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9.0 Weather and Environmental Risks

Introduction

Exploration field employees may work in highly variable physical and climatic environments, and possibly where they have little or no previous experience. Consequently, they risk exposure to unfamiliar natural hazards, which may be weather related, environment related, terrain related or a combination of these hazards. When commencing exploration projects in new and unfamiliar or high risk areas, the best approach is to learn as much as possible from knowledgeable sources and perform risk assessments to determine which risks and hazards are likely to be most significant. It may be advisable to hire experts to help assess the risks, develop safe operating procedures (SOPs) and train field crews, especially if crews are inexperienced. Additionally, it is important not to become complacent about risks and hazards after gaining experience in a region. Information in this section should be helpful in developing safe operation procedures and training topics for safety meetings and to mitigate risks.

9.1 Weather Hazards

Local and regional weather may impact project management. For example, a project field headquarters or a camp should be located where it will not be vulnerable to unusual winds, flooding, lightning strikes, or avalanches etc. Risk assessments should include the means of access to and from the site because access may be compromised by weather if aircraft cannot fly, or if flooding, snow or other events prevent access by road. Contingency plans should be developed to address these possibilities. Traversing activities should be planned to take into account local weather patterns as some areas may be subject to unique weather (e.g., sudden electrical storms, fog at certain times). Therefore, it is advisable to learn about potential weather patterns and know how to make short term predictions. Potential weather patterns can be determined using resources such as Weather Underground and AccuWeather.com that provide current weather conditions as well as seasonal weather averages (almanac) information. The *World Map of Natural Hazards* has information regarding some weather related natural hazards such as lightning and severe storms.

Websites:

http://www.wunderground.com/

http://www.accuweather.com/

http://www.munichre.com/publications/302-05972_en.pdf

9.1.1 General Preparations

Weather related risks and hazards should be addressed for each project.

- Complete a risk assessment and include the potential impact of weather related hazards (refer to section 2.1.5). Include the following:
    - Location: field camps, work sites, drill sites, fuel storage areas, helicopter landing sites, air strips etc.
    - Transportation: potential for stranding and accidents en route to and from sites
    - Terrain hazards and traversing routes for those working on foot

- The project supervisor should develop site specific safe operation procedures (SOPs) and emergency response plans (ERPs) that take into account the observations and conclusions of the risk assessment.
- Develop plans to mitigate risks. For example, if late afternoon lightning storms are common, employees should be required to complete traverses in the early afternoon.
- Training should cover the SOPs, ERPs and specific ways to handle potential weather related emergencies. Hold a practice drill if an ERP includes evacuation procedures.

Employees who traverse or work away from camp should:

- Obtain up-to-date weather forecasts for the project area (if available).
- Receive training to recognize the signs of impending severe weather appropriate for the project area (e.g., flash floods, thunderstorms, whiteouts).
- Learn to recognize cloud formations and the weather they indicate in order to make short term weather forecasts. Watch for sudden shifts in wind direction, rapid temperature changes etc., and recognize the significance of the changes.

Learn the prevailing weather patterns in the area such as:

- When to expect local storms
- When to expect thunderstorms
- The time of day strong winds may develop
- The potential effect of winds or squalls causing dangerous waves etc., if working on or near water
- The potential risks of blizzards, whiteouts, ice storms etc., in winter

9.2 Lightning

Lightning is the electrical discharge between two clouds or between a cloud and the ground. When strong negative charges built up at the base of a thundercloud, they are attracted to positive charges in another cloud or on the earth's surface. Lightning will strike the most conductive object, which is usually a high object (e.g., a tall building, tree, rocky peak, metal tower). However, it is possible for a short object to be struck even when taller objects are nearby if that object provides the most conductive path to the ground. Although the relative risk of being struck by lightning is small, if you are working or sheltering in the wrong place at the height of a lightning storm, your chances of being struck are very much higher than average.

9.2.1 Risks and Hazards

Some of the risks and hazards include but are not limited to:

- Death or injuries caused by lightning strikes. Potential injuries include:
  - Hearing loss (temporary or permanent)
  - Burns on the skin surface or deep body tissue
  - Brain damage, amnesia, seizures, paralysis, coma

  - Heart attack
- Being struck by lightning caused by:
  - Lack of training, taking shelter too late, emerging from shelter too soon after a storm has passed
  - Sheltering in, near or under a conductive object (e.g., tree, power lines, cliff face, shed, open vehicle)
  - Contacting geophysical survey wires or fence lines, being on the water
- Fires caused by lightning strikes to company buildings or equipment, the surrounding area resulting in a forest fire
- Explosion caused by a lightning strike to an explosives magazine

9.2.2 Prevention and Preparation

Safety precautions are essential where lightning is a hazard:

- The project supervisor should develop site specific SOPs and ERPs to address potential lightning risks and hazards. Train all employees to follow the procedures.
- Traversing employees should make plans that take into account potential lightning storms that may develop along traverse routes.
- Watch for changes in weather conditions throughout the day. Thunderclouds can form quickly but they will provide advance warning before the onset of an electrical storm.
- Use the 30 - 30 Rule. Seek shelter when you hear thunder within 30 seconds of seeing a lightning flash; remain in the shelter for at least 30 minutes after the last thunder is heard. Hearing thunder within 30 seconds means the lightning strike is less than 10 km away. Take shelter immediately. Many lightning strikes occur 30 minutes before and after a thunderstorm, and lightning can travel great horizontal distances before reaching the ground. Refer to the following website: http://www.crh.noaa.gov/pub/ltg/crh_boltblue.php
- Where lightning is a frequent risk, consider carrying a lightning detector or a radio set to an AM frequency, which will crackle and indicate when lightning is in the area.
- Advanced project sites subject to electrical storms should locate the explosives magazine at the base of a high bank. Ground the magazine to reduce the possibility of it being struck. When thunderstorms approach, close the magazine and vacate the area.
- Anglo American has granted permission for the PDAC to provide a link to the following: Anglo American Safety, Health & Environment Bulletin 147/2006 *Lightning Safety*. This comprehensive document provides background facts about lightning and information as to developing a lightning safety policy and lighting safety plans, lightning detection equipment and lightning shelters. The bulletin is available here: http://www.pdac.ca/pdac/advocacy/health-safety/health-safety-aac-lightning.pdf

Follow these guidelines when a lightning storm approaches.

- Immediately disconnect the radio antennas; move them away from the radio and ground them. If the antenna is struck by lightning, the charge will travel through the wire into the radio, which could damage it and possibly start a fire.
- Stay away from satellite dishes.

- Disconnect computers, power tools, rock saws and extension cords etc., from their power sources. Employees should not continue working out-of-doors with metal tools such as hammers and wrenches.
- Move well away from drill rigs, as the mast may act as a lightning rod.
- Field geophysical survey crews should disconnect all wires from equipment and stay well clear of the wires and equipment for the duration of the storm. Crews must be especially alert for storms in the survey area, as the wires connecting equipment may stretch for kilometres. Refer to section 11.2 Geophysical Survey Safety.

Seek shelter early – well before the storm arrives.

- Shelter inside a substantial building whenever possible.
    - Choose a large building. Avoid contact with anything metal or electrical, as lightning can travel into buildings through stove pipes or electrical wiring. Electrical outlets, plug-in appliances, radiators, open doors, windows and fireplaces all offer easy paths for lightning to enter a building.
    - Do not use a telephone with a cord – a cell phone or cordless phone can be used if indoors.
    - Avoid contact with water; do not bathe or wash dishes etc.
- Seek shelter in a vehicle with a metal body frame if no safe building is available. Roll up the windows and do not touch metal within the vehicle. Cloth-top vehicles, all-terrain vehicles (ATVs) or utility vehicles do not offer sufficient protection because the metal shell of a vehicle, rather than the tires, affords the protection for the occupants. After a storm has passed, watch out for downed live wires if wind damage has occurred. Do not leave the vehicle if downed wires touch the vehicle or you may be electrocuted when your feet touch the ground. Refer to section 21.3.4 Working Near Power Lines.
- Unless it is designed as a lightning shelter, it is not advisable to seek shelter in an isolated shed, especially if it has a metal roof. Refer to the following website for information about lightning shelters for outdoor workers: http://www.lightningsafety.com/nlsi_pls/outdoor_worker_shelters.html

If no indoor shelter is available, seek the safest outdoor location.

You do not want to be the best conductor in the area, which is usually the tallest object. Avoid sheltering near tall objects such as trees, cliffs or promontories.

- Descend to a lower elevation if you are on a ridge or peak. Seek a bench below a peak and away from local promontories. If you must shelter below a peak or cliff, the cliff or peak should be at least five to ten times your height. You should crouch more than 2 m but less than 15 m away from the base of the cliff.
- Do not stand under isolated trees or in open spaces where you are the tallest object.
- If you are in an open area, a clearing or on an exposed slope, move into an area of small trees or bushes if possible.
- If you are in a forest, seek a stand of young trees of uniform height. Avoid trees with unstable roots or ones that stand significantly higher than other trees in the area.
- Do not shelter in small gullies and shallow caves. Rock overhangs, rocks with wet surfaces, patches of lichen, cracks that hold water, plant or tree roots are all likely to conduct current.

- Avoid water. Get out of the water and onto land if you are boating or swimming. Avoid open water. Avoid being near streams or swamps, as water increases conductivity. Remember to avoid tall trees and rocky promontories by the shore. Move inland at least 100 m from shore.
- Avoid metal and graphite objects (e.g., power lines, fences, tent poles and wires, ice axes, packs with metal or graphite frames). Graphite, like metal, is an excellent conductor.
- Move away from (or avoid the area of) iron formations.

If you are outdoors when lightning is nearby:

- It is vitally important to assume a position that minimizes your contact with the ground. Choose the safest location available. If your hair begins to stand on end and your skin or teeth feel a tingle, you are in grave danger of being struck by lightning.
- The safest position: Crouch down with your knees drawn up and your feet touching together to minimize your contact with the ground. Never let your hands, shoulders or head touch the ground. Any current passing through these parts of your body will also pass through your vital organs. Never lie flat on the ground. Discard your pack, hammer, knife, compass, coins in your pockets etc. Crouch on insulating material, if available (e.g., dry sleeping bag, foam pad or coiled rope). Cover your ears if possible to lessen potential damage to your eardrums.
- If there are several people in a party, spread out at least 6 m apart so the group does not provide multiple paths for the current. Everyone should assume the crouching position.

Figure 9.1 : Crouch with your feet touching together.

Although direct hits by lightning are rare, a person can be severely injured by splash lightning or ground currents that spread out when lightning strikes a nearby object. Lightning rarely kills outright; it paralyzes body functions so recovery is common.

- You cannot receive an electrical shock from a victim of a lightning strike so do not delay administering first aid.
- If someone is struck by lightning, immediately check if they are breathing and have a pulse. Follow the ABCs – **A**irway: is it open? **B**reathing: is the victim breathing? **C**irculation: does the victim have a pulse? If not, immediately begin rescue breathing

and/or CPR. Recovery is common even if some time has elapsed since the strike. Evacuate the victim to a medical centre as soon as possible.

Additional information regarding lightning safety:

The National Lightning Safety Institute and Environment Canada provide information on personal and structural lightning safety on the following websites:
http://www.lightningsafety.com/index.html

http://archive.safety-council.org/info/community/lightning.html

http://www.pnr-rpn.ec.gc.ca/air/summersevere/ae00s19.en.html

9.3 Whiteouts

9.3.1 Risks and Hazards

Some of the risks and hazards include but are not limited to:

- Serious injury or death caused by hypothermia and/or frostbite, lack of emergency shelter and supplies, inability to locate emergency shelter or cache
- Slips, trips, and falls caused by walking on slippery or steep ground with limited visibility
- Disorientation or getting lost caused by limited visibility, loss of battery power (navigation and communication equipment)
- Vehicle crashes caused by operating when visibility is reduced
- Stranding (a potential survival situation) caused by inadequate preparation, lack of emergency shelter and supplies, getting lost, loss of battery power (communication and navigation equipment)
- Risk of animal attack due to the fact that polar bears approaching Arctic camps cannot be seen in whiteout conditions

9.3.2 Prevention and Preparation

Whiteout conditions greatly reduce visibility. The term “whiteout” refers to weather conditions that produce a combination of light, atmospheric and ground conditions when landscape features and the atmosphere appear to merge and become indistinguishable. Due to the loss of depth perception when you cannot distinguish between the land, sky and horizon, it is easy to become disoriented and it can be impossible to see changes in terrain. Whiteouts may occur in the Arctic, in mountain regions, in open areas without trees – especially on plains, or along highways with little side shelter from trees etc. They often develop when blowing snow on snow covered ground obscures visibility and loose, wind-driven snow swirls high into the air. Whiteouts may also develop during heavy snow squalls, blizzard conditions and when clouds merge with glacier or snow covered ground surfaces. A dense fog on a snowy surface may produce true whiteout conditions. “Flat light” conditions may occur when low light is produced by overcast conditions or fog, or when a thin fog covers a snowy surface. Whiteouts may be very local in extent or may cover many square kilometres.

Whiteouts are always dangerous. As whiteouts and flat light conditions may seriously reduce visibility and affect safety, be prepared when working away from the project or camp. It need not

be snowing or foggy for whiteouts to occur; sudden winds may cause whiteout conditions to develop rapidly. Make sure company vehicles are equipped with survival equipment. When renting a vehicle, always carry personal survival equipment and food and water – especially in winter.

Preparations for projects located where whiteouts may occur:

- Develop SOPs and an ERP to address potential whiteouts specific to the project area and train all personnel in the procedures. Hold a drill to make sure employees respond correctly and rescue/evacuation procedures work.
- Designate an experienced person to declare a “whiteout alert” when whiteout conditions occur – or are likely to occur – so warnings can be issued in time for people to return safely to the project or to access established survival shelters.
- Maintain a rigorous tracking system for the location and movement of all employees.
- Erect survival shelters at all drill sites and supply them with food, water, a heat source, first aid and communication equipment.
- Equip projects with sufficient Global Positioning System (GPS) units and spare batteries to allow all employees or field crews who must travel in poor weather conditions to carry them. Make sure everyone working outside the project site knows how to navigate using a GPS unit.
- Consider supplying larger projects with an enclosed Challenger or Bombardier type snow machine equipped with GPS for rescue purposes.

