Winter Camping Field Guide – 2012 version 11/16/11

This Field Guide is Ash Campbell's personal overview of the recommended practices for winter camping. It can help – along with professional instruction (for example, in New Mexico wildvistasadventures.com) and actual experience – in all phases of this healthy activity. But *please* purchase and study some, or all, of the more-complete reference books listed below, and then adapt and apply all these recommendations to your own winter camping trips. This document is also available in the "downloads" section at lamountaineers.org. Please share tips from your experience with the author at ashcampbell@starband.net to improve the quality of future handouts.

What is "winter camping"? In this Guide, it means any time when you must make *substantial* use of snow for your overnight shelter – that is, using snow that has been mechanically compacted (either by you or the wind) to make firm walls and/or platforms. *When* can you do it? Whenever the snow is deep enough (at least 12") that you use it in some way for your overnight shelter. [For example, with 1 foot of snow you can usually make a fine platform to pitch your tent on most slopes. With 2 feet of good snow you can make what the Guide calls a "*Slip-form*" igloo; and even deeper snow makes it possible to build a sturdy shelter completely out of blocks.] *Where* can you winter camp? Just about any place that you'd like – including places that you'd *never* consider in the summer because of, say, slope or lack of water - as long as your site is protected from hazards like windfall and avalanches. *Who* can do it? Anyone in relatively good shape who's willing to plan, work and develop the necessary skills. And finally, *how* is it done? That's for the Guide itself to explain. I strongly suggest that you print a copy of this document, mark it up, make sketches of any shelter (re)design that you intend to build, put everything and a pencil (pens can freeze) in a clear zip bag and take it along!

Contents:

A. GETTING READY

1. Find an *experienced* mentor/group for your first winter camping outing. If this is not your first outing, then select your own party leader (the most mindful and responsible person) by consensus. The leader monitors previous and current

conditions and forecasts; checks out road and TH access; visits campsite(s); researches and obtains permits; checks gear lists of all party members; collects all relevant phone numbers; prepares and prints maps and site plans; organizes camp procedures; makes the critical decisions if consensus cannot be reached, etc.

2. Pick your teammates carefully, and *constantly* take care of each other on the trip; a party of three to four people is best for the real backcountry.

3. Identify and share individual and party goals for the trip (e.g., is this a practice or a real expedition?).

4. Get fit – a person in good shape can work harder and longer (with less food), thereby generating more heat to stay warm. The two most helpful exercises that I do for winter camping are (a) push-ups: toes out straight so that you are putting weight on the top, not the bottom of the toes, thumbs and index fingers touching to make a diamond shape in front of the sternum; do them slowly, about 1.5 seconds per push-up; do as many as you can, then increase slowly by day and do these every morning after stretching (a) stairs: find a place with very little foot traffic, wear thin leather gloves and carry a dumbbell weight in each hand (start with, say, ten pound weights and increase over time to what is a comfortable limit); when going down the stairs bring the forearm vertically above each elbow to give the wrists a rest; when going up lower the arms and twist the torso a little with each step to strengthen the ligaments; do this for ten minutes twice a week moving as fast as you can within your cardio limits; afterwards, set the weights down and walk for several minutes to cool down and recover.

5. Master backpacking basics in the *summer* before going out in winter; make sure that all your clothing layers work well together.

6. Know what you're getting into and be prepared for it; be ultra-conservative; consider taking wilderness first aid and avalanche courses.

7. Scout and prepare your camp sites as much as possible (especially in the summer); before you overnight in winter, stomp out the trail, quarries and shelter sites several days in advance; decide what type of shelter(s) you will use, and have a back-up plan already in place. Situate tents to maximize warm air and sunlight; locate snow shelters in deep shade near sunny patches if you intend to use them all winter.

. 8. Practice every necessary skill/drill you can, then practice again; get used to doing everything in the cold and/or dark.

9. Clean and test *everything* you will take. For example, can you pull zippers with mittens or gloves? can you put on wind pants over boots? do all your layers work together with no single-purpose garments? how much actually fits into your sleeping bag? does the stove platform keep the stove from sliding? where do you stow your hats when you take them off without losing one? how will you hang your sleeping bag to dry so that it doesn't blow away? and so on…Take the kinks and loop knots out of all your string lines.

10. Print up your gear and clothing lists and send them to the trip leader weeks before departure.

11. If you plan on making snow shelters, use your sleeping pads and floor space at home to determine the dimensions you'll need and make a sketch based on the instructions so you understand the construction process visually.

12. File a detailed itinerary with your partner or reliable friend; if you commit to phone contact while out winter camping, make absolutely sure that (a) you will actually be able to make the contact and (b) others in the party know of this commitment, and (c) you do *not* forget to make the contact; otherwise, guess what…
13. Fatten up for several days before departure.
14. Get the car ready: window scrapers, warm blankets, extra water, tire chains, shovel, a bucket of sand and pea gravel, spare car keys, dry clothing, food and electrolyte powders.
15. Avalanche assessment: Consult with local officials (e.g., USFS, NPS, BLM), clubs (e.g., CAIC at 719-520-0020), local hiker network or websites (e.g., Northern New Mexico Avalanche Exchange at nnmae.org) to determine if you will be entering an avalanche-prone area. If so, take an avalanche safety course and equip your party with transceivers and probes, then practice, practice and practice before going out. Because each second counts in terms of survival, *every* person in the party must be proficient in the use of the transceivers.
16. Use the best technologies available for navigation and communication, know what your equipment does and how to use it. For example:

Transceivers (e.g., BCA and Pieps) are beacons that send signals that can be detected by other transceivers (regardless of brand); each person sets his/her unit to "send" and if someone is buried the others immediately set theirs to "find" to locate the buried person.

Personal Locator Beacons (e.g., ACR and SPOT) send a signal to satellites which then notify Search and Rescue (which is coordinated by the NM State Police; all SAR teams are volunteer; NMSP normally requires that a person/party be missing for 24 hours before launching a rescue mission.) GPS-enabled PLB's may take as little as 5 minutes for the notification; standard PLB's take up to 45 minutes. ACR uses a public network and checks the profile you filed with them prior to notifying SAR. The ACR units are expensive, but there is no charge for service; send a signal *only* if you need to be rescued! SPOT is a private network that sends tracks and/or a brief message of your choice (with location) via satellite to your family or SAR, etc. The SPOT units, and service fees, are relatively cheap.

GPS receivers (e.g., Magellan, Garmin) are merely receivers that fix your position and elevation via satellite; current accuracy is roughly 10 meters; when enough 3-frequency satellites have been launched, the accuracy will be about 20 inches, but you'll need to buy a compatible unit.

