3.1 CLIMATE AND SNOW

3.1.1 Summary of Existing Conditions

3.1.1.1 National and Regional Climate

The White Pass Study Area is located between the elevation of approximately 4,400 feet and 6,700 feet within the Pacific Coastal Ecoregion, which has a climate that is characterized by moist, cool winters and warm, dry summers. The mild climate in this region is moderated by the close proximity to the Pacific Ocean. The variation in summer and winter precipitation patterns in this region is due to the seasonal changes in the location of semi-permanent high and low pressure systems and the path of prevailing westerly winds (i.e., the jet stream). In the summer, the Pacific High Pressure system moves northward to a location off the California and Oregon coast, which protects the Pacific Northwest from storms and keeps the summer dry and warm (Ahrens 1993). Occasional thunderstorms develop along the crest of the Cascade Mountain Range as a result of moist marine air from the Pacific Ocean converging with dry unstable air from the east of the crest.

During the winter, weather patterns in this region are dominated by the combined influences of the Aleutian Low Pressure system that is located in the Gulf of Alaska and the path of the jet stream that moves these storm systems from their genesis point to the Pacific Northwest (Ahrens 1993). Once these storm systems reach the mainland, they are uplifted by the Cascade Mountain Range causing significant precipitation. Cold interior air masses commonly move into Western Washington and Oregon during the winter from Canada. Moist air masses that are carried by the westerlies from the Gulf of Alaska converge with these cold air masses along the crest of the Cascade Mountain range, resulting in considerable snowfall. The Pacific Northwest has a greater average annual snowfall than any other region within the continental United States due, in large part, to the climate phenomenon described above (RRC Associates 2002). Additionally, year-to-year climate variations correlate with two large-scale climate oscillations: El Niño/Southern Oscillation and Pacific Decadal Oscillation, both of which are associated with warm years tending to be dry, and cool years tending to be wet (National Assessment Synthesis Team 2000). Therefore, the Cascades would continue to witness variable weather conditions, resulting in low snow deposition during some weather cycles and excessive snowfall during other periods. Specifically, refer to the Northwest Weather and Avalanche Center or www.skimountaineer.com for White Pass snow depth data from 1976 to 2006 (Andalkar 2006), which shows snow depth oscillations during this period.

The global warming hypothesis has been generally accepted by the scientific community and is a significant concern of ski area operators throughout the United States. According to the *Climate Change 2001: Synthesis Report*, it is likely that precipitation will increase over high-latitude regions in both summer and winter with larger year-to-year variations in precipitation, and nearly all land areas will very likely experience warming (Watson et al. 2001). In a more recent report, the Climate Impacts Group examined climate change scenarios for the Pacific Northwest generated by ten different climate models.

All models projected temperature increases throughout the year, and most predicted the largest temperature changes would occur during the summer (June-August). The majority of models projected small decreases in precipitation during the summer, and slight increases in winter (December-February), but little change is projected in the annual mean through mid-century. However, precipitation predictions were more variable and less certain than temperature forecasts, and the precipitation change projections fell within the range of year-to-year variability observed during the 20th century (Climate Impacts Group 2006).

According to the Pacific Northwest National Laboratory (PNNL) climate change model, snow cover in Washington State will be lost within the existing snowline, resulting in a projected rise of the average Cascade snowline from its current 3,000 feet to approximately 4,100 feet in the next 50-80 years (PNNL 2004).

However, the localized affects caused by global warming are still being debated. Climate predictions are frequently based on averages of many climate models, which are often based on single runs using the same emissions scenario, resulting in varied climate projections. The National Assessment Synthesis Team of the U.S. Global Change Research Program notes that:

> "a more reliable regional assessment would require controlled regional-level comparison of several state-of-the-art models, each with a statistical ensemble of multiple similar runs under each of several emissions scenarios" (National Assessment Synthesis Team 2000).