Prepare travel routes in areas where whiteouts may occur.

- Mark all regularly travelled routes with fluorescent orange painted pickets every 10 to 20 metres. Remember that windblown snow may fill in tracks or trails very quickly so the pickets may be the only trail indicators.
- Map routes carefully with a GPS. Label each picket so travellers can identify their position at each stake.
- Stay on established routes whenever possible.
- Employees who travel in poor weather conditions should be required to carry a GPS unit, a satellite telephone and extra batteries in addition to their survival equipment and be trained to competently use all items.
- Snowmobiles should always be fully equipped with survival and communication equipment for long journeys on unmarked routes. Carry extra fuel.
- Fuel: Check that the vehicle is full of fuel before departing on each trip. This is very important when weather conditions are marginal. Vehicles should be fully equipped with survival equipment. Always maintain the fuel tank at least half full when travelling long distances.

When a whiteout is declared:

- All travel should halt and people should remain where they are.
- All mechanical operations should go on standby (e.g., drilling). All work that might result in injury should cease, as rescue is likely to be impossible until the weather clears.

- Contact all personnel outside the base camp or project by radio and verify their location. Maintain radio contact on an hourly schedule.
- Employees at the project site should not walk to any nearby destination unless there is a clearly marked path (e.g., water pumps, garbage disposal areas or fuel caches). They risk becoming disoriented, getting lost, developing hypothermia and/or death.
- Rescue attempts of persons stranded in a whiteout should be undertaken only if the condition of the person is critical and a GPS-mapped route to follow exists. Otherwise, the risk of the rescuers becoming lost is too great.

If you are caught in a whiteout:

- Do not try to travel to the project site if you are near a survival shelter. Go to the shelter.
- If no established shelter is available, build a snow shelter using your survival equipment (refer to section 8.6.3 Shelter). Moving is too dangerous and there is extreme danger of becoming lost or walking off a cliff etc.
- Communicate with the project base and give GPS coordinates if you know them. Keep in contact with the project base on an hourly schedule.
- Think about your precise location and any possible geographic hazards between you and the project site in order to caution potential rescuers.

If travelling on public roads and whiteout conditions develop:

- Slow down and increase your following distance. Avoid passing and changing lanes. Make sure your headlights and tail lights are turned on.
- Find a safe location as soon as possible and pull off the highway as far as possible and wait for conditions to improve. Turn off your lights or another vehicle may think you are on the road and “follow” you. For more information, refer to section 8.5.1. Survival Advice for Cold Climate Conditions.
- If it is necessary to leave your vehicle during whiteout conditions, always tie a cord to yourself and the steering wheel or door handle so you can find your way back.

9.4 Avalanches

Definitions

Loose snow avalanches start at a point on the surface of the snowpack. Snow at the starting point cannot be supported by underlying snow so it slides downslope incorporating more snow as it moves. Loose snow avalanches are usually fan shaped.

Slab avalanches start when a weak layer within the snowpack fails and a large rectangular block (slab) of snow slides down the slope. Slab avalanches are responsible for 90% of fatalities.

9.4.1 Risks and Hazards

Some of the risks and hazards include but are not limited to:

- Death from suffocation or trauma injuries caused by burial

- Impact injuries caused by burial in snow or debris (e.g., head and neck trauma, broken limbs, shock)
- Potential risk of a survival situation caused by:
    - Lack of safety equipment: avalanche safety devices, inadequate communication equipment (wrong type or battery failure)
    - Lack of training, lack or loss of survival equipment, lack of available help due to remote setting
    - Hypothermia and/or frostbite
- Stranding may be caused by: snowmobiles break down, battery failure (e.g., navigation or communication equipment), an avalanche blocking the route

9.4.2 Prevention and Preparation

Avalanches are a serious safety risk and each year knowledgeable people die in avalanche accidents. No one should presume that by reading the PDAC Health and Safety Guidelines that they have gained sufficient knowledge to safely assess avalanche dangers.

When work is planned in avalanche-prone country, exploration companies should seriously consider hiring avalanche experts to help develop SOPs and ERPs and to help plan and carry out field work, including traverses. In addition to the aid and advice of experts, exploration employees should take formal courses to learn the essentials of avalanche safety.

As a minimum, formal training should include: (1) how to recognize avalanche terrain, assess snow conditions and recognize weather conditions that produce avalanches, (2) the types of avalanches and when each type is likely to occur, (3) understand how avalanches are triggered, (4) how to use avalanche safety equipment including a transceiver, avalanche probe and shovel, (5) how to safely cross an avalanche slope if a crossing is unavoidable, and (6) techniques to locate and rescue an avalanche victim.

Preparations for projects located where avalanches may occur

- Hire knowledgeable experts familiar with the risks and hazards in the project area.
- Do not set up project work sites or camps in areas where avalanche dangers are present. Plan to do field work only after the seasonal risks of avalanches have passed.
- The project supervisor should develop site specific SOPs and ER procedures in consultation with knowledgeable experts to address potential avalanche risks and hazards. Make sure all employees are trained in the procedures.
- Training: Try to hire employees who have taken formal avalanche safety classes or provide the training to those who lack it. All employees should receive training regarding SOPs and ERPs and the use of avalanche safety equipment.
- Carry special avalanche safety equipment. Avalanche transceivers emit a signal that can be detected for about 60 metres. Each person traversing should be required to wear an avalanche transceiver around his or her neck – do not keep it in a pocket or a pack. Switch on the transceiver at the beginning of the traverse and check that all transceivers are working correctly. Leave transceivers turned on until the traverse is finished or until everyone is completely out of danger. Use alkaline batteries as they withstand cold temperatures better than regular batteries. Each party member should also carry a collapsible avalanche probe and a durable collapsible shovel for digging out a victim. Be

trained and practice using the equipment in order to effectively locate and rescue a co-worker.

- Plan traverse routes to avoid exposure to potential avalanches.
- Use helicopter support whenever possible to bypass areas where avalanche risks are deemed high or are known to occur.
- Where avalanche risks are unavoidable, never traverse alone or even in pairs; always traverse with several crew members.
- Do not proceed into any area where you can hear avalanches occurring.

Typical Avalanche Terrain

- Typical terrain: Avalanches frequently occur on broad treeless slopes and on slopes above cliffs. Ravines, gullies and narrow canyons also provide routes for avalanches.
- Slope factors: Most avalanches occur on slopes with a pitch between 25° to 60°. They occur less frequently on gentler or steeper slopes. Slopes between 35° and 40° avalanche most frequently. The slope profile contributes to the degree of avalanche danger. Convex slopes are the most dangerous. Straight slopes are somewhat less dangerous and concave slopes are the least dangerous. Avalanche danger will increase where a slope changes angle due to changing stresses that develop within the snowpack.
    - Northern hemisphere: South-facing slopes are the most dangerous in spring and summer, while north-facing slopes are the most dangerous in winter.
    - Southern hemisphere: North-facing slopes are the most dangerous in spring and summer, while south-facing slopes are the most dangerous in winter.
- Avalanches usually occur where they have happened before. Be constantly vigilant for indications of previous avalanches and avoid these areas when traversing.

Causes of Avalanches

- Most avalanches that engulf people are triggered by members in the party – on skis, on foot or on snowmobiles.
- Weather factors: An accumulation of new snow, increased sunshine that causes a rapid rise in temperature, significant wind (both direction and speed), storms and rain all contribute to the risk of avalanche by destabilizing the snow pack.
- Snowpack factors: Snow builds up in layers. The layers reflect the conditions at the time of snowfall as well as changes in the snow granules over time. Some layers are much weaker than other layers. Snow will avalanche when a weak layer within the snowpack on a slope cannot withstand an external force. The force required to start an avalanche may be large or small, depending on the stability of the snowpack.
- Triggers are the forces that start the avalanche. They may be:
    - Additional weight from a new fall of snow
    - A person’s body weight
    - A collapsing cornice
    - A rock fall
    - Falls of ice on a glacier

- Noises or vibrations
- An earthquake

Planning Safe Traverse Routes

- *Before proceeding*, check out the snow conditions in a safe location. Test the snow whenever there is *any* doubt about its stability. Do not take risks. Conditions often change daily and what was safe yesterday may not be safe the next day.
- Do not make assumptions about avalanche conditions when planning a traverse route. Learn to recognize safe traverse routes. Note the following:
  - Traversing on wide ridges is safest. Travel on the windward side of a ridge well back from the edge, as cornices form on the leeward side. Cornices often collapse. Avoid ridges with double cornices.
  - Narrow valley floors are less safe as they may be the runout paths for avalanches. Wide valley floors beyond avalanche runout paths are generally safer.
  - Traversing gullies and slopes are the least safe routes. Leeward slopes are the most dangerous as they receive the most snowfall.
  - Avoid previous avalanche paths as indicated by damaged trees or the lack of trees.
- Be constantly aware of the changing nature of your surroundings when working in avalanche territory. During a traverse your body weight may provide the trigger for an avalanche when there is only a slight change in the slope or snowpack.
- Pay strict attention to the snow as you traverse. Hollow sounding snow is extremely dangerous. If cracks form where you are standing in snow, get off it immediately.

If you must cross a suspicious slope:

- Cross high on the slope so that most of the snowfield is below you.
- Put on gloves, your hat and extra clothing. Detach all pack or equipment safety straps so you can discard them immediately if caught in an avalanche.
- One person should cross at a time. Each person should trail at least 18 m of fluorescent rope. Then, one can be traced more easily if caught in an avalanche.
- Don’t assume that because there are tracks on a slope that it is safe. The first person to cross does not always trigger the avalanche.

If you are caught in an avalanche:

- Shout to attract attention and get rid of your pack. Cover your face with your hood or hat to help prevent snow from entering your nose and mouth. Keep your mouth shut.
- Grab onto a tree or rock to stop being swept away, if possible.
- Make every effort to get to the edge of the avalanche. Keep to the upper surface of the avalanche if possible. Swimming motions may help.
- If you become buried, as you come to a stop make every effort to work your arms in front of your face to create as large a breathing space as possible.

- Your avalanche transceiver should already be activated. Rescuers will turn their transceivers to “receive” to detect your signal and locate you. Activate your Personal Locator Beacon (PLB).
- Try to work your way to the surface only if you can see light. Save your energy for shouting until you hear rescuers. Blowing an emergency whistle is better than shouting.

Additional information regarding avalanches

Refer to the Canadian Avalanche Association and the Canadian Avalanche Centre for extensive information about training and instruction, regional bulletins, and safe practices. Website: http://www.avalanche.ca/

9.5 Floods

Floods are caused by many factors including prolonged rainfall over several days or heavy rainfall over a short period of time (flash floods). Flooding may be routine in the spring when rain falls on melting snow and water runoff increases. Ice jams are a common cause of flooding in many parts of Canada and other northern countries. Beaver dams and spring snowmelt may cause flooding and affect remote roads so that the quality of the road may change from year to year. Storms and tropical cyclones can bring intense rainfall to coastal and inland areas at certain times of the year. However, intense rainfall is not directly related to the wind speed of a storm. Weak storms that stall or drift slowly over an area often result in the greatest amount of rainfall. Some statistics indicate that floods kill more people in North America than any other type of natural disaster. About half of all flood deaths are caused by people in vehicles being swept away by moving water.

Rivers and streams may flood during periods of high runoff caused by either large or small storms, from melting snow and ice, or from ice jams. Flooding may follow heavy rains when the ground is frozen, snow covered, or saturated from previous rains. Flooding may be local or widespread.

Flash floods develop over a short period of time and occur with little warning, often in dry river or stream beds. Flash floods are local in extent and are usually due to heavy rainfall from thunderstorms; they can also occur when a manmade dam or an ice or debris jam bursts.
A glacial outburst flood (“jökulhlaup”) is the sudden release of water from a lake contained by a glacier, a subglacial lake, or the failure of a terminal moraine. This is a potential risk if setting up a camp downstream from glaciers. The event can vary from flooding to a debris flow.

9.5.1 Risks and Hazards

Some of the risks and hazards include but are not limited to:

- Drowning caused by high water, being swept away by moving water
- Impact injuries caused by collapsing structures, moving objects in waters
- Stranding (and a potential survival situation) caused by impassable flooding steams, road bed erosion or if a vehicle is swept away
- Urgent survival or life-threatening situations caused by flash floods
- Electrocution caused by contact with wet electrical equipment or downed wires
- Wild animal risks: snake or insect bites (especially from snakes and fire ants) that result after they are displaced from their normal habitat by high water

- Waterborne diseases caused by bacteria, viruses or parasites in flood waters
- Damage or loss of personal or project property and equipment may be caused by all types of floods.

9.5.2 Prevention and Preparation

Preparations for projects located where flooding may occur:

- Take potential flooding into consideration when planning a camp location. Companies should consider the topography and be familiar with the local climate and weather patterns, especially during the wet season.
- Carry out a risk assessment of the area and develop site specific SOPs and an ERP to address potential flood risks and hazards. This is particularly important with regard to fuel storage areas where flooding might cause environmental contamination.
- Train all personnel to follow SOPs and the ERP procedures with respect to potential floods. Hold a practice drill if the ERP includes evacuation procedures.
- Traversing: When planning traverses, take into account the potential risks of rising streams, flooded roads and flash floods in the field area. While flash floods may be the greatest risk, you may encounter unexpected flooding on remote roads or streams with higher water levels than expected. General tips include:
    - Plan alternate routes and emergency procedures to follow in case flooding blocks your planned route.
    - Be aware of the potential for glacial-fed streams to become a torrent of meltwater in the course of a warm day. Do not be tempted to return to camp by crossing such a stream. Use another route or camp out for the night.
    - Do not walk through moving water. 15 centimetres of moving water can sweep you off your feet, especially on poor ground. If you have to walk in water, walk where the water is not moving and use a stick to check the firmness of the ground in front of you.
    - Avoid valley bottoms after a heavy rainfall.
    - Always carry survival equipment. Keep vital survival equipment on your person so it is not lost if you must abandon your vehicle or pack. Refer to Section 8. Survival.

