation could affect aquatic organisms mainly by indirect impacts due to water pollution. Some believe two-stroke snowmobile engines can deposit contaminants on snow, leading to ground and surface water quality degradation, which subsequently may impact aquatic life. The following information rebuffs those claims:

1. **Snowmobile Trail Chemistry Study** Perry, M.J., (2010) VHB Pioneer, North Ferrisburgh, VT and Vermont Association of Snow Travelers, Inc. http://www.vtvast.org/VAST/Forms/Other-Resources.html

Conclusions: At the request of the Vermont Association of Snowmobile Travelers, VHB Pioneer has completed a snowpack chemistry study that has evaluated the potential environmental impacts associated with the use of snowmobiles on public lands in Vermont. This study was completed with the purpose of evaluating the presence or absence of impact from snowmobile traffic on the chemical composition of snowpack, soil, and runoff in the proximity of heavily traveled snowmobile trails in Vermont, and has provided scientifically valid conclusions about the impact that snowmobile usage has on snowpack, soil, and runoff chemistry at the sites evaluated.

Snowmobile trail usage monitoring has indicated that all sampling stations, except for the Lye Brook Wilderness reference station, were located along heavily used snowmobile trails; therefore, are appropriate for evaluation in this study. Snow samples were collected during the busy snowmobiling season to provide worst-case scenario data. Runoff and soil samples were collected after the end of the snowmobiling season, to capture the maximum amount of contaminants that would potentially have accumulated during the season.

Snowmelt and runoff chemistry monitoring indicated no detectable levels of volatile organic compounds or total petroleum hydrocarbons in surface waters that are located immediately downgradient of the snowmobile trails that were evaluated. Snowmelt samples that were taken immediately following the end of the snowmobile season did not differ in comparison with runoff samples that were taken at the beginning of the snowmobile season, which are considered representative of background water quality conditions. These data indicate that the snowmobile usage during the 2009/2010 season did not have any impact on the surface water quality in the vicinity of heavily used snowmobile trails.

Snowpack chemistry monitoring indicated that there were no detectable levels of volatile organic compounds or total petroleum hydrocarbons in background or on-trail snow sampling stations, with the exception of one chemical compound detected in an on-trail sample taken at Station B2, which is the most heavily used station in the study. 1,2,4-Trimethylbenzene was detected at a concentration of 1.3 ug/L; no regulatory standards apply to snow, but for comparison this concentration is below the drinking water standard of 5.0 ug/L. These data indicate that snowmobile usage during the 2009/2010 snowmobile season did not significantly impact snowpack chemistry in the vicinity of the heavily used snowmobile trails. Therefore, it appears that snowmobile usage has no significant impact on the chemistry of snowpack located on snowmobile trails, but may cause trace levels of volatile organic compounds within the snow, and these levels are likely to be low concentrations that meet regulatory water quality standards.

Soil chemistry monitoring indicated that there were no detectable levels of volatile organic compounds or total petroleum hydrocarbons in background or on-trail soil sampling stations, with the exception of one chemical compound detected in an on-trail sample taken at Station C1. Toluene was detected at a concentration of 24.4 ug/Kg, which is far below the EPA Soil Screening Guidance Level of 12,000 ug/Kg. At six on-trail soil sampling stations, soil chemistry monitoring also indicated detectable levels of polycyclic aromatic hydrocarbons, which most likely were present due to historic railroad use along the Lamoille Valley Rail Trail, other historic activities, and possible natural sources such as forest fires, and tree leaves and needles. All PAH levels in tested soil were below the EPA Soil Screening Guidance Levels with the exception of one exceedence at station A4 on the LVRT, which is most likely the result of the historic railroad use and the highway adjacent to this location. These data indicate that snowmobile usage does not have any significant impact on volatile organic compounds within soil in the vicinity of the heavily used snowmobile trails that were evaluated. Trail usage by snowmobiles and other motorized vehicles may result in low levels of VOCs and PAHs in soil, that are far below applicable regulatory levels and environmental screening levels.