The global warming hypothesis was not used as an integral part of the climate and snow analysis or in the planning for this analysis due to crucial unknowns, the need for more research, the inherent uncertainty of the ability of regional climate models to predict the localized impacts associated with global warming, and the typical 50-80 year timeframes of the projections. As previously described, the White Pass Study Area is located between the elevation of approximately 4,400 feet and 6,700 feet and, according to the PNNL climate change model, snow cover in Washington State will be lost within the existing snowline, resulting in a projected rise of the average Cascade snowline from its current 3,000 feet to approximately 4,100 feet in the next 50-80 years (PNNL 2004). Even with the projected snowline rise, the proposed terrain expansion under Alternative 2, Modified Alternative 4 and Alternative 6 is designed to provide terrain opportunities above 4,100 feet in elevation prior to 2050. Furthermore, the planning period for this analysis and the proposed operation period is 10-20 years. Additionally, the Cascades would continue to witness variable weather conditions, resulting in low snow deposition during some weather cycles and excessive snowfall during other periods (www.skimountaineer.com; Andalkar 2006).

White Pass Climate Data

Two SNOTEL stations are located within the existing White Pass Study Area, defined as the existing SUP area and the proposed SUP expansion area. One site (Pigtail Peak, Station ID 21c33s) is located on Pigtail Peak at approximately 5,900 feet elevation, and is within the proposed expansion area. The other station (White Pass E.S., Station ID 21c28s) is located at approximately 4,500 feet elevation, near the base of the existing ski area. These stations provide site specific climate data over a short period of record, when compared to global climate monitoring. Data is recorded at the station according to the hydrologic water year (October through September), which overlaps calendar years.

According to the SNOTEL Data Network (maintained by the Natural Resource Conservation Service), average annual precipitation at the Pigtail Peak station is 79.6 inches. The average snowpack between January and March is 37.6 inches, measured as a snow water equivalent (SWE). The SWE represents the amount of liquid water contained in the snow. The average maximum snow depth at Pigtail Peak is approximately 58.6 inches measured as SWE. SWE depends largely on the snow density to calculate the snow depth. Snow density within the Cascades averages 20-30 percent during the winter months (Natural Resource Conservation Service 2004). The snowpack typically forms in mid-October and persists until late June or early July. Average yearly temperature within the Pigtail Peak portion of the White Pass Study Area was 35.8 degrees Fahrenheit during the period of record from 1989 through 2003. Temperature ranged from an average high of 51.2 degrees Fahrenheit in August to an average low of 24.2 degrees Fahrenheit in February.

At the White Pass E.S. station, average annual precipitation is 44 inches. The average snowpack between January and March is 17.8 inches, measured as a SWE. The average maximum snow depth at the White Pass E.S. is approximately 24.11 inches measured as SWE. The snowpack at this location typically forms during late October and persists until late May. Average yearly temperatures within the base area portion of the White Pass Study Area were 37.4 degrees Fahrenheit during the period of record from 1989 through 2003. Temperature ranged from an average high of 53.5 degrees Fahrenheit in August to an average low of 24.5 degrees Fahrenheit in December.

3.1.2 Affected Environment

3.1.2.1 Snow Conditions

The quality of the snow, from a skiing perspective, varies considerably during the winter operating season. Snow conditions are typically good (e.g., dry powder, packed powder) during the months of December, January, and February when temperatures average 27 degrees Fahrenheit. Snow conditions can vary from dry powder to spring corn snow during the remainder of the operating season, due to the temperature fluctuations described above.

Avalanche Hazard Areas

The White Pass Study Area is located in a Class C avalanche area according to *The Avalanche Handbook* (USDA 1990c). According to *The Avalanche Handbook* (McClung and Schaerer 1993), Class C means a low incidence of avalanches and a low risk. White Pass has a maritime snow climate, which is distinguished by relatively heavy snowfall, comparatively mild temperatures (for mountainous terrain), deep snow accumulations, rainfall at any time throughout the winter, and cold arctic air that appears several times per year. Maritime snowpacks can be relatively unstable and can have rapidly fluctuating degrees of stability. According to *The Avalanche Handbook* (McClung and Schaerer 1993),

> "Avalanche formation in maritime snow climates usually takes place during or immediately following storms, with failures occurring in the new snow near the surface. The prevalence of warm air temperatures promotes rapid stabilization of the snow near the surface once it falls, thereby limiting the time over which instability persists. A significant cause of major avalanching can be rain if it immediately follows deep, new snowfall. Rainfall may also cause formation of ice layers, which can act as future sliding layers when buried by subsequent snow storms. Due to the deep snow covers and warm snowpack temperatures, the persistence of buried structural weaknesses deep in the snowpack is not usually as common in maritime snow climates as in continental snow climates. Weather observations are primary tools for predicting avalanches in a maritime snow climate."