Flash Floods

Flash floods may occur in many environments, sometimes where they are least expected, and by their nature they are almost impossible to predict. Small streams near the headwaters of river basins will fill quickly if there is a heavy rain (even in alpine areas). Small streams or dry stream beds in or near mountains, in deserts, or in the tropics can fill and flood even before a rainstorm stops. Desert dry washes near mountains are particularly susceptible to flash floods and may become raging torrents after a localized rainstorm occurs many kilometres upstream. Never camp in a dry stream bed because of this danger. Employees should be trained to be aware of the dangers of flash floods and recognize the signs of an impending flash flood.

The warning time is usually minimal when flash flooding occurs. Any of the following may be signs of an impending flash flood:

- Sudden increase in water level

- Water suddenly becomes muddier
- Debris appears in the stream
- Loud noises of rushing water from the upstream direction – this may occur in a dry wash or flowing stream, on flat or steep ground, or in a canyon.
- Thunderstorm or rainstorm nearby, especially if they are within the drainage system

Safe traversing tips with regard to flash flooding

- Listen to local radio stations that issue flash flood warnings and heed them.
- Be aware of your surroundings. If there are washes near mountains and you can see rain or storm clouds, leave the drainage areas immediately and stay out of them.
- If you encounter a flash flood while on foot, immediately move to higher ground and wait on safe ground for the flood to recede before continuing, which may take 24 hours.
- Flash floods sometimes come in quick succession. Once one has passed use extreme caution.
- Flash flooding occurs frequently – even daily – in some tropical areas (e.g., Papua New Guinea). Know the local weather patterns. Be cautious when using a dry stream bed for a temporary helicopter landing site. Always carry survival equipment.
- If flooding is in progress, stop and wait it out or find another route.

Vehicles and Flash Floods

- Never drive in a dry stream bed or dry wash unless there is an obvious escape route.
- Do not attempt to drive across flooded roads or washes without very careful assessment and a capable vehicle.
    - Do not overestimate the vehicle's ability to drive through flood waters: Water 15 cm deep is enough to reach the bottom of most passenger cars. Driving in water this deep is enough to cause a loss of control or stall the car. Water 30 cm deep will float most cars. Water that is .6 m deep has sufficient lateral force to float and sweep away most vehicles, including sport utility vehicles (SUVs) and pickups.
    - The water covering a flooded expanse of road may hide road bed damage such as a washout; if a wheel drops into one, the vehicle can easily tip over, fill with water and be washed away.
    - Before crossing remnant flood waters, check out the flooded road surface on foot. If the water is not moving, it may be advisable to walk through the flooded section, but *only* if you are holding a stout walking stick and probe ahead to search for washouts, ruts and holes. If crossing by foot, consider using an anchored rope for added safety.
    - Do not attempt to drive through partially flooded underpasses, including in urban areas. It is usually impossible to tell the depth of the water and they can fill very rapidly during a storm.
    - In urban areas where rescue is probable, occupants statistically have a better chance of survival by staying with the vehicle when it becomes stranded. They may climb on the roof to get away from the rising water if it is considered unsafe to leave the vehicle.

- Where help is unavailable, consider leaving the vehicle if it stalls in flood waters. Get out and go to safe ground if there is plenty of time and if you can do so safely. Undertow conditions create extremely lethal hazards for persons trying to traverse flash flood conditions. Do not waste time trying to restart the vehicle. Many people drown when their vehicle is swept away in waters as they attempt to restart it.

Additional information is available regarding floods at the following websites:
http://atlas.nrcan.gc.ca/sitze/english/maps/environment/naturalhazards/floods/1
http://www.floodsafety.noaa.gov/

Figure 9.2: Use caution when crossing on foot or by vehicle when water is flowing across a road. © Bill Mitchell

9.6 Mudflows and Landslides

Definitions

Debris flow – a type of landslide that develops when saturated slope material (rocks, soil, vegetation) slides into a stream channel and then follows the channel downslope. There is potential for destruction of roads and bridges crossing the stream channel and of settlements adjacent to the stream channel.

Glacial outburst flood “Jökulhlaup” – water released from a lake contained by a glacier, a subglacial lake, or the failure of a terminal moraine. The water may incorporate sediments and debris to form a debris flow or mudflow downstream.

Lahar – a mudflow and debris flow originating on the slopes of a volcano. Lahars may be very limited in extent or enormous and deposit material over many kilometres.

Landslide – ground movement of a mixture of soil, rocks, vegetation etc., with some water content. Gravity is the driving force. The trigger for the movement includes but is not limited to slope instability, heavy precipitation causing ground saturation and earthquakes.

Mudflow – rapid ground movement due to higher fluid content than a landslide

9.6.1 Risks and Hazards

Some of the risks and hazards include but are not limited to:

- Drowning or suffocation caused by burial in flowing debris, not recognizing or not reacting soon enough to signs of impending mass movement
- Impact injuries caused by being hit by debris
- Stranding (a potential survival situation) due to impassable roads or routes, burial of a camp, lack of or loss of equipment
- Damage or loss of personal or project property and equipment caused by all types of slides

9.6.2 Prevention and Preparation

Mudflows and debris flows are a hazard in many regions. Heavy rainfall may cause loose unconsolidated sediments on steep slopes to erode rapidly. Volcanic eruptions may melt ice and snow, which provides water that mixes with the erupted volcanic debris. Such an event in 1985 caused enormous mudflows in Columbia that killed 23,000 people. Deforestation and poor road building techniques on steep slopes combined with high rainfall can contribute to landslides and mudflows; they may also be triggered by an earthquake.

Preparations for projects located where landslides, debris flows or mudflows may occur:

- Carry out a risk assessment before locating a project work site or camp in slide prone country. Develop site specific SOPs and an ERP that take into account the potential risks of mass movement. Train personnel in the procedures and hold a drill if the ERP includes plans for emergency evacuation.
- Plan project site locations with extra caution where earthquakes are common. Take into account where slides or floods might be triggered by observing the patterns of storm water drainage on slopes and note where runoff water channels converge. Check slopes for signs of mass movement including tilting trees.
- Reduce the impact of exploration on the environment, especially with regard to drill pad and drill access trail construction, trenching and road building activities. Refer to Section 5.0 Land Disturbance in the Environmental Stewardship Toolkit at the e3 Plus website: www.pdac.ca/e3plus.

In areas where there is a risk of mudslides:

- On extended traverses, do not camp in dry stream beds. Be aware of changing water levels at all times. Ridge tops are probably the safest place for camp sites unless lightning storms are likely to occur.
- If you hear loud noises originating in the upstream direction or see signs of a debris flow or mudflow in a stream or river channel, head away from the channel to the highest possible ground at the greatest possible speed.
- Rivers with steep banks may be subject to frequent landslides as currents undercut them. When navigating along rivers, be prepared for potential channel changes that may not be marked on maps. It may be difficult to find your location without a GPS unit.
- When projects are located near active volcanoes, any increased volcanic activity should be cause for evacuation.
- Do not examine old mine works or artisanal mine workings during times of heavy precipitation, as flooding and mudslides are increased potential risks.

9.7 High Winds

Strong winds can pose a significant threat to safety. Isolated or diseased trees and those in marshy areas may be easily uprooted by winds. If working in a forested area when high winds arise, the safest place is in a large clearing or a sheltered ravine. Old forest fire burns can be especially dangerous as the tops of burned trees easily break free. Avoid the base of cliffs. When working on water, follow the SOPs and safety tips in Section 17. Boats, Canoes and Inflatables.

Preparations for projects where dangerous high winds may occur:

- Take potential high winds into account before locating a project, camp or work site. Avoid locations where individual trees might be blown over by winds (remove diseased trees). Consider the potential for windblown dust, sand or snow.
- Carry out a risk assessment and develop site specific SOPs and an ERP to address potential risks and hazards associated with high winds. Train personnel to follow the procedures. Hold a practice drill if the ERP includes plans for emergency evacuation.
- When setting up camp, make sure stationary camp equipment is very securely anchored to prevent damage by wind (e.g., propane cylinders and generators). Tents must be very durable and secured with extra lines.
- Where tornadoes are a high risk, projects should be located in reinforced concrete buildings.
- The Beaufort Wind Scale below can be utilized as a gauge for the severity of wind conditions both on water and land. It is a useful tool when it is necessary to judge the wind speed in a remote location where there are no local weather reports.

Table 9.1: Beaufort Wind Scale Table

Force	Wind Speed		Descriptive Term	Effects Observed at Sea	Effects Observed on Land
	Km/h	***Knots***			
0	Less than 1	Less than 1	Calm	Sea surface like a mirror, but not necessarily flat.	Smoke rises vertically.
1	1 - 5	1 - 5	Light Air	Ripples with the appearance of scales are formed, but without foam crests.	Direction of wind shown by smoke drift but not wind vanes.
2	6 - 11	4 - 6	Light Breeze	Small wavelets, still short but more pronounced. Crests do not break. When visibility good, horizon line always very clear.	Wind felt on face. Leaves rustle. Ordinary vane moved by wind.
3	12 - 19	7 - 10	Gentle Breeze	Large wavelets. Crests begin to break. Foam of glassy appearance. Perhaps scattered whitecaps.	Leaves and small twigs in constant motion. Wind extends light flag.
4	20 - 28	11 - 16	Moderate Breeze	Small waves, becoming longer. Fairly frequent whitecaps.	Raises dust and loose paper. Small branches are moved.
5	29 - 38	17 - 21	Fresh Breeze	Moderate waves, taking a more pronounced long form. Many whitecaps are formed. Chance of some spray.	Small trees in leaf begin to sway. Crested wavelets form on inland waters.
6	39 - 49	22 - 27	Strong Breeze	Large waves begin to form. The white foam crests are more extensive everywhere. Probably some spray.	Large branches in motion. Whistling heard in telephone wires. Umbrellas used with difficulty.
7	50 - 61	28 - 33	Near Gale	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind.	Whole trees in motion. Inconvenience felt in walking against wind.
8	62 - 74	34 - 40	Gale	Moderately high waves of greater length. Edges of crests begin to break into the spindrift. The foam is blown in well-marked streaks along the	Breaks twigs off trees. Generally impedes progress. Walking into wind almost impossible.

Force	Wind Speed		Descriptive Term	Effects Observed at Sea	Effects Observed on Land
	Km/h	***Knots***			
				direction of the wind.	
9	75 - 88	41 - 47	Strong Gale	High waves. Dense streaks of foam along the direction of the wind. Crests of waves begin to topple, tumble and roll over. Spray may affect visibility.	Slight structural damage occurs, eg. roofing shingles.
10	89 - 102	48 - 55	Storm	Very high waves with long overhanging crests. Dense white streaks of foam. Surface of the sea takes a white appearance. The tumbling of the sea becomes heavy and shock-like. Visibility affected.	Trees uprooted. Considerable structural damage occurs.
11	103 - 117	56 - 63	Violent Storm	Exceptionally high waves. Sea completely covered with long white patches of foam. Visibility affected.	Widespread damage.
12	118 - 133	64 - 71	Hurricane	Air filled with foam and spray. Sea entirely white with foam. Visibility seriously impaired.	Rare.

Source: Beaufort Wind Scale Table, URL: http://www.msc-smc.ec.gc.ca/weather/marine/beaufort_e.html, Marine Weather Services, 2007. Reproduced with the permission of the Minister of Public Works and Government Services Canada, 2009.

9.7.1 Tornadoes

Definitions

Tornado Watch – when local conditions are favourable for the development of severe thunderstorms that can produce tornadoes

Tornado Warning – when a tornado has been spotted or is indicated by radar

Risks and Hazards

Some of the risks and hazards include but are not limited to:

- Impact injuries or death caused by flying debris, large hail
- Survival situation caused by the destruction of camp or living quarters, loss of equipment and supplies
- Stranding caused by impassable roads or routes

- Damage or loss of personal or company property and equipment caused by winds, large hail

Although tornadoes may appear to be a remote risk, Canada ranks third in the world for number of recorded events with about 13 per year.

Nation	Period	Total Tornadoes
United States	1920-1998	44,417
United Kingdom	1950-1997	942
Canada	1950-1998	625
Argentina	1930-1979	368
France	1680-1998	294
Australia	variable	239
South Africa	1905-1996, 1998-9	195
Italy	1991-1999	158
Germany	1594-1999	136

Source: http://www.islandnet.com/~see/weather/almanac/arc2007/alm07jun.htm

Note that it is suspected that many countries under-report tornadoes. To quote the above mentioned website:

"Deaths attributed to tornadoes are another way to look at the disaster potential of tornadoes, though such numbers must be looked at with population densities, building materials, and storm-warning programs in mind. The United States leads Tom Grazulis' list of top ten countries for total tornado deaths during the last century. Bangladesh follows second, then Russia, India, Canada, Italy, South Africa, France and Argentina. Grazulis suggest China may slip in ahead of Canada but data from that nation are sparse for much of the century."

Thus it should be noted that countries that have high death rates are not on that top 9 list – notably: Bangladesh, Russia, India. The fact that South Africa is the country in Africa with highest recorded tornadoes is almost certainly due to systematic recording rather than implying that South Africa has the highest risk in Africa.

Prevention and Preparation

Exploration company employees should know whether they are working in an area where tornadoes can be expected. Carry out a risk assessment and access local knowledge for sound advice regarding appropriate shelter, safety precautions and procedures. Exploration companies should provide employees with a reinforced concrete structure for living quarters.

When setting up a camp where tornadoes are a high risk, find the safest location for shelter in the immediate area. If threatened by a tornado, the safest place will not be in a tent or a temporary camp structure that winds can destroy. The lowest area – a ditch or creek bed, or deep in a stand of small trees is safer than sheltering in tents or vehicles. Know how to access this spot when it is dark, as the sky will be very dark and tornadoes sometimes happen at night. If such a shelter is necessary, it may be advisable to keep a small emergency kit at this location (securely anchored) that includes flashlights and spare batteries, a radio capable of receiving weather reports, a first aid kit and essential survival equipment.