Phones: cell phones (even ones like Jitterbug that utilize all networks) and satellite phones (like Globalstar that is having problems with satellite coverage) only work in certain areas/times in the backcountry; same for short-wave radios.

B. KEEP IN MIND during the trip:

1. Eat *before* you're hungry and drink *before* you're thirsty. Eat, drink and be merry!
2. Use the terrain and the snow to your *advantage*.
3. Stay *busy* and *keep warm* in camp; do the work first.
4. The colder and stronger the *wind*, the more you must protect yourself from it.
5. Be mentally and physically alert to stay *warm, safe and dry*.
6. Minimize caffeine and alcohol (it chills and dehydrates you) and never do drugs on the trip - you must remain totally *alert and hydrated* to survive in adverse conditions.
7. Maintain a *warm and positive* mindset; be both *creative and logical*.
8. The more extreme the conditions, the more *impeccable* your camp must be.
9. We *lose heat* in five ways: conduction (direct contact with a cold surface), convection (cool air passing over the skin), radiation, evaporation and respiration. Of these, evaporation is the most rapid heat loss - dry clothing can be up to 25 times warmer than wet clothing – so the biggest danger in the winter is getting too warm and sweaty.
10. We *produce heat* in three ways: metabolism (eating), exercise and shivering. Exercise can be 18 times as metabolic as the basal rate; it's much easier to maintain body temperature than generate it.
11. If you're dressed properly, you should *never get wet from snow* – the challenge is to wick away your perspiration and ruthlessly minimize contact with snow inside the shelter.
12. *Mandatory* "self-leadership"

- monitor your own physical and emotional comfort level
- be completely honest about your abilities and energy level
- raise your awareness to the highest possible level, and read the conditions as though *you* were the party leader
- frequently pose problems to yourself, like: if we had to make an emergency camp right here, how would we do it?

13. Cold and snow slow you down; figure on only 50% to 20% of the normal summer *travel distance…if* you can get there at all!

C. GEAR

1. *individual:* back pack - comfortable, the simpler the better, all buckle straps, tested to carry all your gear, at least 90 liters (or 20 liters larger than a comparable summer trip), ideally with outside straps for snowshoes and/or skis; two snap rings on shoulder harness for hat, etc. and two snap rings on load strap at waist belt for spares or hauling); large, high-loft sleeping bag with breathable shell, beefy collar and draft tubes all the way down the zipper (consider Big Agnes Classic-style synthetics – 15-deg for snow shelters and 0-deg for tents - these have lots of room in the foot box for storing/drying clothing and you do not slip off the pad); add silk or thermolite sleeping bag liner if you sleep cold; two sleeping pads (one closed-cell) with total R value close to 6 (consider Big Agnes Dual Core for shelters and Two-Track for tents); high winter

gaiters (Black Diamond Front Point recommended) adjusted for your boots; skis and/or snowshoes of appropriate style and size for terrain and total weight that are light and rugged (note: 1 lb on your feet is equivalent to 6+ lbs on your back!); adjustable trekking poles with large snow baskets that screw on (like Black Diamond or Leki); micro-spikes (Kahtoolas recommended) if significant parts of the trail are hard-packed; clip-on thermometer with compass and modern (post-2000) wind-chill chart; packets of hand and toe warmers (note: you may have to modify liner gloves to hold the hand warmers in their proper position on the inside of the wrist, and/or modify liner socks to hold toe warmers in their proper position on the shim just above the ankle); map of campsite and routes on waterproof paper; small tarp (either blue poly 6x8 or AMK Heatshield 5x8'); med/large camp towel; extra watch; SPF 20 and 30+ sunscreens; moisturizer; SPF lip balm; two flexible 32-48 oz wide-mouth water bottles that can take warm/hot liquids, with insulated jackets; one-liter pee bottle, wrapped in cloth tape with tight-fitting lid; toilet paper; LED headlamp with both white and red lights, tested with head gear + extra batteries; sitting pad (REI Lite Core inflatable is recommended, but high-density foam pad or chair seat that uses your top sleeping pad are also good); lockable knife or multi-tool; trowel; notebook and pencil; your normal dietary supplements and medications + extra day supply; avalanche probe (for snow-depth testing or avalanche rescue); signal mirror and whistle; bright-colored eating utensils leashed together; repair kit for your personal stuff (duct tape, wire, variety of safety pins, needle and thread, spare pack buckles, spare binding parts, fabric repair tape, cord, webbing, etc.); personal first aid stuff (antiseptic wipes, petroleum jelly, athletic tape, 4x4 gauze pads, ibuprofen, large-patch band aids to prevent heel blisters, beefy knee brace, Super Glue for emergency suturing, etc.); bowl; butane lighter kept in a shirt pocket; cleansing wipes (e.g. Summer's Eve) that you keep from freezing prior to use; ice axe if you will be on hard, steep snow/ice; crampons suitable (i.e., flexible or rigid) for your type of boot if you will be on hard steep snow/ice; extra snow baskets for your type of trekking pole; 50' of utility cord; telescoping avalanche shovel that extends to at least 39-41" ; snow saw (see snowsaw.com); 1-gallon freezer bags for trash and used toilet paper (these can store clean stuff on the way in); 10' of 3mm or 1/8" orange cord for a sleeping bag clothesline; lightweight pillow ("Cocoon" inflatable, insulated pillow is recommended); container for storing clothing inside the shelter (REI micro-duffle is perfect); ditty bags for organizing all the small stuff; a roll of plastic orange flagging; insulated mug with lid leashed to handle; small fanny pack for keeping snacks, camera, lip gloss etc warm under layers next to your belly while working; coupler straps to keep two pads touching for extra warmth (see bigagnes.com.); an ice-box dish with closed-cell foam in the bottom for keeping stuff (lipgloss, watch, etc.) handy at night; 3-4 draw-string kitchen trash liners (two to keep gear dry in the shelter, and two doubled-up to haul out frozen poop and paper); emergency bivvy (AMK Heatshield is very affordable). If you're traveling solo, scour the next list as well!