2. **Effects of Snowmobile Emissions on the Chemistry of Snowmelt Runoff in Yellowstone National Park.** Arnold, J.L., & Koel, T.M. (2006) Yellowstone National Park, Center for Resources – Fisheries and Aquatic Sciences Section. http://www.nps.gov/yell/parkmgmt/upload/snwmbil_snwmlt_rpt.pdf

Executive Summary: Created in 1872, Yellowstone National Park forms the core of the Greater Yellowstone Ecosystem, and is arguably the largest intact naturally functioning ecosystem remaining in the lower 48 United States. The park was created to protect the unique geothermal features and headwaters of the Madison, Snake, and Yellowstone rivers, while providing for the enjoyment of this unique environment by visitors. Approximately 44,000 hectares of lakes and 4,300 kilometers of streams exist in Yellowstone National Park, all which are classified as Outstanding Natural Resource Waters (Class I), meaning they must receive a very high level of protection against degradation.

More than three million people visit the park each year to engage in a wide range of recreational activities. Throughout the winter season (December–March), most park roads are closed to vehicular travel and are groomed and maintained for oversnow transportation. As a result, many visitors during winter months travel by snowmobiles. A significant increase in use of these machines was first documented in the late 1980s, when the numbers had increased nearly tenfold over that in 1968. By the mid-1990s the number of snowmobiles entering the park had increased to nearly 75,000 per year. During this time most snowmobiles had two-stroke engines, known to burn fuel inefficiently. Consequently, the steady increase in snowmobile use within the park was a concern to resource managers because of the potential that the increase in fossil-fuel combustion could result in greater levels of emissions entering the pristine surface waters of the park.

During late March through mid-April of 2003 and 2004 snowmelt runoff samples were collected from four sites along the heavily used road corridor between Yellowstone National Park's West Entrance at West Yellowstone, Montana, and the Old Faithful visitors area. Three of these sites were located immediately adjacent to the roadway in the vicinity of the West Entrance, Madison Junction, and Old Faithful. The remaining site was used as a control, located near Madison Junction approximately 100 meters from the roadway and away from the effects of snowmobiles. Each site was visited on 9–10 different days during the spring sampling period, with visits dependent on having a daily temperature >5oC and good potential to obtain snowmelt runoff. In situ water quality measurements (i.e., water temperature, dissolved oxygen, pH, specific conductance, and turbidity) were collected. Snowmelt runoff samples were analyzed for nine volatile organic compounds (VOCs), including benzene, ethylbenzene, ethyl tert-butyl ether, isopropyl ether, meta and para-xylene (m- and p-xylene), methyl tert-butyl ether, ortho-xylene (o-xylene), tert-pentyl methyl ether, and toluene. Of these nine compounds, only five were detected during any one sampling event. The detected compounds included benzene, ethylbenzene, m- and p-xylene, o-xylene, and toluene.

All in situ water quality measurements were within acceptable limits. The VOCs were most prevalent at the Old Faithful site, which receives extremely high use by snowmobiles each year. Fortunately, the concentrations of all VOCs detected each year were considerably below the U.S. Environmental Protection Agency's (USEPA) water quality criteria and guidelines for VOCs targeted in this study. During the course of the study, VOC concentrations of snowmelt runoff in Yellowstone National Park were below levels that would adversely impact aquatic systems. However, future research in Yellowstone National Park on snowmobile emissions should address the potential for another group of harmful chemicals known as the polycyclic aromatic hydrocarbons

(PAH). The PAH tend to be more capable of persisting in the environment for longer periods than VOCs and are suspected at the Old Faithful site as it received runoff from a paved parking area.

3. **Impacts of Two-Stroke Engines on Aquatic Resources.** (1999) Effects of Winter Recreation on Wildlife of the Greater Yellowstone Area: A Literature Review and Assessment. Olliff, T., Legg, K. & Kaeding, B. Greater Yellowstone Coordinating Committee, Yellowstone National Park. pp. 145-149. http://www.nps.gov/yell/parkmgmt/upload/wildlifewint.pdf

Summary: Impacts to aquatic species that can be attributed to atmospheric deposition from snowmobiles have not been well studied. Field studies are extremely difficult to conduct because atmospheric deposition rates could be affected by numerous factors, including temperature, proximity to water, and combustion efficiency of individual snowmobiles. Tremendous uncertainty accompanies this topic with reference to affects on aquatic resources of the Greater Yellowstone Area.

In situations where snowmobiling occurs over open water, obvious impacts will include direct discharge into aquatic habitats. Appreciable contamination from emissions from backcountry snowmobiling probably occurs less frequently.