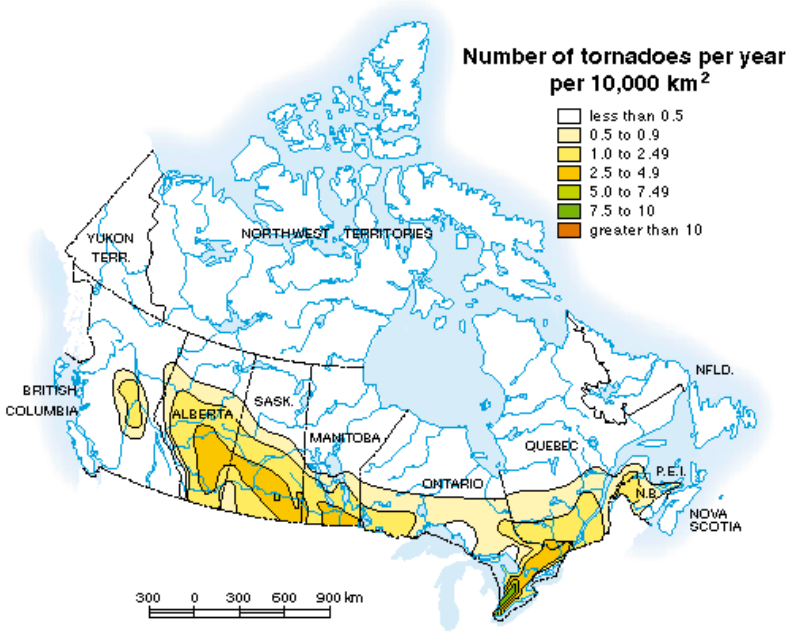

Figure 9.3: Map of the Annual Number of Tornados

Source: Map of the Annual Number of Tornadoes in Canada URL:http://atlas.nrcan.gc.ca/site/english/maps/environment/naturalhazards/naturalhazards1999/majortornadoes/number_tornadoes_per_year.gif/image_view. Natural Resources Canada. 1999. Reproduced with the permission of the Minister of Public Works and Government Services Canada, 2010.

Tornado Danger Signs

Strong winds associated with severe thunderstorms occasionally develop into tornadoes. Winds in funnel-shaped clouds can reach 500 km/h (300 mph) and can do severe damage – much of it wrought by flying debris. Be alert to the possibility of tornadoes whenever there are severe thunderstorms in the area. Listen to a radio for severe weather watches and warnings and avoid unnecessary travel. Tornados can develop rapidly at any time of the day or night and there are occasions when there is no advance warning. If you see or suspect an approaching tornado, seek shelter immediately to protect yourself from flying debris.

Be familiar with features of thunderstorms and signs that indicate a potential tornado:

- Dark, yellow or greenish coloured sky
- Hail (sometimes large) often precedes tornadoes. Hail can cause injuries to people and serious damage to equipment.
- Funnel cloud: An approaching cloud of debris can mark the location of a tornado even when a funnel cloud is not visible.
- Wall clouds indicate of strong rotational updrafts, a primary indicator of potential tornado formation. Wall clouds appear as a solid dark cloud attached to the bottom of the main cumulonimbus cloud base. A rotating wall cloud is a danger sign, as tornadoes may develop within it and then descend to the ground.

- Tornadoes generally occur near the trailing edge of a thunderstorm. It is not uncommon to see clear sunlit skies behind a tornado.
- Sometimes the weather may be fine. Suddenly the wind will die down and the air will become very calm – just before severe weather and a tornado develops.
- Tornadoes usually make a continuous sound like a loud roaring plane or train as they approach. However, sometimes the noise is not audible until the tornado is very close.

If inside shelter is available:

- Shelter in a reinforced concrete building, if possible. This type of shelter is advisable for projects in high risk locations. A storm cellar or confined space within a basement is best. If this is unavailable, go to the lowest floor and the interior of the building. Cover yourself with a mattress, blankets or sturdy furniture for protection from flying debris. Stay away from all windows, doors and exterior walls.
- Do not seek shelter in vehicles, mobile homes/caravans or large buildings with wide-span roofs, as these are particularly vulnerable to damage from tornadoes (e.g., big box stores, auditoriums, gymnasiums).

If you are outdoors:

If you are in a tent camp or on foot when a tornado advances in your direction:

- On foot: Seek a low place. Seek shelter in a ravine, gully, a ditch, a cave or a culvert – but be aware of the potential for flooding. If only a field is available, seek the lowest area possible as it offers more protection from flying debris. If possible, hang on to something such as roots or a rock while covering your head for protection.
- Abandon your vehicle. Do not take shelter downwind from a vehicle and do not shelter under a tree or in a highway overpass. The overpass may act as a wind tunnel as the tornado passes.
- Lie flat, protect your head and body (blankets, helmet) and wear goggles if available.
- It is not advisable to try to outdrive a tornado in a vehicle. Tornadoes can change direction quickly and can lift a car or truck and toss it through the air. If stuck in a vehicle, stay down as low as possible below window level.
- Get off the water as fast as possible if a tornado approaches while you are in a boat. Go to shore and move inland at least 100 m. Waterspouts (tornadoes moving over water) can easily flip a boat and drown the occupants.

Additional information regarding tornadoes is available at the following websites:

http://www.spc.noaa.gov/faq/tornado/index.html

http://www.pnr-rpn.ec.gc.ca/air/summersevere/ae00s02.en.html

http://www.pnr-rpn.ec.gc.ca/air/summersevere/ae00s09.en.html

http://www.pnr-rpn.ec.gc.ca/air/summersevere/ae00s27.en.html

http://www.on.ec.gc.ca/severe-weather/camping_factsheet_e.html

9.7.2 Hurricanes, Cyclones and Typhoons

Definitions

Tropical cyclone – is the common term for a severe rotating tropical storm in either hemisphere, although there are a variety of local names (typhoon, hurricane). Tropical cyclones have very high winds that range from 110 to 300 km/h. Tornadoes may accompany them. Because these storms cover a large area, government agencies usually issue warnings.

Hurricane Watch – issued for a specific area when hurricane conditions are possible within the next 36 hours

Hurricane Warning **–** issued for a specific area when hurricane conditions are expected within 24 hours or less

Risks and Hazards

Some of the risks and hazards include but are not limited to:

- Injuries or drowning caused by high water from a storm surge or inland flooding
- Injuries or death caused by the impact of debris, falling trees and structural collapse due to winds and/or high water
- Damage and loss of personal or project property and equipment caused by winds, inland flooding or storm surge
- Stranding (and potential survival situation) caused by a storm surge, loss of equipment, impassable roads, or if a vehicle is swept away
- Electrocution caused by contact with wet electrical equipment or downed wires
- Wildlife risks: animals, snake or insect bites (especially from snakes and fire ants) that result after they are displaced from their normal habitat by high water
- Water-borne diseases caused by bacteria, viruses or parasites in flood waters

Prevention and Preparation

- Know when tropical cyclones can be expected and listen for warnings on local radio stations. Project personnel should be able to move to safety with sufficient warning. Do not ignore official warnings. Stay informed regarding up-to-date road conditions and move to a safe area before access is cut off by flood waters.
- Always evacuate to a safe shelter when the project structures are mobile homes (caravans), tent structures, lightly built structures or when the project is located near the coast, a river or flood plain where flooding may occur.
- Inland flooding usually causes more deaths than coastal flooding from storm surges. In an inland area, preparation is necessary and evacuation may be advisable depending on the project location and the path of the storm.

If a tropical cyclone is expected and evacuation is not possible:

- Seek protection in the most solid building available on high ground. Board or tape up windows.
- Assemble lots of drinking water and store it in tightly capped containers to prevent contamination. Assemble emergency food rations, a first aid kit, radio and extra batteries for radio contact. Be prepared to survive several days without outside help.

- During the storm, remain inside in the strongest part of the building. Do not go outdoors until you hear official word that the storm has passed. The eye of the storm may give an illusion of safety. Listen for official information frequently.
- After the storm, wear heavy boots to protect your feet from glass and debris during cleanup procedures. Be aware of additional risks and hazards during cleanup work.
    - Slips, trips and falls
    - Downed electrical wires
    - Contaminated water (don't use it for cleanup or drinking)
    - Cuts and injuries caused by chainsaw accidents
    - Wildlife: snakes, scorpions, spiders, fire ants etc., seek high ground too.

Additional information: Hurricane information and forecasts for the eastern Pacific and Atlantic oceans are available from the following website: http://www.nhc.noaa.gov/index.shtml?epac

9.8 Environmental Risks

Exploration workers face many challenging environmental conditions: cold and windy, hot and humid, or high altitude – which can be either hot or cold and windy. Exposure to temperature extremes and to high altitude can cause disorders with subtle and progressive symptoms that are difficult to diagnose accurately. Your body can function well only if your core body temperature (that of your heart, lungs, liver, kidneys and brain) remains very close to "normal", which is 37ºC. Your body may tolerate a variation of ±1.5°C from this optimum core temperature without much impact. A variation beyond this range will result in stresses that interfere with your biochemical processes and may result in a life-threatening condition. Your brain requires blood at the correct temperature and oxygen level in order for you to think clearly. For this reason, confusion and lack of muscular coordination are some of the signs of dehydration, hypothermia, hyperthermia, and altitude illness.

Your body controls its internal and surface temperatures through processes that result in heat loss and heat gain. Heat loss takes place through evaporation, convection, conduction and radiation from your skin surface and through respiration from your lungs. Heat gain is a function of your metabolism and activity level. Under extremely hot conditions you may experience heat gain through radiation from the sun and/or the environment. To a great extent, you can control heat loss and heat gain through your behaviour (e.g., food and water intake, clothing, exercise, rest). Keeping your body properly hydrated and acclimatized along with the proper use of clothing are major factors in preventing hypothermia, hyperthermia, and altitude illness. Thorough preparation before work and an understanding of these environmental disorders may save your life or that of a co-worker.

9.9 Cold Injuries

It is usually possible to prevent cold injuries by wearing appropriate clothing in layers to regulate your comfort level, by taking warm-up breaks, and by paying careful attention to preventing dehydration and fatigue. Dehydration will affect your blood flow, which in turn affects your circulation. Diminished blood circulation will lead to hypothermia, frostbite, and immersion foot.

9.9.1 Risks and Hazards

Some of the risks and hazards related to cold injuries include:

- Death or injuries caused by hypothermia, falling into cold water, breaking through ice
- Injuries to body parts caused by frostbite or immersion foot. Injuries may include temporary or permanent tissue and/or nerve damage.
- Loss of fingers, toes or feet caused by serious cold injuries (frostbite, immersion foot)
- Hypothermia or frostbite may be caused by:
    - Wearing inadequate clothing, getting wet, dehydration, fatigue
    - A work schedule that lacks sufficient warm-up breaks
    - Travelling by snowmobile at too high a speed
- Increased severity of cold injuries may be caused by:
    - Low temperatures combined with wind chill
    - Lack of training, lack of an emergency shelter and/or emergency cache
    - Remote location causing difficulty getting a patient to medical care
    - Co-workers that do not recognize the symptoms of cold injuries
- Transportation risks: delays in moving a victim to a medical centre caused by storms, whiteouts, mechanical breakdown
- Survival situation for individuals or a group caused by one or more members developing hypothermia

9.9.2 Project Planning to Prevent Cold Injuries

Project planning should include the following measures.

- Complete risk assessments that include a review of the potential impacts of cold-related risks and hazards on project and drill site locations, traversing routes, fuel storage etc., and first aid emergencies. Develop strategies to mitigate the risks and hazards.
- Develop site specific SOPs and ERPs that address the observations and conclusions of the risk assessments.
- Training should cover the SOPs, ERPs and specific ways to recognize and handle potential cold-related emergencies. First aid attendants should be trained to recognize and treat hypothermia, cold water immersion hypothermia, frostbite and immersion foot. Hold a drill if an ERP includes evacuation procedures.
- Plan outdoor work schedules with warm-up breaks appropriate for the daily temperature and wind chill factor.
- Extensive information regarding working in cold conditions is available at the following websites:
  http://employment.alberta.ca/documents/WHS/WHS-PUB_gs006.pdf

  http://www.labour.gov.sk.ca/coldconditions

9.9.3 Hypothermia

Hypothermia is preventable. Hypothermia develops when your body loses heat faster than you can produce it through metabolism and exercise. As a result, your core body temperature falls to a level where internal organs, including your brain, cease to function effectively. Hypothermia can develop quickly and it can be fatal. Wet, cold, windy weather combined with hard physical effort can lead to exhaustion and leave you vulnerable to hypothermia. Temperatures need not be especially cold for hypothermia to develop; it frequently sets in at temperatures between -1° and 10°C.

9.9.3.1 Prevention and Preparation

Stay Warm – Stay Dry – Avoid Fatigue – Avoid Dehydration – Avoid Hunger

- Stay warm: Dress appropriately in layers. Wear several layers of loose-fitting clothing with enough space between each layer to entrap 4 mm (1/4 in) of air. Keep your head warm by wearing a wool hat. Wool clothing is recommended, as it retains 80% of its insulating qualities even when wet. Polar fleece fabrics offer good warmth. Down is a good insulator only when it is dry. Try to avoid 100% cotton as it provides minimal insulation even when dry; when wet, it conducts heat away from your body many times faster than wool. Wear an external windproof layer and always carry waterproof rain gear, preferably the “breathable” kind, as it allows perspiration to escape. Refer to section 6.3.5 Clothing.
- Stay dry: Try not to work up a sweat as wet clothes may chill you. Strive to maintain a comfortable body temperature. Anticipate how your activity will impact your body temperature and remove a layer of clothing before you begin strenuous activity. You will warm up soon, and if you don’t, you can put the layer back on. If you get too warm while working, cool down by removing gloves first (if your hands won’t be exposed to ice or snow). Next, remove your hat and scarf exposing your neck area. Then, loosen the clothing at the wrists and waist. Some jackets have armpit zippers that open to provide ventilation. Finally, remove layers of clothing. A polar fleece or down vest helps keep your trunk warm and allows your arms to remain cool. Rain gear: Rain jackets should be long enough to prevent rain from leaking into your pants. For the best protection, put on rain gear *before* you get wet.
- Avoid fatigue: Rest frequently. Fatigue is often the factor that aggravates a difficult situation. When resting, take shelter from the wind and sit on something (a pack) for insulation from the ground or snow. If it will be necessary to set up a camp, do so before fatigue sets in as it is easier to warm up if you are not fatigued.
- Avoid dehydration and hunger: Your body cannot combat the cold efficiently if you are dehydrated or hungry. Dehydration reduces your blood volume and impairs circulation, so drink plenty of fluids throughout the day. Start the day well nourished and snack often on high energy foods. Carry waterproof matches and fire making materials to make a fire and a hot drink, if necessary.
- Recognize weather conditions that may cause hypothermia. Be prepared.
- Beware of wind chill. The cooling effect of wind on your body can be enormous. Wear windproof clothing, a hat and take shelter from the wind, if necessary. See 9.9.7 Wind Chill Calculation Charts.
- Use the “buddy system” and be on the lookout for signs of hypothermia in yourself and others. Recognize and address the early signs and symptoms to avoid further problems.