2. *for each group (up to 4) in the party*: NOLS recommends white gas, but I prefer the MSR Reactor stove with plenty of 8 oz. isobutene fuel canisters (take three times as much fuel as summer); custom, very-well-insulated platform for stove that holds the fuel canister firmly; second snow pre-melting pot that acts as a lid to the pot on the stove; if you don't make shelters out of snow, then take what you need for a *fabric shelter* (see section "K" below); approximately 3x4' door flap with holes and tent pegs (unless

you take a tent); big first aid kit; Spot Messenger (or satellite/cell phone verified to have service in travel area); repair kit for tents, packs and snowshoes (pole splint, Seam Grip, Super Glue, zip ties, rip-stop and duct tape, tent fabric, sewing kit, awl, extra buckles and webbing, extra zipper pulls, some 2-4 mm cord, etc.); waterproof matches and windproof lighter; 30 m of 7-8 mm climbing rope if you will cross gullies or streams; two types of measuring tape (one of which is a colored, plastic folding yardstick); several 16" long ¼" dowels for hanging light objects inside a snow shelter; at least one GPS unit with maps and waypoints loaded; inclinometer or small plastic level; ice axe if you want to chip ice to access running water – also extremely effective for removing dead man anchors; extra pair of trekking poles; scrubbie and soap for cleaning pots; (two) thin-walled 1-1/4" vent pipes; probe thermometer + magnifying glass + old credit card + Life-Link Crystal Card for shear/pit testing (or see kits available at backcountryaccess.com and brooks-range.com); digital thermometer for taking body temps; red/white LED lantern (1/shelter); whisk broom and plastic pan (1/shelter); extra flood/spot led headlamp and batteries; folding wood saw for cutting branches and/or snow shelter poles (if considered necessary); lightweight (2-4 mm) plastic sheeting for emergencies and/or snow-shelter practice (100 s.f.); small empty spray bottle for snow shelter construction; extra waxes and binding repair stuff if skis are taken; wind gage; 2x2' closed-cell pad; at least one pair of small snowshoes with limited rotation binding (for stomping paths, quarries, etc.); 3 colored (yellow, red or orange) plastic summer stakes and 20' of colored string line (PMI 1/8" orange is fantastic); base-plate compass and map; small digital camera; long zip ties; a candle lantern for the kitchen area; extra dead man loops (3' lengths of 3-4 mm colored cord with water knot); small NOAA receiver if trip is longer than 2 nights and service is verified; a laminated field guide (like this one, marked-up for your use); plastic bevel square; thin bailing wire; a square foot of fleece and another of nylon. *Seriously* consider taking an expedition toboggan (for example, see skipulk.com) for heavy loads, emergency evacuation or hauling vigas - rigged with load straps for a duffle, and crossable haul poles that clip to the hauler's waist belt; leash every sled connector that could get lost. See also rei.com winter/snow camping checklist.

D. FOOD

1. twice the calories that you'd take on the same hike in the summer (average man 6-7,000 calories/day; average woman 5,000 calories/day); carry one extra day's worth of food; consult winter camping cookbooks (see NOLS in references) and make your food selection varied and appealing
2. 50% carbohydrates (honey, granola, dried fruit that stays soft like raisins, mango, cranberries and apricots; crackers, corn and potato products; brownies, cookies, bread, dried soups), 30% fats (cheese, chocolate, canned/jerked meat, canned fish, sausage, nuts, butter) and 20% protein (nuts, beans, cheese, grains). Seriously consider sunflower seeds, bacon bits, whole-grain snacks and spices.
3. plenty of high-quality snacks, protein and electrolyte powders; warm up energy bars and chocolate in your clothing or belly fanny pack *before* having to see the dentist; have plenty of vitamin C, potassium and Ca/Mg/Zi tabs handy; while your hands are warm in camp, begin the corner tear of the day's energy bars wrappers before you store them

4. melt snow: you can fill a solar shower bag, black plastic garbage bag or any bottles with snow and place them in direct sun *or* use a stove and bring water to a short boil; do not bring *any* water filters unless the temperatures are going to stay above freezing
5. drink frequently in small amounts – aim for 4-6 liters/day; take plenty of your favorite protein and electrolytic supplement recipes; fill an insulated container with hot liquid and cocoa/herb tea/honey whenever possible; first course at dinner should be a tasty soup; pre-mix milk powder in with your cocoa; put butter and honey in all hot drinks; check out "PowerBar" gels and "nuun" tablets (+ honey) to flavor hot water; consider a toddy after desert [for example, Backpacker Magazine specialties: *Wintermint* - steep a peppermint tea bag in water and add an ounce and a half of Baileys Irish Cream; or *Pumpkin Spice* - 4 T canned pumpkin pie mix, 2 oz heavy cream, 1/4 oz unsweetened hazelnut syrup and 1.5 oz. anejo tequila].
6. cut cheese and meats into small squares before packing; unwrap and bulk-bag everything that you can, getting rid of any unnecessary packaging; put butter in containers with screw-on lids; consider taking frozen veggies and meats
7. leave snacks and a bottle with dry supplements in your duffle in the car to replenish when you come back out

E. CLOTHING

You must stay *warm and dry* in the winter in order to be *safe*. The function of winter clothing is to (a) trap heat and (b) wick away moisture. As your body heat rises from work and exercise, so does the dew point of the air in your garments. This increases the amount of condensation and consequent evaporation that will occur, setting you up for rapid chilling (that can become life-threatening) when you stop to rest. Take the right clothing when you winter camp, and adjust it *frequently and wisely* to stay "comfortably cool". Encourage everyone else in the party to do the same, and *always be helpful and patient* when anyone needs to make clothing adjustments.

1. feet: warm, stiff boots with upgraded insoles that are waterproof, broken in, recently tested and rated to 20 degrees below what you expect to encounter. I once tried, and you might really like, boots with removable insulating liners or waterproof socks [e.g., SealSkinz] between liner and insulating socks. My standard approach is taking two pairs of liner socks of different weight and material (merino wool and coolmax) and two different pairs of thick, stretchy, cushioning (like Smartwool PhD snowboard or Expedition) socks. I also take comfy down booties for the shelter.

2. body: thin, tight torso base layer with thumb holes: pick two (merino-wool zip turtle, Under Armour cold gear mock turtle, synthetic heavy weight base layer); thin, tight leg base layers: merino-wool *and* synthetic base-layer; extra synthetic underwear; insulating layers: pullover and pants, ventable fleece or wool or wool/polyester blend; next layer: ventable soft shell or wind shell jacket or puffy jacket, all with hood; camp clothing: light down or Patagonia micropuff (vest or) jacket; waterproof/breathable outer shell jacket with adjustable or ergonomic hood that is big enough to fit over everything else; side-zip

wind, soft shell or waterproof/breathable pants; two light knee pads. Zippers: put easy pulls on all zippers, stagger your zippers and have them on all pockets. Eliminate redundancy.

3. hands: merino wool *and* synthetic liner gloves; waterproof/breathable insulated gloves *and* puffy mitts; waterproof/breathable mitten shells. Practice dressing and undressing with just your glove liners on.

4. head: visor hat; heavy Turtle wool, or fleece/nylon bomber, hat; ear jock; comfortable fleece hat for sleeping; non-scratchy balaclava; face shield with neck gaiter (note: you lose a *significant* percent of your body's heat – up to 70% in some estimates - above the shoulders); two pairs different-colored/dark sunglasses in hard cases; ski goggles if extreme wind and cold are anticipated above tree line; wool scarf.