4. **Effects of Snowmobiling across Open Water on Fish and Wildlife.** (1999) Effects of Winter Recreation on Wildlife of the Greater Yellowstone Area: A Literature Review and Assessment. Olliff, T., Legg, K. & Kaeding, B. Greater Yellowstone Coordinating Committee, Yellowstone National Park. pp. 161-162. http://www.nps.gov/yell/parkmgmt/upload/wildlifewint.pdf

Summary: Snowmobiling on open water involves a daring or, in some cases, intoxicated snowmobiler with a powerful machine who attempts to either make it across open water or to take a round trip on open water without submerging the snowmobile. Snowmobiling on open water has the potential to affect water quality; aquatic species, such as invertebrates and trout; and riparian-dependant wildlife, specifically moose, furbearers, waterfowl, and bald eagles.

Snowmobiling on open water has the potential to pollute the water with snowmobile exhaust and spilled oil and/or gas, to stir up sediments on the bottom, to disturb winter-stressed fish and other aquatic wildlife, and to displace wildlife from important winter habitat. A literature search produced little information on the effects of snowmobiling on open water.

Agency managers need to be aware of the potential for snowmobile use on open water and that there are possible effects to water quality, fish, and wildlife. This activity is in defiance of common sense, and agencies should prohibit it on public land to avoid impacts to water quality, aquatic species, and riparian-dependant wildlife.

5. **Effects of Snowmobile Use on Snowpack Chemistry in Yellowstone National Park, 1998.** Ingersoll, G.P. (1999) U.S. Department of the Interior – U.S. Geological Survey, Water-Resources Investigations Report 99-4148, prepared in cooperation with the National Park Service

Abstract: Snowmobile use in Yellowstone National Park has increased substantially in the past three decades. In areas of greatest snowmobile use, elevated levels of by-products of gasoline combustion such as ammonium and benzene have been detected in snowpack samples. Annual snowpacks and snow-covered roadways trap deposition from local and regional atmospheric emissions.

Snowpack samples representing most of the winter precipitation were collected at about the time of maximum annual snow accumulation at a variety of locations in and near the park to observe the effects of a range of snowmobile traffic levels. Concentrations of organic and inorganic compounds in snow samples from pairs of sites located directly in and off snow-packed roadways used by snowmobiles were compared. Concentrations of ammonium were up to three times higher for the in-road snow compared to off-road snow for each pair of sites. Thus, concentrations decreased rapidly with distance from roadways. In addition, concentrations of ammonium, nitrate, sulfate, benzene, and toluene in snow were positively correlated with snowmobile use.

Patterns of Chemistry Relative to Snowmobile Use: Although clear patterns have emerged to establish ammonium and sulfate as reliable indicators of snowmobile emissions in nearby snowpacks, particularly along the corridor from West Yellowstone to Old Faithful, nitrate concentrations are not much influenced by these local effects. With the exception of the extreme exposure of the direct exhaust sample at Supply Forks, snowpack concentrations of nitrate were relatively unaffected by snowmobile traffic.

Siting off-road sampling sites 50 m from snowmobile routes seems adequate to eliminate contamination from snowmobiles and allow observation of regional effects. Comparisons between chemistries at the West Yellowstone sites 50 and 1,000 m off-road show similar values for all major ions and also are similar to background levels elsewhere in the Rocky Mountain region; therefore, contamination from snowmobiles is less likely 50 m from highway corridors, especially when compared to in-road chemistry. Furthermore, two sites 50 m off-road and a third site 1,000 m off-road around Old Faithful also had good agreement between major-ion concentrations and also were unaffected by snowmobile traffic, as shown by the in-road snow chemistry. Comparisons of these off-road and in-road sites in the Old Faithful area located within 2 to 3 km of the geyser also indicate negligible effects on sampling results from the geothermal activity.