Always believe the signs, not the patient, as he or she may not recognize them as hypothermia.

- Be aware of and follow Workers Compensation Board guidelines for time limits for working outdoors in cold temperatures. Come indoors periodically to warm up and drink hot fluids.
- If there is the slightest chance that someone is suffering from hypothermia, never leave the person alone or let them wander off, as their condition may suddenly deteriorate.
- Use good judgement and respect safe outdoor procedures.

9.9.3.2 Symptoms and Recognition

Hypothermia is a progressive disorder. The severity of hypothermia is clinically determined by core body temperature, which is difficult to measure in a field setting as it requires a rectal thermometer that measures lower temperatures than regular thermometers. It may be possible to treat mild hypothermia (core temperature >32°C) in the field, but severe hypothermia (<28°C) is life-threatening and is extremely difficult to treat in the field. Therefore, it is vitally important to recognize and address early indications so that hypothermia does not progress to the severe stage and create a potential field medical emergency. There are both physical and behavioural signs and symptoms caused by reduced blood circulation to the limbs and brain. Early symptoms can be subtle and hard to recognize, and no single symptom is diagnostic of hypothermia. Never leave a potential hypothermia patient alone as their condition may deteriorate suddenly.

To help remember the signs of mild hypothermia, a mnemonic from *Medicine for Mountaineering & Other Wilderness Activities*, by James A. Wilkerson is very helpful:

"The hypothermic subject mumbles and grumbles (personality changes) and fumbles, stumbles, and tumbles (loss of coordination)."

Mild Hypothermia (35°-32°C)

- Cold extremities: Feeling cold and numb is the first symptom.
- Shivering may be intermittent or constant and uncontrolled.
- Rapid heart rate (tachycardia)
- Rapid breathing (tachypnea)
- Slight loss of coordination (i.e., some difficulty performing tasks with the fingers and hands)

A person with mild hypothermia may be alert and answer questions sensibly – or not. He or she is focused on getting warm rather than the task at hand. A person may just appear "tired" when he or she is actually hypothermic. It is very important to treat a hypothermic patient at this stage. Do not allow him or her to become colder.

Moderate Hypothermia (32°-28°C)

- Further loss of coordination and clumsiness (may stumble frequently)
- Weakness and drowsiness, fatigue (wants to rest or go to sleep)
- Reduced shivering
- Dehydration

- Slurred speech and amnesia
- Apathy, poor judgement

A person with moderate hypothermia stumbles frequently and is uncooperative and may be confused. Speech becomes slurred and shivering may cease as the patient loses more body heat. The patient may wish to be left alone. A patient of moderate hypothermia is in grave danger and may die if hypothermia progresses. Stabilize the patient to stop further heat loss and *gently* transport him or her to a medical facility.

Severe Hypothermia (<28°C)

- Total loss of shivering
- Inappropriate behaviour (e.g., removes warm clothing)
- Reduced level of consciousness
- Muscle rigidity
- Slow heart rate and low blood pressure
- Cardiac arrhythmia (irregular heart rhythm)

The inability to walk or stand indicates severe hypothermia. A person who appears asleep may actually be in a coma. Severe hypothermia cannot be properly managed in the field so evacuation to a medical facility is necessary. Handle the victim very gently as rough handling may cause ventricular fibrillation due to the presence of arrhythmia, which often results in death.

9.9.3.3 Treatment for Mild Hypothermia

When you encounter someone with hypothermia, take immediate action to prevent further cooling. Mild hypothermia can be treated in the field, but moderate and severe hypothermia should be treated at a medical facility.

1. Prevent the patient from losing more body heat. Insulate the patient from the ground.
2. Get the patient into some sort of shelter. If there is no indoor shelter, use whatever is available (a tent, an overturned canoe, a space blanket or tarp, branches, rocks or snow) for a windbreak to help prevent the patient from cooling further. Build a fire as soon as possible, but beware of potential carbon monoxide poisoning from a heat source in an enclosed space. Carbon monoxide directly reduces the oxygen carrying capacity of the blood and this effect increases with altitude.
3. Gently remove the patient's wet clothes without exposing the patient's bare skin to wind or rain, if possible. A group can share dry clothing to the extent that no other member becomes endangered. If wet clothing cannot be replaced, gently remove clothes, wring them out and replace them.
4. Hypothermic wrap: Insulate the patient including the head and neck. Insulate all extremities with a hat, gloves and socks to prevent further heat loss, but do not apply external heat to these parts of the body. Covering the head is very important, as about 50% of body heat can be lost from the head of a hypothermic person. Wrap a survival blanket or other vapor barrier around the (wet or dry) clothed patient to prevent evaporation and add more insulation by further wrapping with blankets, sleeping bags, spare jackets etc.
5. Warm the patient:

- Place warmed objects next to the patient such as chemical hot-packs, hot water bottles or heated rocks that have been wrapped with a cloth to prevent burns to the skin. Place them under the armpits and the sides of the chest; do not warm the extremities (limbs) initially, as this can cause the peripheral blood vessels to dilate and result in a drop in blood pressure. The dilation of peripheral blood vessels also allows cooler peripheral blood to enter the torso area, which can cause the core temperature to drop further – a condition known as “afterdrop”.
- If a hypothermic wrap is not possible, you can warm a patient by placing him or her, stripped, in a warmed sleeping bag next to or between one or two other stripped people who are not suffering from hypothermia. Their body heat will slowly warm the patient.

The following measures will also help treat hypothermia.

- Give warm drinks (without caffeine or alcohol) to a patient who is conscious and not shivering uncontrollably. Sweeten drinks with sugar (not with sugar substitutes) and dilute full strength soft drinks and fruit juices with lots of water.
- Always handle the patient gently. Do not rub the skin or make the patient perform vigorous exercise if they are approaching signs of moderate hypothermia. Rough handling and movement can cause cardiac arrhythmias that may cause death.
- A patient with moderate and severe hypothermia should avoid unnecessary activity to prevent cold blood from circulating from extremities into the body core. Place the patient in a horizontal position so cold blood does not pool in their legs. Seek medical attention as soon as possible; complications frequently develop with hypothermia.
- Severe hypothermia may result in respiration and pulse rates that are undetectable; the pulse may be less than 20 beats per minute and even as low as one beat per minute. For this reason, never consider a patient to be dead until he or she is “warm and dead”.

9.9.4 Cold Water Immersion Hypothermia

Falling into cold water (<21ºC) is a life-threatening emergency that may put an individual or an entire group at risk by creating a serious survival situation. Hypothermia develops swiftly if you fall while crossing a cold mountain steam, capsize a raft or fall through ice. It is essential to wear an appropriate personal flotation device (PFD) while working where you could fall into cold water. You won’t float without a PFD, and the combination of “cold shock” and wearing heavy clothing, boots, hammer, a vest with field equipment (and perhaps a heavy pack with rocks) makes it almost impossible to swim. Your chances of survival are very poor unless you are wearing a PFD, as demonstrated on the following website: http://www.coldwaterbootcamp.com/

Note: Even prolonged exposure to water as warm as 27ºC will cause cold water immersion hypothermia.

Treatment

It is important to treat all people rescued from cold water immersion as hypothermia or shock victims. Treat victims *very* gently and whenever possible, lift them from the water in a *horizontal* position rather than with a vertical lift. Once on shore, build a fire immediately with the contents of your survival kit, which should be distributed in your clothing. Concentrate on warming the head and trunk areas and put on dry clothing. If none is available, remove clothing one item at a time, wring it out to reduce the water content and put it back on. Transport victims horizontally to a medical centre, if possible.

Refer to section 17.12.3 Cold Water Immersion Hypothermia for detailed general and technical information.

Refer to section 15.11 Cold Water Immersion Hypothermia – Falling Through Ice for additional information including the best self-rescue method.

Refer to Section 17.5.3 Information about Specific Equipment regarding various PFDs.

9.9.5 Frostbite

Frostbite occurs when body tissue freezes. Early indications of frostbite are white patches on the skin. Exposed skin (ears, nose, neck, cheeks) and extremities (fingers, toes) are most commonly affected because blood circulation is reduced when your body attempts to keep its core temperature stable. Blood circulation is further restricted when wearing tight clothing or boots. Hypothermia and frostbite often develop at the same time and wind chill is frequently a contributing factor.

Risks and Hazards

- The risk of frostbite is caused by:
    - Exposure to cold temperatures below freezing when wearing inadequate clothing or boots, restrictive clothing or boots that cut off blood circulation, skin is exposed
    - Lack of training when co-workers fail to recognize or ignore the signs of frostbite
    - A work schedule that lacks sufficient warm-up breaks
- Permanent tissue damage, gangrene, and even amputation caused by severe cases of frostbite to extremities (hands and feet), the ears and nose
- The severity of frostbite may increase with exposure to wind chill caused by riding a snowmobile at high speed.

Prevention and Preparation

- Stay warm and stay dry. Many precautions to prevent hypothermia apply to frostbite.
- Wear appropriate clothing: Pay attention to the areas of your body that may be exposed to cold and wind.
    - Boots: Make sure that boots are not tightly laced or fit too tight. Much heat is lost through the soles of the feet so if insoles are worn for extra insulation, buy boots large enough to accommodate them. Don't wear extra socks if they cause boots to fit too tightly. If working on glaciers, release tight crampon straps when taking a break.
    - A balaclava or face mask will protect your face (especially your chin and throat) better than a hat alone.
    - Wear mitts rather than gloves for greater protection.
    - Avoid tight clothing that might restrict circulation (i.e., jacket cuffs or gloves).
    - Clean clothing insulates better than dirty clothing (e.g., socks, long underwear and outer garments).
- When riding a snowmobile, the combination of speed, exposed skin and weather conditions may lead to severe wind chill and frostbite. Wear appropriate clothing including

a special warm helmet with liner and very warm gauntlets. See section 9.9.7 Wind Chill Calculation Charts below and refer to Section 15. Snowmobiles.

- Use the “buddy system” and watch for signs of frostbite on co-workers – white patches on their nose, cheeks, ears etc.
- Wiggle your fingers and toes occasionally to encourage circulation.
- Set reasonable time limits for working outdoors in cold temperatures. Come indoors periodically to warm up and drink hot fluids. Companies should follow Workers Compensation Board guidelines for time limits for working outdoors in cold temperatures. Refer to the following website for an example of a warm-up schedule: http://www.labour.gov.sk.ca/coldconditions
- Wear gloves when handling volatile fuels, as these products may cause immediate frostbite when they come in contact with your bare skin. Cold metal surfaces can do the same. Protect your hands when working with metal tools (wrenches etc.).

Symptoms of Frostbite

Frostbite develops when water in and around cells begins to form ice crystals. As cells freeze, blood can no longer circulate through the affected tissue and eventually the tissue freezes solid.

- Numbness: Be alert for numbness or pain in fingers, toes, nose, cheeks or ears. If the weather remains the same and the pain or numbness subsides, the condition of the affected area is getting worse, not better. Warm any cold area of your body as soon as you detect numbness.
- Frostnip: Skin is pale, numb and cold but is still soft and easily moved; it is not true frostbite. White or gray patchy skin develops on the face (ears, tip of the nose, cheeks), fingers or toes.
- Superficial frostbite: Skin does not move easily over the knuckles or toes; skin becomes hard and waxy and a dent will remain if you push on it.
- Deep frostbite: The affected area becomes frozen solid.

Treatment

Address frostnip and superficial frostbite as soon as possible to prevent increasing tissue damage. Major tissue damage can occur if a frozen area is incorrectly warmed. Never thaw frostbitten tissue if it is likely to refreeze, as this causes permanent tissue damage. Transport the victim to a medical facility for thawing procedures.

- Frostnip and superficial frostbite may be treated in the field; deep frostbite should be treated only at a medical centre. Deep frostbite should be taken as seriously as a severe burn.
- Warm the frozen part(s) against a warm part of the body. For example hold fingers under the armpits.
- Do not rub affected areas with anything. Rubbing will cause trauma within the frozen tissue as the ice crystals rub against cells.
- Never thaw the frostbitten area with direct heat (e.g., fire, heating pad, chemical hot packs).
- Protect the thawed areas with sterile dressings, especially between affected fingers and toes. Keep the victim warm to promote good circulation and elevate the feet.

- Do not break any blisters that may form. This will help prevent infection, which commonly accompanies frostbite injuries. Seek medical attention as soon as possible if blisters form.
- For large frostbitten areas: Thaw the affected area rapidly in a tub of warm water 37°-39°C. This temperature is important and must be maintained. Suspend the affected limb in the water so that it does not touch the sides of the tub. If the ears or face are affected and cannot be submerged, use hot compresses maintained at this temperature. This procedure is painful and should be done in a medical facility whenever possible.

9.9.6 Immersion Foot

Immersion foot (also known as trench foot) results when blood vessels in the feet constrict because of prolonged exposure to cold, wet conditions, often when temperatures are in the -1° to 5°C range. It is a non-freezing injury due to poor blood circulation that causes nerve and muscle injury when insufficient oxygen reaches the tissues. If ignored, immersion foot may eventually develop into wet gangrene, which is difficult to treat. Although immersion foot usually develops when the victim works long hours in wet leather boots and socks, it can also develop from continuously wearing sweat-soaked socks in boots. You need not be working in mountain snowfields or streams to develop immersion foot.