5. car: leave a small duffle with a dry, warm change of clothing in the car at the TH (cotton is okay here, but *never* on the trail in winter!)

F. SNOW

Snow is the most complex surface on which you can travel because its consistency changes constantly from the moment it falls. And the layers in the snow pack at any given location will vary from year to year depending on wind direction and speed, snow type, volume and air temperature (etc.) *during* each storm. The snow in the West interior (Rockies, Wasatch, Wind Rivers, etc.) is typically much drier than the snowfall on either coast (Appalachians, Cascades, Sierras, etc.), and the cold, clear nights on the Continental Divide make for strong thermal gradients (the temperature difference between the ground and the surface of the snow pack). This accelerates the metamorphic process, eventually creating thick layers of granular snow starting up from ground level that can almost never be compacted for use in a shelter. This process is temperature-dependent: it proceeds more slowly on north-facing slopes than south-facing, making south-facing slopes safer for travel in early-to-mid winter and more dangerous in late-winter and spring. Since you *must*, by my definition, use compacted snow to winter camp, you should be as *familiar as possible* with the probable structure of the underlying snow along your route. So keep a record of the local snow storms and take notes on your observations as you scout the route.

1. three main types:

a. sugar: unconsolidated, metamorphosed; granular; pours; very dangerous as "depth hoar" below heavy new fall; frustrating to compact

b. dry: fell in cold air as light powder; facets or crystals that usually consolidate in lower depths; compactable

c. wet: fell near freezing level; bonds well; high moisture content; extremely stable if it freezes after melting or rain

2. four avalanche types

a. loose slide: snow without cohesion, typically after storms or warming rain; starts at point and spreads out, usually on slopes above 35

degrees; an indication of a homogeneous snow pack; usually harmless unless they sweep you into nasty terrain; downhill speed up to 60 mph

b. slab: highly cohesive upper layer breaks free from deeper layer, typically with a broad fissure ("crown") across the top; high speed down slope with large blocks; an indication of heavy snow over sugar or hoar frost; typically on slopes of 30-45 degrees in winter, but lower slope angle in spring; "whump" collapsing or cracks shooting out from your skis or snowshoes are indicators of slab formation over a loose layer; extremely dangerous and almost always triggered by the victim; downhill speed up to 150 mph

c. cornice collapse: wind-loaded overhang on lee side of ridge; typically cleaves off on a line extended up the lee slope

d. ice: toppling seracs or columns of water ice

3. four avalanche variables to analyze and integrate:

a. snow pack: "strong" does not mean "stable"; do a pit test by shovel or hand before crossing a suspect slope to analyze the relative cohesiveness of layers and the bonding between layers in light of monitored previous conditions; a storm that starts out cold and gets warmer will produce more avalanches than one that goes the opposite way; *slopes need time to stabilize*

b. weather: rapid changes of *any* kind (wind > 10 mph, sun after storm, more snow, your weight) can stress the snow pack beyond its holding strength; most natural avalanches occur during or within 24 hours of a fast-loading storm (above 1"/hr) when the slope can't adjust to the weight of the new snow; cloudy warm weather after a storm will promote quicker densification and stabilization, while cool temperatures and shade will slow it down; rain will either promote rapid consolidation or greatly increase the risk of avalanche

c. terrain: be wary of anything over 25 degrees in shadow; typical release point in degrees in the Rockies is mid-to-high 30's, in maritime areas is high 30's to mid-40's; avoid convex slopes

d. human factor: a high percentage of avalanches triggered by humans were caused by climbers who considered themselves "experienced"; do not be overconfident or too peak-hungry

G. TRAVEL

1. raise awareness level to the highest possible level; notice and discuss *every* thing you see and do

2. leader should monitor all relevant conditions (weather, snow, party fitness, etc.) *and* keep notes on every important aspect, including date and depth of quarries, viga supply, temperatures, wind speed and direction; plan for the worst conditions forecast

3. maintain constant body temperature to greatest extent possible by removing or

adding layers in the transition before the *next* phase of activity (moisture on skin is conductive cooling that is much faster than air convection; dry clothing will insulate up to 25 times better than wet); if you feel cold, adjust clothing and eat and drink immediately, then get moving; use roll-on antiperspirant on the bottom of your feet – or foot powder - if they tend to sweat a lot; stop in sunny spots rather than shade; "under-dress" as much as you can to be "comfortably cool" when you're in motion so that you don't build up a sweat (that will chill the body in a hurry when you stop); always have warming layers quickly available; test *all* of your base/insulating/outer layers in a variety of conditions so that you know how they, and you, perform; for safety and aesthetic reasons, don't punch through a snowshoe track with boots and don't snowshoe in a ski track; always wear eye protection to prevent sun blindness and pokes in the eye.

4. be especially aware of the chilling effect of wind: exposed flesh can take just a few minutes to freeze when the wind chill is significantly below zero; stop and hunker down out of the wind; set up camp and build snow walls to minimize the impact of wind; keep merino wool liners in your pants pockets to put on immediately whenever you have to take off your heavy mitts, and face into the sun when working with liners on; huddle close when talking to keep warm and communicate better.

5. avalanche travel: keep exposure to a minimum; don't travel above another person; keep each other in sight; stop to rest only in safe places; ascend gradual slopes first to get a feel for the stability; avoid long traverses above cliffs/dense forest/gullies; favor ridge approaches; traverse going slightly downhill to speed up the crossing; use the sides of an open slope whenever possible; if you fall try to sit to minimize stress on snow pack; one person descends at a time while others watch; pre-select an escape route; do a shear test (see references) and/or try to trigger an avalanche to test a suspect slope before crossing it; remove all lanyards and unclip all belts and snaps before crossing; if caught in an avalanche yell to the others and try to get free of your heavier gear and stay on the surface working your way to the side with a rolling or backstroke swimming motion then raise one arm completely and cover your mouth with the other hand as you come to a stop; skirt the run-out area of obvious avalanche areas (trees knocked down or chopped off, lots of young trees in an obvious track, etc.); be *especially* careful on north-facing slopes (where the snow is colder and it takes longer for bonding to occur anyway) with a convex slope (where the bulges outward are more likely to fracture); stay out of gullies; spread out when crossing a suspect area to reduce the chance that the entire party will get caught; stick to ridges on both ascent and descent; if a member of your party is swept away in an avalanche, visualize the line of their probable descent and look there first; use your trekking pole to probe the consistency of the snow (smooth, even resistance means it is less likely to slide); keep in contact – sight and sound – with the person behind you; rotate the lead