Hydrocarbon levels in the snowpacks near snowmobile use were elevated relative to background snowpack chemistry in the study but were lower, in general, than concentrations at hundreds of locations nationwide representing a full spectrum of watershed settings ranging from subalpine to urban (Dennehy and others, 1998). Detectable concentrations of VOC's in Yellowstone ranged from 12.2 to 973 ng/L (table 5). VOC concentrations detected in urban storm water in the United States have been found to range from 200 to 10,000 ng/L, with more concentrated levels observed less frequently (Lopez and Bender, 1998; Lopez and Dionne, 1998). In a variety of urbanized, forested, and agricultural settings in New Jersey (Reiser and O'Brien, 1998), median concentrations of seven streams detected for benzene (60 ng/L), MTBE (420 ng/L), toluene (60 ng/L), and o-xylene (10 ng/L) were markedly higher than concentrations in snowmelt runoff at Yellowstone except for except for toluene (table 8). Little is known about levels of VOC's in Rocky Mountain snowpacks. Bruce and McMahon (1996) reported concentrations in snowfall collected in the Denver metropolitan area to be low.

Toluene concentrations in snowmelt runoff in Yellowstone (less than 25 to 252 ng/L; table 8) further indicate the potential sensitivity to contamination of snow and surface-water samples. Even at Loch Vale (table 4), the backcountry site in Colorado several kilometers from the nearest roadway, toluene concentrations were similar to those detected in the snowpacked roadway at Sylvan Lake (108 ng/L; table 5). Additionally, toluene concentrations in the snowpacked roadway at Old Faithful also were very similar to the concentration in snow 1 km off the highway (table 5). In some cases, there was a more clearly observable pattern, such as with comparisons between in-road and off-road sites at West Yellowstone and at the site 8 km east of West Yellowstone (West Yellowstone, 8 km east, table 5). The Tower Falls site, several kilometers from snowmobile traffic, had a low concentration (89.3 ng/L) similar to that detected in both the original (91.5 ng/L) and replicate (III ng/L) snow samples at Loch Vale, Colorado (table 4). Oddly, the snowmelt runoff grab sample from the area near Tower Falls contained the highest concentration of toluene (252 ng/L). Clearly, more investigation is needed to determine whether these anomalously high values for toluene (relative to benzene, MTBE, and xylenes) in snowmelt runoff are due to the sampling methodology, other sources of contamination, analytical techniques, or ambient conditions. In spite of these uncertainties, the toluene snow chemistry positively correlates with other hydrocarbon and major-ion concentrations.

Drinking-water standards for benzene (5,000 ng/L), toluene (1,000,000 ng/L), and xylenes (10,000,000 ng/L) published by the U.S. Environmental Protection Agency (1996) far exceed any levels detected in either snow or snowmelt runoff at Yellowstone in this study. A drinking-water standard for MTBE has not yet been determined, but future regulation is planned. Even the highest detections of benzene in snow (167 ng/L at in-road site 8 km east of West Yellowstone) or snowmelt (less than 10 ng/L at all sites), or toluene in snow (726 ng/L at in-road site 8 km east of West Yellowstone) or snowmelt (252 ng/L near Tower Falls) at Yellowstone are far less than the established standards for water consumed by humans (less than 4 percent and less than 1 percent, respectively).

Conclusions: Snowpack-chemical analyses for ammonium and sulfate have proven to be repeatable indicators of snowmobile use in Yellowstone National Park and in Colorado, and the hydrocarbons benzene, toluene, and xylenes correlate well with patterns observed in 1998 for ammonium and sulfate in the park. Concentrations of ammonium and sulfate at the sites in snowpacked roadways between West Yellowstone and Old Faithful were greater than those observed at any of 50 to 60 other snowpack-sampling sites in the Rocky Mountain region and clearly were linked to snowmobile operation. Concentrations of ammonium, sulfate, and hydrocarbon compounds found in gasoline correlate with snowmobile use and traffic levels; where traffic volumes per day were greater, so were chemical concentrations. Thus, these combined analyses of chemistry of Yellowstone snowpacks are good indicators of the effects of high or low snowmobile traffic levels in the park. These chemical data establish important baselines for future evaluations. Further, these results indicate that snowmobile use along the routes originating at the South and East Entrances, and not including the immediate area (within 1 km) surrounding Old Faithful, may not be substantially affecting atmospheric deposition of ammonium, sulfate, and hydrocarbons related to gasoline combustion.

Preliminary analyses of snowmelt-runoff chemistry from five of the snow-sampling sites indicate that elevated emission levels in snow along highway corridors generally are dispersed into surrounding watersheds at concentrations below levels likely to threaten human or ecosystem health. Localized, episodic acidification of aquatic ecosystems in these high snowmobile-traffic areas may be possible, but verification will require more detailed chemical analyses of snowmelt runoff.