According to Section 2343.12 of the USFS Manual, the USFS authorizes control of avalanche areas at ski areas by other than Forest Service personnel through a special use authorization. Avalanche control is undertaken on an as-needed basis at the White Pass Ski Area to ensure that the public is protected from avalanche related conditions. Currently, White Pass uses explosives for avalanche control on an as needed basis in certain areas (i.e., trails crossing the cliff band).

Slide areas within the existing White Pass Study Area are readily accessible to control personnel from the upper terminals of Chairs 1 and 2. No control work is currently done in Pigtail or Hogback Basins. Avalanche hazards within the Pigtail and Hogback Basins are negligible due to the combination of terrain and stable snow conditions (refer to Figure 3-1). The basin's north aspect minimizes conditions associated with high solar radiation and springtime instability. The uniform temperature through the season contributes to snowpack stability during the ski season. Additionally, average slope angle is between 10 and 15 degrees and most avalanche activity occurs on slopes from 30 to 45 degrees.

The avalanche hazard to the south of the White Pass Study Area in Miriam Basin is high. Miriam Basin contains slopes of 20 to 30 degrees, with steep rock outcrops at the head of the basin (refer to Figure 3-1). Wind is the primary factor creating hazard, resulting in heavy, unstable snow deposits and cornices along the ridgeline.

Other areas outside the White Pass Study Area are considered to be moderate. This is primarily due to weather-induced changes within the snowpack. The temperature of the snow itself is generally near freezing and this causes the snow crystals to bind together. Freezing and thawing cycles also contribute to stable conditions. However, there are cycles of extreme instability caused by wind-deposited snow, especially during and immediately following storms.

3.1.3 Environmental Consequences

The actions associated with the alternatives and their potential to affect climate and snow conditions comprise the impact mechanisms. These actions are related to the operation of the White Pass Ski Area and represent short-term impacts that affect climate and snow conditions during the course of one or more operating seasons, within the timeframe of the alternatives.

3.1.3.1 Snow Conditions

Alternative 1

Under Alternative 1, no new development would take place at White Pass. White Pass would continue to witness variable weather conditions, resulting in low snow deposition during some weather cycles and excessive snowfall during other periods. As predicted by climate models (PNNL 2004), in the event of an average Cascade snowline increase to the projected 4,100 feet prior to 2050, the White Pass Ski Area (with a base elevation of approximately 4,500 feet), would remain above the average snowline and would not be adversely affected. Additionally, the planning period for this analysis and the proposed operation period is 10-20 years.

Existing grooming operations at White Pass would continue to artificially compact the snow. This snow compaction tends to result in a two to three week persistence of the snowpack into the summer months compared to undisturbed areas (Rixen and Stockli 2000; Rixen et al. 2001).

Alternative 2, Modified Alternative 4 and Alternative 6

Due to the inherent uncertainty in the prediction of localized impacts associated with global warming, no changes are expected in the local climatic regime. In both the short and long-term, there would be no changes expected to the macro-climatic regime that would significantly influence snow deposition and skiing conditions within the White Pass Study Area.

Under Alternative 2, Modified Alternative 4 and Alternative 6, grooming operations would be introduced in Pigtail and/or Hogback Basin, in association with the new lift(s) and trails. As a result, increased skier use of the basins and grooming operations would alter the natural snowpack, as compared to existing conditions. As described under Alternative 1, the snowpack would be artificially compressed through grooming and would likely extend the persistence of the snowpack two to three weeks.

White Pass would continue to witness variable weather conditions, resulting in low snow deposition during some weather cycles and excessive snowfall during other periods. As predicted by climate models (PNNL 2004), in the event of an average Cascade snowline increase to the projected 4,100 feet prior to 2050, the White Pass Ski Area (with a base elevation of approximately 4,500 feet), would remain above the average snowline and would not be adversely affected. Additionally, Alternative 2, Modified Alternative 4, and Alternative 6 would provide terrain opportunities above the predicted 4,100 feet snowline elevation prior to 2050 (PNNL 2004). Additionally, the planning period for this analysis and the proposed operation period is 10-20 years.