H. CAMPSITE

1. Obey local regulations and allow lots of time (2 hours?) to make and break camp; the leader should have already visited the site and distributed a plan showing the access, staging, shelters (close enough to communicate), kitchen, dining kiva, lavs/latrines (also used for kitchen waste), watershed (where you'll get snow – up to 3 cf/day/person - to melt for water), quarry (where you'll mine blocks for construction projects – ideally on a flat area out in the sun), sleeping bag drying area; place the site well off a trail and take a circuitous route from the trail to it. Put the entrance either downhill or at right angles to the prevailing wind. Note: when using a fabric shelter, make sure that you place line hitches (tensioners) *above* the snow surface to make all the guys taught for strength.
2. The ideal site will:
a. have the minimum snow depth – fresh snow is definitely the best - for your intended type of shelter; put a snow shelter where the snow is deepest and with the most shade so that the quarry can be adjacent and any shelter/walls built with snow won't be deformed by the sun, if you intend to use it several times over the course of the winter
b. present no danger from avalanches or falling timber (especially aspen)
c. be out of the prevailing and orographic winds (that pool in valleys and increase over ridges and cols)
d. be level and get full sun nearby as early in the morning as possible
e. have great views - and nearby water if you need to conserve fuel
f. have powder snow hit by the sun close to the snow shelter or walls to use as mortar
3. Slow down and add layers 15-20 minutes before reaching camp to reduce moisture and generate warmth; during this time, discuss *who* will do *what* once you reach camp; upon arrival, stomp down (wearing skis/snowshoes) a staging area for gear on the access route just outside the perimeter of the camp site and change into a dry base layer immediately if yours is still wet, and put wet socks on your shoulders next to your wicking layer to dry them out
4. Take a long drink and eat a snack (cheese, brownies, etc.) and take a drink with protein/electrolytic/energy supplements every 15 minutes; *never eat snow*
5. Implement the site plan without delay by stomping down snow in lifts in the tents, kitchen (with windproof stove counter and "fridge" – hole in snow wall with foam floor and block door), "kiva" (circular area 6-8' in diameter with benches for a party of 4-6), watershed, quarry (min 18" deep when compacted is best) and potential snow shelter spots; generally make the quarry ten times as big as the shelter and running across the slope so that you can go downhill more and get better compaction; have the heaviest person make the quarry while wearing his/her pack and using small snowshoes after the initial pass; one person should immediately begin melting snow for hot liquids (always start with an inch of water in the pot and add snow by handfuls till it is full, then put on the lid if this is the final pot, or set a second pot full of snow on top to melt; use wool liner gloves – synthetics can melt on hot surfaces). If you brought along a little wood stove (for example, see titaniumgoat.com) dig all the way down to the ground and make a kiva pit around for comfy conversations.

6. Stomp out paths till they bear your weight on foot. For lavs make at least two for privacy and dispersal of waste, and try for one per tent; ideally located on the south side of a large tree or rock, with a privacy wall of block; provide a hanging bag at the lav so that you can pack out *all* your toilet paper; leave trekking poles or a shovel at each lav hole for balance. Make ramps, not steps; keep the watershed pristine, since this is where your drinking water may come from; clear out areas where sleeping bags can be hung to dry the next morning (e.g., clotheslines between trees or tipped skis).
7. Cutting blocks: Decide well in advance how big – in cubic feet - your quarry has to be and stomp it with snowshoes in both directions until it feels firm underfoot. Most 2-person snow shelters will take around 200 cf of compacted snow; the best blocks come from quarries that were compacted a day or two before construction. (Note: you should sweep *new* snow off the quarry surface – rather than trying to stomp down.) But if you have to make a quarry the same day as you build the shelter, then stomp it, wait at least 20 minutes before cutting. Here's a quarry/shelter relationship that's extremely efficient: smooth down the quarry surface with your hands, and use two colored plastic stakes to string a taut length of 1/8" brightly-colored (PMI orange accessory) cord from one side of the quarry to the other about 8' away from, parallel to, the planned outside wall of the shelter. (In this example, we'll be making 8x16" block from a quarry that is over 14" deep.) Standing on the surface of the quarry, make a cut perpendicular to the quarry surface along the line with long saw strokes. Move the string line 16" in the direction away from the shelter, and, standing on the side away from the shelter, make a similar cut, then move the stakes and repeat this once again. Go to one edge of the quarry and make a cut at right angles to the three lines and remove the snow with a shovel on the fluffy side of the cut to make a short quarry "face". Set the string line 8" in from the face and make that cut, then kneel down and make the horizontal cut across the bottom (as far below the surface as you can but only going in 8") of the two blocks. Each block should settle slightly when it's ready to move; when you feel/hear/see this, set the saw with the handle up in the snow nearby (so that it does not get stepped on), put the pan of the shovel under the block at the bottom cut and lever and slide the block out a bit with the shovel. Swing the block on the shovel pan, balancing it carefully, and slide it off, bottom side down, onto the quarry surface on the shelter side. The block should be laid down carefully on its side and the loose, usually-granulated snow squared off the bottom face before being transported over to the shelter. Move the string line in 8" and repeat until you reach the other side of the quarry. This creates a 32"-wide trench that is now the long quarry "face". At this point move the string line 8" in the direction away from the shelter and cut block that are 16" long, standing in the trench the whole time. (If you need to make custom cuts for a particular location, the quarry cutter and block mason should each have a ruler so that dimensions can be called out without delay.) If blocks are too heavy, then make them smaller; if one crumbles then it's not structurally sound enough and should be put in the pile to melt for water. Always cut more blocks than you think you'll need for the shelter – they'll be needed for breakage and chinking/wedges, and can always be used for wind walls (about 3 high and extending at least 2 feet past the shelter on