Risks and Hazards

Some of the risks and hazards of immersion foot include:

- Sore feet, blisters and ulcers caused by prolonged exposure to cold, wet conditions
- Permanent muscle, nerve damage and even gangrene and potential amputation may result from severe immersion foot.

Prevention and Preparation

It may only take about 12 hours to develop immersion foot, therefore prevention is important.

- Dry socks: Keep a good supply of dry socks on hand and change them during the day if work requires your feet to get wet.
- Boots: Wear appropriate boots. Make sure boots and socks are not too tight – avoid constricting blood flow to your feet.
- Wear appropriate layered clothing to stay warm so your body does not automatically reduce blood flow to extremities in an effort to keep your core organs warm.
- Put on dry boots and socks when you return from work.
- Make sure your feet are dry and warm at night – never sleep in cold wet socks.

Symptoms

- Feet become swollen, cold and pale; they feel numb or tingling.
- In extreme cases the feet become cold, swollen and the skin appears mottled and bluish (cyanosis).
- When feet are warmed they become red and there is a painful pounding as the blood pulses through the feet. It may take 24 hours before the pain sets in.

Treatment

- Warm your feet slowly at room temperature, if possible.
- Elevate feet to reduce the swelling and avoid walking.
- Ibuprofen may help reduce swelling and pain, although pain may be so severe that medication does not help.

Table 9.2: Wind Chill Calculation Chart

Where T air + Air temperature in °C and V_{10} = Observed wind speed at 10 m elevation, in km/h.

T air / V_{10}	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50
5	4	-2	-7	-13	-19	-24	-30	-36	-41	-47	-53	**-58**
10	3	-3	-9	-15	-21	-27	-33	-39	-45	-51	**-57**	**-63**
15	2	-4	-11	-17	-23	-29	-35	-41	-48	-54	**-60**	**-66**
20	1	-5	-12	-18	-24	-30	-37	-43	-49	**-56**	**-62**	**-68**
25	1	-6	-12	-19	-25	-32	-38	-44	-51	**-57**	**-64**	**-70**
30	0	-6	-13	-20	-26	-33	-39	-46	-52	**-59**	**-65**	**-72**
35	0	-7	-14	-20	-27	-33	-40	-47	-53	**-60**	**-66**	**-73**
40	-1	-7	-14	-21	-27	-34	-41	-48	-54	**-61**	**-68**	**-74**
45	-1	-8	-15	-21	-28	-35	-42	-48	**-55**	**-62**	**-69**	**-75**
50	-1	-8	-15	-22	-29	-35	-42	-49	**-56**	**-63**	**-69**	**-76**
55	-2	-8	-15	-22	-29	-36	-43	-50	**-57**	**-63**	**-70**	**-77**
60	-2	-9	-16	-23	-30	-36	-43	-50	**-57**	**-64**	**-71**	**-78**
65	-2	-9	-16	-23	-30	-37	-44	-51	**-58**	**-65**	**-72**	**-79**
70	-2	-9	-16	-23	-30	-37	-44	-51	**-58**	**-65**	**-72**	**-80**
75	-3	-10	-17	-24	-31	-38	-45	-52	**-59**	**-66**	**-73**	**-80**
80	-3	-10	-17	-24	-31	-38	-45	-52	**-60**	**-67**	**-74**	**-81**

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Low risk of frostbite for most people
Increasing risk of frostbite for most people in 10 to 30 minutes of exposure
High risk for most people in 5 to 10 minutes of exposure
High risk for most people in 2 to 5 minutes of exposure
High risk for most people in 2 minutes of exposure or less

Source: Wind Chill Calculation Chart, URL:
http://www.msc.ec.gc.ca/education/windchill/windchill_chart_e.cfm

9.10 Heat Illnesses and Solar Injuries

Your body can develop heat illness (or heat stress) when you lose excessive amounts of water and electrolytes through sweat and/or your core body temperature rises too high. Although the combination of high temperature, high humidity, strenuous activities, dehydration (lack of fluid replacement), and lack of acclimatization all contribute to the development of heat illnesses, the most important contributing factor is dehydration. Temperatures need not be especially hot. Heat illnesses can develop if the air temperature exceeds 23°C and the humidity exceeds 50%. The higher the temperature and humidity, the more likely a heat illness will develop. If there is not enough water available within your body to produce the necessary amount of sweat to cool you, your core temperature will rise. Because evaporation of sweat is the main mechanism for cooling the human body, you must be continuously able to produce sweat in quantities that will cool you. Furthermore, sweat that pools and runs off your body does little to cool you. Sweat must evaporate from your skin for maximum cooling effect.

Field employees and their supervisors should recognize the need for acclimatization and fluid replacement to prevent heat illness, especially when employees are engaged in strenuous work. Pregnant women should be especially careful to avoid heat illness, as it may damage the fetus.

9.10.1 Risks and Hazards

Some of the risks and hazards related to heat illnesses include:

- Death, permanent brain injury and damage to internal organs may be caused by severe heat illness (heat stroke).
- Heat illnesses may be caused by:
    - Dehydration
    - Lack of acclimatization to hot working conditions
    - Failure of co-workers to recognize the signs of heat illness in each other
    - A work schedule that lacks sufficient work breaks to cool off
    - Medications that contribute to the development of heat stress

9.10.2 Project Planning to Prevent Heat Illnesses

Project planning should include the following measures.

- Complete risk assessments that include the potential impacts of heat related hazards on employees, including site locations and traversing routes etc. Develop strategies to mitigate the risks.
- The project supervisor should develop site specific SOPs and ERPs that address potential heat related risks and hazards.
- Training should cover the SOPs, ERPs and specific ways to recognize and handle potential emergencies caused by heat illnesses. First aid attendants should be trained to recognize and address heat exhaustion and heat stroke. Hold a practice drill if an ERP includes evacuation procedures.
- Plan work schedules to include acclimatization requirements and cooling rest breaks.

- Extensive information regarding working in hot conditions is available at the following websites:

  http://employment.alberta.ca/documents/WHS/WHS-PUB_gs006.pdf

  http://www.worksafebc.com/publications/health_and_safety/by_topic/assets/pdf/heat_stress.pdf

9.10.3 Hyperthermia

Heat illnesses are gradational in severity. There are four main forms of hyperthermia: (1) heat cramps, (2) heat syncope, (3) heat exhaustion and (4) heat stroke. Each heat illness disorder is caused to some degree by dehydration and the body's inability to get rid of excess heat. While heat illness most commonly occurs in warm climates, it may also occur where you might not expect it (i.e., the Arctic). A hot windy day or a breeze may make you feel cool, but if you don't maintain fluid levels you may become severely dehydrated. Almost all cases of hyperthermia can be prevented by drinking sufficient water to avoid dehydration.

9.10.3.1 Prevention and Preparation

The key to preventing heat illness is preparation and recognizing the circumstances that produce heat stress.

1. Prevent dehydration. Drink plenty of water. Hydration is essential to maintain the correct body temperature and volume of blood flow to produce sweat. When performing moderately strenuous work in a hot environment, you need to drink at least 5 litres of water throughout the day. Distribute your water intake throughout the day rather than drink large quantities rapidly once or twice in the day.
   - Do *not* rely on thirst to indicate how much to drink. Drink plenty of water before beginning work *plus* about 250 ml every 20 minutes while you work. Water is best; carbonated drinks are less effective.
   - Carry enough fluids when traversing in hot conditions. A can of juice is simply not enough. Carry water purification tablets in your survival kit but do not count on finding enough water to replenish your supply.
   - Judge your own state of hydration by the frequency and volume of urine you pass; urine should be clear and copious. If the amount of urine declines and becomes dark yellow, you need to drink more water.
   - "Sports drinks" are acceptable, but it is not advisable to replace fluids exclusively with sports drinks. If you feel your electrolyte balance is affected by sweating, it is usually better to eat a salty snack and drink water rather than a sports drink. A sports drink may be useful when it is combined with drinking water, but water is usually a better choice.
   - Do not drink a high caffeine "energy drink" for rehydration purposes. It is *never* advisable to administer drinks containing caffeine to anyone suffering from dehydration, hyperthermia or hypothermia. Caffeine increases urine output and therefore contributes to dehydration.
2. Wear appropriate clothing. Wear a broad brimmed hat in the sun. Wear light coloured, loose fitting clothing that does not leave much skin exposed. Cotton is an excellent choice of fabric but it should be fairly tightly woven for UV protection.

3. Acclimatization: It is important to become acclimatized whether you are new to a hot climate or are returning from a break, sickness or annual leave. New employees should become acclimatized before being assigned a full work load. When exposed to hot environments, your body undergoes profound changes to improve its ability to cope with heat. Changes include the following:
    - Your sweat rate increases over a period of several days. It is possible to lose 1.5 litres of sweat per hour when working strenuously under hot conditions; you need to consume a lot of water to replace such losses. You begin sweating earlier and at a lower skin temperature as your body responds more efficiently to heat.
    - The electrolyte concentration in your sweat decreases, which allows your body to retain most of the electrolytes it needs. See Nutrition in #4 below.
    - Your behaviour changes. You quickly learn to use any available shade, to rest frequently if necessary, and to replace water lost through sweat by drinking more of it.
    - Full acclimatization can take five to seven days. Exposure to hot environments should be gradually increased over the first four or five days.
4. Additional preparation and prevention:
    - On the job: Perform the heaviest work during the coolest part of the day and take frequent short breaks in cool shaded areas to allow the body to cool down. Pace yourself.
    - Nutrition: Avoid eating large meals before work. Several small meals or snacks require less energy from your body for digestion than one large meal. Eat well balanced meals. Salt: Increase your salt intake slightly. If you salt your food liberally it should be sufficient to maintain your electrolyte balance. Field work is *not* the time to eat salt reduced snacks. You need more salt than normal because your sweat contains salt and the more you sweat the more salt you lose. However, salt tablets are not advisable because salt does not enter the body at the same rate as fluids and too much salt at one time can increase body temperature and thirst, which can make you feel ill.
    - Verify with a doctor or pharmacist whether any medication you take may have adverse side effects when working in hot environments.

9.10.3.2 Less Serious Forms of Hyperthermia

Prickly heat rash is an annoying but not a disabling form of heat stress. Heat cramps and heat exhaustion result from increased levels of dehydration and salt depletion as the body sweats to lower its internal temperature.

Prickly Heat and/or Heat Rash

Prickly heat (or heat rash) is a common skin condition in the tropics, as it is aggravated by high humidity. Tiny droplets of sweat become trapped under the outer layer of skin, which appear as an irritating, blister-like red rash. Frequent showering helps prevent it. Sometimes a drying lotion and mild talcum powder helps, but ointments and creams will clog up the sweat glands even more.

Heat Cramps

These painful spasms usually occur in the arm and leg muscles. They can be disabling, but they are preventable if you avoid dehydration. Regular cramps respond to rest and massage. Treat heat cramps by rehydration and replacing lost electrolytes. Pain may be relieved by gently stretching the muscle and applying ice.

Heat Syncope

Heat syncope is a fainting episode that occurs immediately after ceasing an activity. During exercise, the muscles perform a pumping action that ensures the return of blood to the heart. When exercise ceases, this pumping action stops and blood tends to pool in the lower limbs. This causes weakness or dizziness, which may be followed by a fainting episode. Heat syncope may precede symptoms of heat exhaustion. A person with heat syncope should lie down in a cooler area, elevate their legs and pelvis and drink fluids when conscious enough to safely do so. They should not carry out heavy activity for the rest of the day.

9.10.3.3 Heat Exhaustion and Heat Stroke

The difference between heat exhaustion and heat stroke is one of degree. If untreated, heat exhaustion can rapidly develop into heat stroke. Heat stroke is a medical emergency requiring immediate medical attention.

Heat Exhaustion

Heat exhaustion occurs when the body cannot get rid of the heat it generates through metabolism and exercise. If fluids and electrolytes lost through sweating are not replaced, heat exhaustion may develop, which is more serious than heat cramps and heat syncope. Although a person suffering from heat exhaustion can continue to produce sweat, the production is not great enough to satisfactorily cool the body. Their core body temperature may be normal, but it usually ranges from 38.8° to 40°C. Anyone with heat exhaustion must be closely monitored, as their condition can rapidly escalate into heat stroke, which can be fatal.

Symptoms of Heat Exhaustion

- Pale, cool, clammy skin
- Normal mental state
- Weakness or fatigue
- Dizziness and/or fainting
- Headache, nausea and/or vomiting
- Muscle cramps
- Decreased or dark coloured urine

Treatment for Heat Exhaustion

Treatment for heat exhaustion is the same as for heat syncope, although transportation to a medical centre may be necessary if core body temperature remains high. See the heat syncope section above for treatment details.

- Although a victim of heat exhaustion may feel better almost immediately and wish to return to work, this should not be permitted until the next day. Fluids and electrolytes must be replaced and it takes about 24 hours for adequate rehydration.
- Seek medical attention if the person does not feel better after a short while, as heat exhaustion can develop quickly into heat stroke.
- If someone has been sweating excessively or has been vomiting, they may need to drink oral rehydration salts or other electrolyte replacement solutions. These come pre packaged for adding to water or they can be made from commonly available ingredients. If the only liquids available are water and a sports drink, dilute the sports drink in half with water to achieve a better electrolyte balanced than with the drink alone, which has a high sugar content. Drinks containing caffeine, especially energy drinks, should not be administered.
- Refer to section 12.8.3.5 Fluid Replacement Therapy for detailed information about how to make fluid replacement therapy solutions.

Heat Stroke

Heat stroke is a life-threatening condition demanding immediate medical attention. With a rapidly rising core temperature approaching 41°C, the victim can no longer produce sweat. Skin usually becomes hot and dry (classic heat stroke), but for heat stroke caused by exertion, the skin *may* remain relatively cool and clammy. If the core body temperature continues to rise, the patient will die. *Exertional heat stroke more commonly affects field employees and is linked with strenuous work,* whereas classic heat stroke usually develops in inactive people. Heat stroke can cause permanent brain damage and injury to internal organs. Provide interim treatment immediately and transport a heat stroke victim to a medical treatment facility as soon as possible, as complications frequently develop. Monitor the patient constantly and be prepared to administer CPR.