Alternative 9

Under Alternative 9, climate change would be as described for Alternative 2, Modified Alternative 4, and Alternative 6. Pigtail and Hogback Basins would not be included in the White Pass operation, so snow conditions would remain unchanged from the existing condition in Pigtail and Hogback Basins. Additional terrain in the current SUP area would be developed (*PCT* lift and trails and new trail in the *Paradise* pod; refer to Figure 2-8). As a result, increased skier use and grooming operations in the eastern portion of the SUP area (*PCT* pod) and the new trail in the *Paradise* pod, would alter the snow conditions in these areas. As described under Alternative 1, the snowpack would be artificially compressed through grooming and would likely extend the persistence of the snowpack two to three weeks.

White Pass would continue to witness variable weather conditions, resulting in low snow deposition during some weather cycles and excessive snowfall during other periods. As predicted by climate models (PNNL 2004), in the event of an average Cascade snowline increase to the projected 4,100 feet prior to 2050, the White Pass Ski Area (with a base elevation of approximately 4,500 feet), would remain above the average snowline and would not be adversely affected. Additionally, the planning period for this analysis and the proposed operation period is 10-20 years.

3.1.3.2 Avalanche Hazard Areas

Alternative 1

No changes to avalanche control practices within the White Pass Study Area would occur under Alternative 1. The White Pass Ski Patrol would continue to assess the avalanche conditions within the existing ski area on an as-needed basis and post their assessment to all skiers.

Alternative 2, Modified Alternative 4 and Alternative 6

Under Alternative 2, Modified Alternative 4 and Alternative 6, White Pass would expand operations into Pigtail and/or Hogback Basin, an area of low avalanche hazard. Avalanche control work would continue to be done on an as-needed basis to ensure that the public is protected from avalanche related conditions.

The current use of the Pigtail and Hogback Basins for Nordic and backcountry skiing would be altered by the operations of groomers and alpine ski facilities (refer to Section 3.11-Recreation). Consequently, the current users of the Pigtail and Hogback Basins would be displaced, perhaps to recreate in Miriam Basin, where avalanche hazard is higher. With increased use, the potential for skier-released avalanches in Miriam Basin would be increased, as compared to Alternatives 1 and 9. Alternative 6 would increase the potential for skier-released avalanches in Miriam Basin slightly less than Alternative 2 and Modified Alternative 4 because only Pigtail Basin would be developed, leaving Hogback Basin available for backcountry skiing.

The use of ungroomed, unpatrolled and unevaluated areas is a risk that is inherent in any winter backcountry activity (refer to Section 3.11 – Recreation). To offset this potential risk, a Boundary Management Plan would be developed as described in Mitigation Measure MM15 (refer to Table 2.4-2). This plan would include designation of no more than two signed gated ski area exit points along the boundary between Pigtail Basin and Miriam Basin, and one exit point downslope of the proposed expansion area. Additionally, the plan would include signage indicating that skiers would be responsible for any search and rescue costs, and inform users of the risks outside the permit area.

Alternative 9

Under Alternative 9, White Pass would develop new trails within the existing ski area. No expansion into the Pigtail or Hogback Basins would occur. Avalanche control work would continue to be done on an as-needed basis within the existing ski area to ensure that the public is protected from avalanche related conditions.

Nordic and backcountry use of Pigtail and Hogback Basins would continue as in Alternative 1. Therefore, the avalanche potential in the Pigtail, Hogback, and Miriam Basins would remain unchanged.

3.1.4 Cumulative Effects

No past, present, or reasonably foreseeable actions or projects that would result in a cumulative effect to climate and snow conditions have been identified. Similarly, implementation of the Action Alternatives would not affect climate and snow conditions in the White Pass Study Area, outside of the two to three week extension of snowpack persistence. White Pass would likely continue to witness variable weather conditions, resulting in low snow deposition during some weather cycles and excessive snowfall during other periods. There would be no cumulative effects to avalanche hazards from the proposed expansion.