both sides) fridges and gear lockers, a sculpture garden, etc. Tip: use the snow saw blade as a ruler to save time. Snow shelters, and every site exposed to the wind, will need block, so an efficient quarry close to the campsite is *essential*.
8. Shovel out an east-facing kitchen and kiva dining area, build a snow wall to protect the cooking counters and high (to keep feet off snow) eating benches, continue to compact with snowshoes/skis until it bears your weight on foot
9. Keep loose snow out of shelter; use whisk/pan as needed; brush snow off your clothing and gear frequently; sweep ice crystals from condensation into piles before they melt inside the tent or shelter; prevent spills of any kind
10. *Never* put on cold boots, socks or hand wear; keep mitts and gloves off the snow; use chemical warmer packets *whenever* in doubt (you've already carried them in, but always save some for the worst phases of the trip)
11. *Never* expose bare hands or feet to extreme cold or metal surfaces
12. Put sleeping pads side by side to maximize body warmth when possible
13. Lay out sleeping bag to loft at least 60 minutes before getting in, and insert liner
14. Melt snow and fill every available water bottle, some with very warm (hot shower temperature) water to put in sleeping bags and insulated jackets (see Granite Gear Air Coolers) or booties (if not wearing) to drink during night; those with cold water you can store by cutting a box into the snow with a wedged, tight-fitting door from a snow slab or by just burying them upside down in the snow; make sure to mark storage locations with orange flagging; melt one final pot of water and put it in the "fridge" or bury it in the snow till morning (there should be at least 2 liters/person available in the morning); pick up and store all cooking gear.
15. Take a *moderate* hike or ski before settling down for the night to raise body temperature, and visit your lav before heading into the shelter
16. Set snowshoes/skis in protected areas near the tent entrance; keep packs in tent vestibules or covered alcoves built off the snow shelter wall; whisk off boots and keep them inside the shelter in a bag (with chemical packs if they're wet inside); lay outer shell and nylon garments between your sleeping pads; use light duffles of different colors to store clothing inside the shelter; talk through the arrangement of all your gear with your shelter mates so that people know where your stuff is; be open to suggestions
17. Take off/put on insulating layers *inside* the bag to generate/preserve heat; wear loose-fitting wool base layer, fleece hat; wear large dry socks and booties, and spread out damp clothing from the day in the thigh or stomach area to dry during the night; take turns getting into bed – one person at a time; let your feet air dry while you do a few sit-ups to generate heat; sleep with your face out of the bag to reduce moisture inside and wear a scarf or neck gaiter rather than cinching up the bag draw cord
18. Bring snacks, your mittens/gloves and boot insoles/liners into the sleeping bag for the night; shove your insulating layer inside down by your feet and cover the foot box of the sleeping bag with your parka if it can contact a snow wall; place stuff sacks strategically to block contact with snow walls; put two chemical

warmers in the bottom of the sleeping bag; if you sleep cold, then lay your 5x8 tarp ("space blanket") over the sleeping bag; a light bivvy is simply perfect

19. Have a final drink and snack and set pee bottle nearby with lid tightened; check with your tent mates to see if they're fully prepared for the night; set up a small red LED lantern (especially in snow shelters, which are otherwise tomb-like) and have your own headlamp handy

20. In the morning, do a few stretches and sit-ups while still in the bag, dress quickly to maintain body heat, fire up the stove and get some hot drinks down and organize the chores efficiently so that everyone is moving around and being productive

21. Hang out sleeping bag to dry first thing in the morning (it helps if there is *any* wind or sun, but even dry snow falling is okay – assume that your bag has absorbed a cup of moisture during the night); warm up boots and dry any wet gear in sunlight or near the (emergency only) fire whenever possible

22. Keep fuel warm (it does not freeze and will be at air temperature) and cook in tent vestibule or snow shelter *only* when preferable to an outside kitchen area

23. Don't leave *anything* lying around for animals or the wind to carry off, or the overnight snowfall to cover

24. Leave NO TRACE when you pack out; cover your latrine - you might be back!

I. MEDICAL

Try to imagine how *any* of the following medical complications could affect the entire party, and then commit to taking, and helping everyone else take, *every* precaution to prevent such complications from happening. If there is a serious medical problem, some one should write down a *SAMPLE*: *S*ymptoms, *A*llergies, *M*edications, *P*ast medical history, *L*ast food and fluids and *E*vents leading to injury.

1. cramps:

prevent: drink lots of fluid with electrolytes, especially potassium tabs, and do not exhaust yourself

symptoms: crippling muscle pain, inability to move the limb, etc.

treatment: as quickly as possible after onset stretch the cramped muscle gently, put weight on the limb and massage the cramped muscle

2. blisters:

prevent: break your boots and gloves in completely; apply second skin and/or large bandaids to suspect areas before starting out; use foot powder

symptoms: hot, painful sensation at friction point; fluid pocket forms

treatment: clean with antiseptic wipe then puncture with sterilized needle and massage/drain completely, apply antibiotic and cover with blister dressing

3. hypothermia:

prevent: anticipate sudden chilling after exertion, or sudden onset of precipitation/wind or abrupt drop in air temperature and adjust clothing and eating/drinking; wear clothes that shed snow; practice in advance with

all your clothing to know how it functions; strip off unneeded layers; head straight back to camp if you are soaked

symptoms: sudden chill, hunched posture, drop in energy level, cold fingers and toes, loss of coordination, fumbling, listlessness; more severe stages: shivering stops and person is disoriented, eventual loss of consciousness; in early stages body temperature drops to 95 degrees, middle stages down to 90 degrees, late-middle to 86 and late stage to 78 degrees (unconscious)

treatment: try food, drinks and exertion; if this fails, then get person into sleeping bag with pads underneath and protected from the wind and pile other sleeping bags on top; if this fails, wrap the bags in a tarp and put hot water bottles in hands, underarms and groin areas first then also neck and torso; if you also use chemical heat packs follow the directions very closely; in severe cases, be careful moving the person, don't offer fluids and try to evacuate with professional assistance

fire: if you have to build a fire in an emergency, dig down almost to ground level in a sheltered clearing downwind of the (flammable) tents, collect dead wood and lay the largest pieces on the snow, make wood shavings and kindling with a knife, douse completely when you are done and cover completely with snow

4. frost bite

prevent: dress properly on feet, hands, ears and face, and consume food and liquids adequately; always wear liner gloves when touching cold objects; always shelter and warm a body part up immediately if it feels cold; avoid tight-fitting clothes and boots

symptoms: superficial (numbness, pale color, cold but pliable skin, sharp pain when skin thaws) and deep (tissue is hard, numb, cold, either white or very red, may blacken and slough off)

treatment: superficial ("nip"): put affected area against warm skin; do not massage or pop any blisters, take ibuprofen; deep ("bite"): insulate the person and evacuate as soon as possible; attempt to thaw a body part only if there is no danger of re-freezing and if the person doesn't need help walking out

5. trench foot

prevent: keep feet warm and dry, especially at the end of the day's exertion

symptoms: blood flow is cut off after hours of exposure to wet and cold, leading to permanent nerve and circulation damage; foot may appear "wooden" with mottled skin

treatment: elevate and gently dry and massage the foot; take ibuprofen

6. falls/trauma

prevent: avoid slips and tumbles, especially when fatigued going downhill

symptoms: varied; check for bleeding without removing clothing and look for possible head/spinal injury

treatment: immobilize neck/spine if necessary; stop bleeding by pressure unless it cuts off vital circulation; if bruise/swelling treat with *r*est, *i*ce, *c*ompression and *e*levation ("RICE")