Symptoms of Heat Stroke

- Pale, cool, damp skin *or* hot, dry, red skin: Either condition may be present in exertional heat stroke; only the latter is present in classic heat stroke.
- Irrational, hostile behaviour, confusion: A person with heat stroke exhibits mental changes even if they are still able to produce sweat.
- Headache, dizziness
- Nausea, vomiting
- Rapid, shallow breathing
- Irregular pulse
- Possible seizures and unconsciousness
- Collapse and coma

9.10.3.4 Interim Treatment – Prior to Evacuation to a Medical Centre

1. Move the victim out of the sun into the coolest possible location.
2. Remove any heavy clothing, loosen tight clothing and elevate the feet.
3. Cool the victim as quickly as possible, paying particular attention to the head, armpits back of the neck and groin. Drape the victim with lukewarm wet sheets or towels to

conduct heat away from the body. Use water with a temperature that is warm to the touch, but cooler than skin temperature. This temperature produces the best cooling effect by evaporation and conduction. Ice packs and water that is too cold will effectively shut down the blood supply to the skin (vasoconstriction), which can induce shivering as the body works to warm up that local area.

4. Fan the body using electric or handheld fans. Try to place the victim on a screen or hammock so they can be cooled both from above and below. The aim is to maximize evaporation from the body to cool the core body temperature – without chilling the victim. Should the patient becomes chilled, vasoconstriction will occur and less blood will circulate, which is counterproductive – *increased blood circulation is the objective.* Massage the victim's arms and legs to increase the circulation of cooler blood to the core organs of the body.
5. Have a conscious victim drink cool water, about 1 cup 250 ml every 15 minutes, unless nauseous or vomiting. You can add a little salt to the water but do not give full strength fruit juice, soft drinks, drinks with caffeine, or alcoholic beverages.

TRANSPORT A HEAT STROKE VICTIM TO A MEDICAL CENTRE AS SOON AS POSSIBLE.

An efficient way to cool a victim: If transporting by vehicle, douse the victim with lukewarm water or cover with wet clothing. Place the victim in a vehicle and open all the windows so that he or she is exposed to moving air. Use air conditioning, if equipped, in addition to the open windows as long as the victim does not become chilled and shiver. Drive to a medical treatment facility as soon as possible.

9.10.4 Sunburn

The sun produces ultraviolet (UV) radiation that can cause serious burns to the skin and eyes. As both direct and reflected radiation cause burning, the best way to avoid sunburn is to avoid as much sun exposure as possible. Various products are available that contain agents to block out UV radiation.

Risks of Sun Exposure (Ultra Violet Light)

- Sunburn, skin cancers, cataracts, and corneal ulcers are all caused by exposure to excess sunlight or artificial UV radiation.

Preparation and Prevention

Factors influencing UV radiation exposure:

- Altitude: Each elevation gain of 300 m increases UV radiation exposure by 4%. Living or working at high altitude results in high UV exposure all year around.
- Latitude: The closer one works to the equator, the more intense the UV radiation.
- Time of day: UV radiation causes most damage between 10 A.M. and 3 P.M. when the sun is highest in the sky.
- Season of the year: Except near the equator, UV radiation is more intense during summer months when the sun is closer to the earth.
- Wind masks the effect of UV radiation and you may not realize that sunburn is developing.

- Filters: Sunglasses fitted with polarizing lenses will cut down glare; other lenses will also cut out UV radiation. Select sunglasses from a reputable source suitable for the working conditions. For example, when working on glaciers or snowfields, you may require different eye protection than when working on water.
- Ozone depletion of the upper atmosphere: Some areas on the earth are now less protected from UV radiation due to ozone depletion (Arctic, Antarctic, southern South America and parts of Australia).
- Environment: Depending upon your surroundings, varying amounts of UV radiation are reflected. Light coloured surfaces reflect a greater percentage of UV than darker surfaces. Some examples:
    - Vegetation reflects only 2.5%
    - Sand reflects 20%
    - Glaciers and snowfields reflect 85%
    - Water can reflect almost 100% if the sun is overhead.

Take the following precautions:

- Clothing: Wear a broad brimmed hat, long sleeved shirt, long trousers, sunglasses and sunscreen when appropriate. Shorts expose your legs to sunburn.
- Sunglasses: Wear lenses that block UV radiation.
- Sunscreen agents protect skin from ultraviolet light. There are two damaging components to ultraviolet light – ultraviolet A (UVA) and ultraviolet B (UVB). The UVA component penetrates skin more deeply and damages collagen that keeps skin firm; it also suppresses your immune system thus contributing to cancer development. The UVB component is responsible for producing most sunburns and is thought to be the primary cause of skin cancer, as it damages DNA. Look for a broad spectrum sunscreen that protects against both UVA and UVB. The sun protection factor number (SPF) measures a sunscreen's effectiveness. The higher the number, the longer the protection from burning (i.e., if the SPF is 10, the protection is 10 times longer than when using no sunscreen). This effectiveness is reduced if you are sweating or swimming. There are two types of sunscreen agents. Physical agents block or scatter UV radiation by reflection; they are usually thick creams such as zinc oxide. Chemical sunscreen agents block UV radiation by absorption. For continuous protection, you must apply sunscreen frequently to exposed skin, especially if sweating or swimming.
- Wear a broad spectrum, water-resistant, sweat-proof sunscreen with a SPF of at least 15 (use a SPF of at least 30 on your face). You need this amount of protection no matter what your race. For full effect, apply sunscreen carefully and thoroughly on exposed skin, especially to the face and the back of your hands, at least 15 minutes before going out.
- Certain medications may increase one's sensitivity to UV radiation. These include Tetracyclines – especially Doxycycline and sulphonamides including "Bactrim". Check with a doctor or pharmacist regarding potential sensitivities due to medications you take.
- When using insect repellent, apply the sunscreen first and then apply the insect repellent.
- Additional information is available at the following website: http://www.ccohs.ca/oshanswers/diseases/skin_cancer.html

Treatment

- Loosely cover the sunburned area to prevent further sun exposure.

- Cold compresses help relieve pain; creams or lotions (calamine) may help including Aloe Vera gel, but do not apply them to blisters. Do not break blisters.

9.10.5 Snow Blindness

Small blisters can develop on the corneas when the eyes are exposed to too much sunlight (UV radiation). Although the condition develops most frequently when working on ice or snowfields, it may also happen when working on water, at high altitude, high latitude during summer months, or using short wave ultraviolet (UV) lamps for more than half an hour at a time. The higher the altitude – the greater the risk. In high latitudes, UV protection increases in importance during late winter, spring and summer as the sun rises higher in the sky.

Risks and Hazards

Some of the risks and hazards include:

- Intense pain in the eyes is caused by burns to the corneas
- Permanent eye damage (ulcerated cornea) is caused by exposure to too much UV radiation

Preparations and Prevention

Cut down on direct and reflecting sunlight.

- Always wear large and curved sunglasses with dark lenses that are guaranteed to filter out UV radiation. Choose high quality protecting sunglasses as many brands make unwarranted claims. Carry an extra pair of glasses in case of loss or breakage. Camps should have dark tinted safety glasses available.
- In high risk areas such as snowfields, use sunglasses with side shields for more protection. Goggles may provide the best protection.
- Wear a hat with a wide brim.
- Wear protective glasses (appropriate PPE) whenever you work with short wave UV lamps and use the lamps for short periods only.
- Emergency glasses can be made by using cardboard and cutting slits to see through.

Symptoms

- Symptoms develop 8 to 12 hours after exposure and last 24 to 48 hours.
- The eyelids swell and there is intense pain, as though hot sand were in the eyes.
- Excessive tearing occurs and the eyes are very sensitive to light.

Treatment

Seek medical attention. To reduce inflammation:

- Bandage the eyes with thick sterile pads; the victim should rest in the dark.
- Apply cold compresses (not ice); ice should not be used as ice can also cause vasoconstriction of the eyeball and result in further eye injury.
- Give oral pain medicine such as aspirin or Tylenol.

- Do not rub the eyes and do not apply topical eye ointments or eye drops unless prescribed by a physician.
- If the eyes are still sensitive to light after 12 hours, re-bandage for another 12 hours. Vision is normally restored after 18 hours.

9.11 Altitude Illness

The earth's atmosphere contains about 21% oxygen at all elevations. Because air pressure diminishes with increasing altitude, there are fewer oxygen molecules to breathe at higher elevations. If you rapidly ascend to elevations above 2,500 m, your body may have trouble adjusting to the reduced available oxygen ("thin air"). Anyone can be affected; it is not a question of fitness, age or gender, as altitude illness may suddenly develop even after previous trips when no effects were experienced. All people should check with a medical advisor before working at high altitude (and especially those with asthma or sickle cell disease and pregnant women).

Altitude illness is preventable. Acclimatization – ascending to high altitude in gradual stages – allows your body to adjust to the reduced available oxygen (see #2 in section 9.11.6 below). The time required to acclimatize varies with the individual and the actual altitude attained.

Definitions

High Altitude – 1,500-3,500 m

Very High Altitude – 3,500-5,500 m

Extreme Altitude – above 5,500 m

Acclimatization – the process of the body adapting to the reduced available oxygen at high altitude

Acute Mountain Sickness (AMS) – a disorder that presents a group of symptoms in a person at high altitude before acclimatization takes place. There is no precise altitude at which the symptoms develop; it depends on the individual.

High Altitude Pulmonary Edema (HAPE) – a severe form of AMS that develops when body fluids derived from blood fill the alveoli in the lungs and replace air. Potentially, a person can drown in their own fluids.

High Altitude Cerebral Edema (HACE) – a severe form of AMS that develops when brain tissue swells from the accumulation of fluid derived from blood.

High Altitude Retinal Hemorrhage (HARH) **–** a form of AMS when bleeding from the retina occurs in the eyes.

The following medical terms are used to describe symptoms of AMS, HACE and HAPE. They are included to help interpret the *Lake Louise Consensus on the Definition of Altitude of Altitude Illness* in section 9.11.2.2 Recognition and Classification of Acute Mountain Sickness (AMS).

- Ataxia – the loss of muscle coordination, clumsiness (e.g., fingers fumble with objects, a person stumbles or fall and cannot walk a straight line)
- Cyanosis – bluish or greyish discolouration of skin, lips and fingernail beds due to insufficient oxygen in the blood
- Dyspnea – difficult or laboured breathing when a person is at rest
- Edema – tissue swelling caused by fluid accumulation in extremities (hands, feet) or in the brain

- Hypoxia – deficiency of oxygen in the blood, which affects organs and the brain (i.e., the ability to think clearly)
- Tachycardia – abnormally rapid heartbeat
- Tachypnea – abnormally rapid respiratory rate (continuous)

9.11.1 Risks and Hazards

Some of the risks and hazards related to altitude illness include:

- Death caused by HAPE or HACE
- Seizures and/or permanent brain damage caused by HACE
- Developing acute mountain sickness (AMS) caused by:
    - Lack of acclimatization as altitude is gained
    - Dehydration caused by inadequate fluid intake combined with the body's increased requirement for fluids
    - Performing hard work without sufficient hydration and/or acclimatization
- Risk of increased severity of AMS may be caused by:
    - Continuing to gain altitude when symptoms of AMS are present
    - Lack of training to recognize the signs and symptoms
    - Denial that symptoms are present
    - Lack of oxygen therapy equipment at a high altitude camp
- Misdiagnosis of AMS caused by the presence of hypothermia, dehydration, or carbon monoxide poisoning (from using a fuel-burning heat source in an enclosed space)
- Transportation risks due to remote locations and difficult access when evacuation is required
- Increased risk of developing AMS caused by some pre-existing medical conditions

9.11.2 Acute Mountain Sickness (AMS)

Acute mountain sickness develops when the body does not acclimatize to the reduced supply of oxygen at high altitude. AMS is a progressive disorder and presents a group of gradational symptoms that may develop very rapidly or over several days. Mild AMS is uncomfortable and feels much like a hangover; moderate AMS requires careful monitoring and attention as it can quickly develop into severe AMS, which is often fatal. Acute mountain sickness is preventable by ascending to high altitude in gradual stages over several days, which allows your body to acclimatize to the reduced available oxygen in the atmosphere. The time required to acclimatize varies with each individual and the actual altitude attained.

Various risk factors contribute to AMS, which include but are not limited to:

- Lack of acclimatization – Acclimatization requires periods of rest along with progressive altitude gain. The faster the ascent to altitude, the higher the risk of developing AMS.

- Altitude – The higher the altitude, the higher the risk
- Activity level – Strenuous activity upon arrival at high altitude increases the risk.
- Predisposition – Those who have had AMS before are more likely to develop it again.
- Age – Young people are more susceptible to AMS than older people.

9.11.2.1 Symptoms of AMS

Symptoms of acute mountain sickness may develop above 2,500 m, although occasionally some healthy people experience AMS above 1,800 m. If you feel ill when working at altitude, it is wise to assume you have AMS unless there is another obvious reason for the illness. If the symptoms are not alleviated through acclimatization, mild AMS can develop and progress to moderate and then to severe AMS, which may take the form of high altitude cerebral edema (HACE) or high altitude pulmonary edema (HAPE). One or both forms of severe AMS may develop at the same time.

Persistent symptoms should be monitored carefully and appropriate action taken – descent to a lower altitude. Do not ascend to a higher altitude again until all symptoms are gone. It is advisable to insist that a person receives medical attention when AMS is a possibility, as victims who do not wish to descend can easily disguise some symptoms. Use the *Lake Louise Consensus on the Definition of Altitude of Altitude Illness* in section 9.11.2.2 to help determine the form(s) of altitude illness.