7. acute mountain sickness (AMS):

prevent: spend time acclimatizing to elevation and watch for early symptoms above 8000'; hydrate fully and take adequate supplements of vitamin C and calcium.

symptoms: headache, difficult breathing, loss of appetite, nausea, fatigue leading to loss of coordination and possibly pulmonary edema (HAPE - gurgling sound in lungs) or cerebral edema (HACE – severe headache, rapidly deteriorating level of consciousness, sometimes hallucinations)

treatment: rest at current elevation for 20 minutes, during which time the person should consume water, vitamin C (500-1000 mg), calcium (up to 1000 mg, preferably blended with magnesium and zinc) and an energy snack/candy bar; if symptoms wane, keep on going; if symptoms persist or worsen (e.g., vomiting) then head down right away

8. snow blindness

prevent: wear dark, 100% UV block wrap-around (or glacier) sun glasses

symptoms: burning of the cornea, painful sand-in-the-eyes sensation

treatment: cold wet compresses to the eyes in a dark environment

J. SNOW SHELTERS

Why invest all the time to build a shelter with snow? Well, consider this: You'll generate heat and enjoy great teamwork and fun with this amazing construction material. If you're going to be around for a few days, or come back later, a snow shelter is a welcome base camp that will protect you *much* better in storms, and be warmer and more stable - but always slower and *much* heavier to set up - than a tent. A snow shelter can be eerily quiet, will bear the weight of heavy new snow and maintain a steady, occupied interior temperature between 30 (with just two occupants) and 36 degrees F (with two occupants and a single candle lantern) regardless of the ambient conditions. (Snow is a better insulator than down, but when spring hits it's frankly better to be in a tent if the night is calm.) If a solid shelter is built in full shade, it can be used till early spring. And finally, experimenting with a variety of snow shelters will improve your knowledge of snow types, develop your construction skills and better prepare you for future outings…and unforeseen emergencies.

What snow shelter should you build? That depends on the shelter size and complex factors like the depth, age and type of snow in each layer and the slope, orientation and vegetation of the site. The smaller the shelter, the stronger and easier it will be to construct, so if time is critical do an *emergency* or an *A-frame* for each person opening onto a communal kiva. An 80"-diameter dome can easily accommodate one adult, a 90"-diameter dome can tightly accommodate two, a 100"-diameter dome can tightly fit 3 adults, and so on. The viga-style structures described below assume that a 66x100" flat area (80" for pads and 20" for circulation at the foot end) will accommodate 2-3 people. For most 2-person structures, use a very affordable 6x8' blue poly tarp as a ground cloth - the finished dimensions are 66 x 90" and it already has grommets, which are handy for staking it in place. Block structures have two big advantages over the *Quinz-hee, Mole's Cave* and *Digloo*: (a) if you've compacted a good quarry in advance, you can be

absolutely sure of building your shelter, and (b) you know what kind of snow is overhead when you're inside. And viga (pole rafter) structures are preferable to those three and the *Slip Form* in that: (a) the vent holes that are high on vertical walls can never get plugged by overnight snow, (b) the highest courses are much easier to finish, (c) they go up in a big hurry if the blocks and vigas are a few feet away, (d) the rectangular floor plan is more efficient for gear (e) it's easy to include a raised gear/sitting bench inside, which adds a lot of comfort, (f) they retain their original shape much longer, and (g) you can take in some eye screws, small biners/snap rings and cord to hang things from the vigas, then take the eye screws out with you. Note: Wilderness regulations typically allow you to cut only downed trees, so spend a day in the late summer cutting your vigas (aspen are light and, in some groves, very straight). Then either carry them over ground, or haul them by sled in the winter, to be concealed at the shelter site.

Building on a slope: One of the great features of winter camping is that you can - and actually must - make level platforms for your shelter with snow. Since you're not restricted to flat spots (as you are in the summer) you're very likely to pick winter sites that are on slight-to-moderate slopes. (As noted above, if your shelter is a tent, put the platform in full sun; if you're building with snow, put the platform in full shade.) When leveling the platform, you'll quickly observe that snow just slides downhill as you snowshoe across it - and the steeper the slope the more you sideslip without a wall to hold things in place. So try this: with your snowshoes on, stomp down a level trail across the slope from one side to the other, and near the downhill edge, of your intended platform. Then, standing on this trail, sweep snow down from above and keep on stomping back and forth until you've firmly built up the trail a foot or so. Go below the trail and press one snowshoe gently against the bank below the compacted trail, then return to the trail, sweep more snow down, press the downhill bank and so on. Then, with the trail as a retaining wall, work your way uphill, sweeping snow down and stomping it, building up the trail and its downhill bank as needed, until you have a platform that's fairly level and can be stomped more productively. (For a quarry on a gentle slope, start stomping on the downhill edge and work your way uphill.) Since quarries don't *have* to be level, very few of mine are, so always make the so-called "vertical" saw cuts across the slope at a right angle to the quarry surface. If you need to build up the depth of a quarry, pack it down once, then toss/sweep and level large amounts of snow, then stomp again, and repeat.

A variety of "add-on" features (gear lockers and benches, etc.) to the main sleeping chamber are described at various points below. You can mix and match these, and modify your design, to include these in the shelter. But in general, all snow shelters: (1) *must* have an entrance tunnel with an outside face that slopes inward so that the door flap will lay against it, and, preferably, a floor that's at least 6" lower than the interior floor so that cold air can pool there (2) *must* have at least one small wall vent hole (1" to 1-1/2" in diameter) up high opposite the entrance (bring in a thin-walled plastic pipe 16" long (24" if snow is expected overnight) for this purpose and push it through horizontally right after the interior has been patted down) (3) should use a dark floor tarp (to make snow visible) - decide what type of shelter you will make and cut it to size before you go, and (4) *must* have a door flap with a vent hole (1" to 1-1/2 " in diameter at least 12" above the bottom

in case it snows that night) that seals the entrance - make a one-size, arch-shaped piece of tarp or clear 6 ml plastic with sewn seams that is 48" high and 36" wide with tabs and grommets across the top and two pieces of dowel end-to-end sewn across the bottom. (I've sewn an R-foil layer on our floor and flap to make the shelter super cozy.) As a safety precaution, I keep a snow saw inside at night, but we've never had a collapse even with rapid, heavy snowfall overnight.