The symptoms of AMS are progressive – the more aggravated the symptoms, the more serious the illness. People usually, but not always, have several symptoms at the same time, and some of them are also symptoms of hypothermia and dehydration. Symptoms that indicate AMS include:

- A persistent headache develops that is not diminished by lying down; it is aggravated by exercise. A headache caused by AMS should respond to aspirin, Tylenol, or ibuprofen. As the headache *may* be due to dehydration, drink at least one litre of fluid and take the pain medicine.
- Insomnia: Difficulty sleeping is normal at high altitude until your body is acclimatized. Never take sleeping pills as they will decrease oxygen intake by limiting your deep breathing efforts to gain oxygen.
- Loss of appetite and mild nausea are common indicators. Nausea that progresses to vomiting is a serious sign.
- Shortness of breath: It can take a long time to recover after exertion. Dizziness is a common symptom. A person should be able to breathe at a normal rate after 15 minutes at rest.
- Fatigue or lassitude: Learn to distinguish between normal exhaustion and fatigue and lassitude. Normal exhaustion responds to a good night's sleep, while fatigue due to high altitude does not. Rest, food and increased fluid intake do not alleviate the symptoms of fatigue and lassitude. As AMS advances, fatigue may progress to lassitude so that a person does not get out of bed to eat, drink or urinate, which is a very serious sign.
- Increasing breathing difficulties are serious signs. The victim probably needs to descend to a lower altitude until the symptoms abate.
- A persistent dry cough develops that progresses to a watery cough and finally to a bloody cough; the chest may feel tight.

- A crackling sound (crackles or rales) in the lungs may be heard when you listen to the victim's chest. This symptom indicates HAPE. Rales sound like hair rubbed between your fingers when held next to your ear.
- Fluid retention, decreased urine output and dark yellow urine all indicate dehydration, which is a sign that your body is not acclimatizing well.
- A rapid pulse >110 beats per minute when at rest
- Cyanosis: A pale or bluish colour develops on the lips and fingertips from lack of oxygen in the blood.
- Loss of balance and muscle coordination: A person cannot walk a straight line for 5 m in a heel-to-toe manner without stumbling or falling. This is a sign of serious AMS as this indicates the brain is affected by swelling.
- Disorientation, poor judgment and poor coordination indicate severe AMS. Mental confusion and hallucinations indicate HACE.
- Confusion, delirium and coma are followed within a few hours by death.

9.11.2.2 Recognition and Classification of Acute Mountain Sickness (AMS)

Because the range of symptoms for AMS may vary from mild to severe, it can be very difficult to correctly classify the condition. Criteria to determine the form of AMS should follow the ***Lake Louise Consensus on the Definition of Altitude Illness***. The figure below is available at the following website: http://www.ismmed.org/lake_louise_criteria.htm

Table 9.3 The Lake Louise Consensus on the Definition of Altitude Illness

AMS	In the setting of a recent gain in altitude, the presence of headache and at least one of the following symptoms: • Gastrointestinal (anorexia, nausea or vomiting) • Fatigue or weakness • Dizziness or lightheadedness • Difficulty sleeping
HACE	Can be considered "end stage" or severe AMS. In the setting of a recent gain in altitude, either: • The presence of a change in mental status and/or ataxia in a person with AMS [inability to walk a straight line] • Or, the presence of both mental status changes and ataxia in a person without AMS
HAPE	In the setting of a recent gain in altitude, the presence of the following: **Symptoms:** at least two of: • Dyspnea at rest [difficult, laboured breathing] • Cough • Weakness or decreased exercise performance

	• Chest tightness or congestion **Signs:** at least two of: • Crackles or wheezing in at least one lung field • Central cyanosis [bluish coloured skin, lips, fingernails] • Tachypnea [abnormally rapid respiratory rate] • Tachycardia [abnormally rapid heartbeat]

Reproduced with the permission of Charles S. Houston M.D. from: "The Lake Louise Consensus on the Definition and Quantification of Altitude Illness" in *Hypoxia and Mountain Medicine,* by J. R. Sutton, G. Coates, and C. S. Houston (eds). 1992.

9.11.2.3 Treatment for AMS

- The best treatment is **descent** to a lower altitude until the symptoms are gone.
- Drink extra fluids and eat small meals high in carbohydrates.
- Acetazolamide (Diamox) can prevent AMS and it also may be used for treatment under medical direction.

9.11.3 Severe AMS – High Altitude Cerebral Edema (HACE)

HACE is a form of severe AMS that develops when there is pressure from fluids on the brain. Early recognition of symptoms is important for recovery, as HACE can cause permanent brain damage or death. HACE usually develops at altitudes over 3,600 m, but occasionally it may develop at altitudes as low as 2,500 m. It may occur alone or in conjunction with HAPE. Victims should not go higher even for a brief time (e.g., for a day's work).

- Recognizing HACE: Symptoms usually develop 2 to 5 days after reaching high altitude, although sometimes they develop almost immediately. People who develop HACE usually also display symptoms of AMS, but not always. See the *Lake Louise Consensus on the Definition of Altitude Illness* in the previous section.
- Treatment for HACE: Immediate DESCENT is essential to an elevation where symptoms are resolved, which means a descent of at least 600-1,200 m. Oxygen should be administered – it should always be available at high altitude camps – but descent is absolutely necessary. Do not put off descent to wait for transportation if the weather permits walking down. Victims must never be left alone as their condition can deteriorate very rapidly, even during descent. Seek medical treatment as soon as possible.
- NOTE: Use a simple test for HACE that demonstrates the loss of muscle coordination (ataxia). Have the victim walk a straight line at least 5 m long in a heel-to-toe manner. If the victim staggers or cannot turn around and return along the line without falling, the victim must descend. He or she is probably suffering from HACE.

9.11.4 Severe AMS – High Altitude Pulmonary Edema (HAPE)

HAPE kills more people than any other form of altitude illness. Pulmonary edema is the buildup of fluid in the lungs to the degree that they cannot function properly and victims can drown in their

own body fluids. Victims should not go higher even briefly. Those who have suffered HAPE have an increased susceptibility whenever they return to high altitudes.

- Recognizing HAPE: Early recognition of HAPE is essential for successful treatment and recovery. Symptoms usually develop 2 to 4 days after reaching an altitude over 2,500 m. See the *Lake Louise Consensus on the Definition of Altitude Illness* in section 9.11.2.2.
- Treatment for HAPE: Treatment for HAPE is DESCENT to a lower altitude where the symptoms are resolved. Oxygen should be administered – it should always be available at high altitude camps – but a descent of at least 600-1,200 m is absolutely necessary. Oxygen therapy and medication can be administered by a medical person in camp. Victims must be accompanied during descent and never left alone as their condition can deteriorate very rapidly. Seek medical treatment as soon as possible; contact a medical facility for advice if unable to descend due to weather.

9.11.5 Other Altitude-Related Illnesses

Thrombophlebitis

There are indications that blood will clot more easily at high altitude, especially in the legs. This may be due to restrictive clothing and/or dehydration, or also as a result of sitting for extended periods of time on long airline flights or long vehicle trips. Refer to section 12.8.2 Deep Vein Thrombosis (Blood Clots) for additional information.

- Risks: Pulmonary embolism may occur if a clot breaks free.
- Symptoms: Pay attention to soreness and swelling in the calf, thigh, the back of the knee, or if the pain increases when the foot is flexed.
- Treatment
    - Loosen any tight clothing, remove boots but keep the patient warm.
    - Aspirin will reduce the blood's ability to clot and relieve pain, but beware of potential nose bleeds.
    - Transport the patient to lower altitude. The patient should not walk.
- Preparation and prevention
    - Stay warm and wear clothing that is loose enough so blood circulation is not restricted (boots, socks and gaiters).
    - Drink lots of fluids to avoid dehydration.
    - Exercise legs and feet if you are confined in a tent due to adverse weather.

High Altitude Retinal Hemorrhage (HARH)

- HARH is a form of AMS when bleeding occurs from the retina. It is common above 4,300 m.
- Symptoms: Most victims are unaware of its occurrence unless there is a lot of bleeding. It may affect vision if hemorrhaging is severe and near the macula area of the retina where most vision occurs.
- Treatment: There is no treatment as vision problems usually disappear when the person returns to low altitude.

9.11.6 Planning for High Altitude Projects

Project managers should make the following preparations when planning high altitude projects. Individual employees should take precautions, be familiar with the requirements of acclimatization (#2 below), and be trained to mitigate the risks of working at high altitude.

1. High altitude related risks and hazards should be assessed and addressed.
    - Complete risk assessments and include the potential impacts on employees working at high altitude. Risk factors include the altitude of the site, traversing routes and potential transportation crashes. Develop and carry out risk mitigation plans based on the observations and conclusions of risk assessments. Refer to section 2.1.5 Risk Assessments.
    - Develop site specific safe operating procedures (SOPs) and emergency response plans (ERPs) that address high altitude hazards, altitude illness and potential accidents.
    - Training should cover the SOPs, ERPs, appropriate survival techniques and additional potential risks associated with high altitude (e.g., dehydration, hypothermia, hyperthermia and carbon monoxide poisoning). First aid attendants should be competent and trained to recognize and treat AMS, HACE and HAPE and the additional potential injuries or illnesses. Hold a practice drill if an ERP includes evacuation procedures.
    - Plan work schedules to include acclimatization requirements. Acclimatization should be a part of risk mitigation plans.
    - People who routinely work at altitude should have a blood test before returning to altitude to verify that they are healthy and don't have a virus. High altitude may have an adverse affect on viruses in your system, which may cause breathing or heart problems to develop.
2. Acclimatization – Everyone should acclimatize each time they go to altitude. During acclimatization, a person breathes more frequently and deeply in an effort to acquire the same amount of oxygen as at lower elevations. The body makes additional adjustments because it is impossible to breathe rapidly enough to obtain the same amount of oxygen as at sea level. Employees returning from even short trips to lower altitude need to re-acclimatize. During acclimatization:
    - You breathe more rapidly.
    - Your heart beats more rapidly to distribute the oxygen to your organs.
    - You urinate more frequently to rid body of fluids.
    - Your blood volume decreases due to the loss of fluids, while some tissue may accumulate water (edema).
    - You sleep less soundly because you breathe less frequently and then wake up in order to breathe more deeply to restore oxygen to the lungs.

    Pay attention to the following points to help your body acclimatize:

    - Rate of ascent: Do not rush to high altitude without sufficient rest days. The higher the work site, the more important this is to prevent developing severe AMS, HACE and/or HAPE. Once you reach an altitude of 3,000 m, do not ascend more than 1,000 m per day without a rest day.

- Rest: When going from sea level to 2,400-3,000 m, refrain from strenuous work for several days. However, light activity accelerates acclimatization. Further rest is recommended if travelling to 3,600 m.
- Work high and sleep low. When possible, sleep each night at a lower altitude than the work site, preferably below 2,500 m. It is advisable to locate project sleeping quarters as low as possible (without increasing the overall risks due to transportation etc.). If it is necessary to sleep at an altitude over 3,000 m, gradually increase the altitude at which you sleep by no more than 300 m per day.
- Fluid intake: Part of acclimatization includes fluid loss through increased urination. Therefore, drink sufficient water to pass lots of clear, light coloured urine. This requires drinking *much more* water than is required to quench your thirst – usually four to six litres per day. Avoid caffeine drinks and alcohol, including local fermented drinks. Dark urine indicates dehydration.
- Diet: Eat a diet high in carbohydrates; avoid a high protein diet. Eat frequent small meals.
- Avoid smoking, as it reduces the blood's supply of oxygen. Avoid sleeping pills, as they decrease your respiratory rate during sleep and contribute to hypoxia (insufficient oxygen circulating in the blood).
- Previous AMS: If you have previously had AMS, spend at least one or two nights at an elevation around 1,500 m before advancing to higher altitudes.

3. Equipment: All high altitude projects should require the following medical equipment at each camp.
    - Oxygen therapy equipment and a hyperbaric bag should be available and staff should know how to use them correctly. While oxygen should be used to relieve symptoms, it should never be regarded as a cure for moderate or severe AMS for which descent to a lower altitude is necessary. Refer to the following website for information regarding portable hyperbaric treatment options: http://www.high-altitude-medicine.com/hyperbaric.html.
    - High altitude projects should be equipped with intravenous (IV) equipment to administer fluid replacement products and with pulse oximeters to regularly check the oxygen saturation level of employees' blood.
4. Medications: Drugs are available that may help prevent AMS, but they have side effects and any medication should be taken only under medical supervision. When using the drugs, avoid alcohol and be sure to take more than enough for the duration of the trip. Diamox is the most widely tested drug for the prevention and treatment of altitude illness. Consult with a medical advisor regarding the possible use of Diamox and other drugs.
    - Acetazolamide (Diamox) can help reduce the severity of symptoms of altitude illness and decrease the time necessary for acclimatization. It is available only by prescription in Canada, but may be purchased over the counter in some countries. Obtain medical advice before using Diamox and follow the directions regarding the dose and duration of use. While Diamox may help reduce nausea, headache and sleeplessness, the medication produces side effects that include tingling in the lips, fingers and toes, ringing in the ears, peculiar taste sensations and increased urination. As Diamox is a sulphonamide drug, people with allergies to sulpha drugs should not use it. Consider trying the drug before travelling to a remote location, as severe allergic reactions have occurred in people who have not previously exhibited allergic reactions to sulpha drugs.

Whenever possible, it is better to acclimatize naturally than to depend on medication.

- Ibuprofin and Acetaminophen are usually effective for treating high altitude headaches.

5. Individual preparation and preventive measures:
    - Be familiar with and follow the acclimatization guidelines in #2 above.
    - Avoid flying directly to high altitude; it is better to drive. Postpone a trip if you have a cold or flu and have a blood test to check for viruses before departing.
    - It should be mandatory to have a medical examination (including a blood test) as part of trip preparation, especially if it is your first trip to high altitude. Discuss the potential use of medication to help prevent AMS with your medical advisor. Have a blood test when you are returning to altitude.
    - Use the "buddy system" to monitor your co-workers and watch for signs and symptoms of AMS.
    - If you develop symptoms of AMS, it is advisable to descend to prevent developing more serious symptoms. Do not go higher. Go higher only after the symptoms disappear.
    - The following websites provide excellent information about AMS: http://www.ismmed.org/np_altitude_tutorial.htm

      http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/07vol33/acs-05/index_e.html

9.12 Resources

The Prospectors & Developers Association of Canada (PDAC) thanks the following for granting permission to include material from their publications.

Anglo American

Association for Mineral Exploration British Columbia (AME BC)

Dr. Charles S. Houston

Their permission does not imply that they endorse the PDAC Health and Safety Guidelines. The PDAC is solely responsible for the content of these Health and Safety Guidelines.

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