Entrance tunnels are fun and easy. Decide before you start where the entrance will be – the downhill/leeward side is best – and situate the shelter and build that wall with that in mind. Make the finished door and tunnel just large enough to crawl, and pass packs, through. In all of the block-style shelters, you'll cut a trench that is 20" wide under the future wall, remove the block and then fill the trench to the top as a temporary support for a 10-16"-wide wall. The first course should be a 20" block that sits directly over the entrance; the second course two 20" blocks that meet over the center of the entrance, the third course with a long 24" block ("lintel") also centered on the tunnel, and the fourth course with two long blocks that meet over the door center, and so on. When you're ready for the door itself, cut an arch up from the sides of this trench so that the peak of the arch is just under the center of a lintel, remove the material, then test for access and expand as little as needed - 36" from the trench floor is generally a good door height. Set 18-20" long blocks on edge (to make a wall that is 10" wide) on each side of the trench, with the long dimension parallel to the trench, against the shelter wall and bevel the bottom to follow the door outline, then trim each one for full contact with the wall and set them on loose snow, with much more loose snow in the front (away from the shelter) so that the block will tip back into the shelter wall. Mortar well, and put a second course on top, following the door profile. Finally cut two long blocks (typically 24-26"), either bevel the bottoms for the side walls or cut the side walls flat, and set them at right angles to the side walls and mortar well. Then trim the face so that it slopes inward a bit and the door flap will lie against it, crawl in and back out to see how it feels, then rub down and spray all the contact surfaces and the face of the tunnel. Finally rub and pat down the interior of the entire structure so that it will be smooth and not have overhangs or ledges (especially the *Flat-block* shelters below) for condensation dripping when it ices over (as will the entire shelter interior when you occupy it).

Maintenance: Keep a shelter log that notes the location, date, type, snow conditions, peak height and wall thickness at time of construction. Visit a shelter when in the area, and write down the date, depth of new snow, changes to the interior shape and peak height and any packing, cutting or removal of snow. Tamp all the new snow in place with your shovel to add strength, insulation and usable life to the shelter. Clean out the wall air vent. Always carry a snow saw when staying in a snow shelter built on a previous trip so that you can modify the entrance door to offset any structural sag that is caused rapidly by the sun, or slowly by warm wind.

Laying block: If the walls are straight, then start laying block with the appropriate overlap at the ends (or the corners) and cut the last block in the center to fit. Start at the corners and end in the middle. The best technique is to sprinkle loose snow on the wall as mortar, then support the new block so that the bottom of its trailing end (that will

contact the existing block) is touching the leading top of the existing block then lower the leading end of the new block and press gently backwards on it while you push the trailing end of the new block down into place – rubbing it against the leading face of the existing block for bonding. If this is a round wall you have two choices once the new block has been positioned a the appropriate angle and inset: (a) to minimize waste, make a radial cut on the leading edge of the new block while you press against the side of the wedge you're cutting off, then push/jiggle the wedge into the gap between the new and existing blocks, or (b) to maximize strength, cut the trailing side of the new block to line up with the leading edge of the previous block, then set the new block in place and make the radial cut on its leading edge. For every type of wall, very gently thump the new block gently back toward the existing one and mortar - rub loose, especially sticky, snow – into all the joints, holding the new block firmly with one hand/forearm and applying gentle counterforce while you press and rub with the other so that the block does not jiggle. Then cut the tops to be level and smooth down the tops of both blocks. Note: If the blocks are really icy and hard (typically when a quarry was packed on a warm day before a freeze) and the available loose snow is granular and not sticky, then saw the vertical joint between the new block and the old while pressing the new block toward the old, and then saw the horizontal joint under the new course.

Final tips: Wear waterproof gear with waterproof mitts (and chemical hand warmers if necessary) during construction. Rotate individuals around the crew as necessary to keep everyone warm, but start with the people who never seem to get cold as masons, and those who must be active to stay warm do the cutting and carrying. Once the structure is complete you should trim, plaster the light spots and rub and pat smooth the entire interior surface (so that condensation will run down the wall rather than dripping) by hand and then scrape/sweep loose snow from the floor with the shovel and level and pat the floor with your hands before bringing in the floor tarp and gear. Make sure that you've put at least one vent hole (see above) high on the wall. Chink and rub down the outside. Put sturdy smooth sticks/dowels or plastic stakes at an angle into the wall for light-weight objects like LED lanterns, etc. and/or cut a "nicho" into the side of the entrance near floor level for an LED lantern. Candles are great for light and warmth but *must* be kept away from gear and the walls and *never* hung from a metal snow stake; a candle lantern is ideal. For a 2-3 person block shelter, the ideal team size is six (repeat, 6!): two "mason/helper" pairs and one "support" pair (quarry work, hot beverages, breaks, etc), each with a tape, shovel and snow saw; rotate teams from time to time. A good plastering technique is to load a shovel with loose snow, put the front of the pan against the wall and push loose snow forward with a fist, then rub gently with a flat palm. Never pound the snow.

1. *Quin-zhee* (Athapaskan for "snow shelter"): avalanche-probe carefully for obstacles, set a colored summer stake in the center and use the colored tape/string to set the radius and draw the interior perimeter circle, then stomp around the outside to make a foundation 16-24" wide, setting tall sticks/poles in the snow at the outside of the foundation. Remove the stake and build a dome-shaped mound of snow *at least* 6' high above the foundation, taking snow from *outside* the foundation and tamping with a shovel as you go, and let it age-harden for at least 1-2 hours while you replenish and work-

harden the outer surface by whacking it with shovels, make wind walls, kiva, etc. Insert several dozen sticks, each 16" long, into the mound as thickness guides, and start excavating from the downhill and/or leeward side by digging down almost to the ground and creating a comfortable opening for excavation. Wear knee pads with waterproof pants, kneel on the 2x2' foam pad, use a short shovel (ideally with a curved handle) and carve, don't pry, the interior snow loose. Always dig upward first until you hit the ends of the guide sticks, then remove the snow from the ceiling down to the floor – you can actually use a snow saw in this process to mine block - to minimize the amount of snow over your head in case of collapse, and always have another person at the entrance to remove snow (and block). When finished, make a short tunnel from compacted blocks to reduce the opening and retain more heat. Comments: typically done on level or low-slope terrain; can be built by one person; wet digging for the person excavating inside; if the opening is too big, close it in with blocks as part of the tunnel construction.

2. *Mole's Cave*: find a deep (at least 6'), hazard-free snowdrift on the lee side of a ridge, boulder or fallen tree, av-probe for buried obstacles, and toss down and tamp lots of snow from above and below with a shovel to create a bigger mound than a *Quin-zhee*, and excavate from downhill in the same manner, keeping the roof at least 2' thick (insert sticks as guides). When finished, make a short tunnel from compacted snow blocks to reduce the opening and retain more heat. Comments: typically done on a much steeper slope, with easier snow piling, than a *Quin-zhee* but equally wet digging for the mole inside; can be done solo. Flag around the outside (orange flagging and ski poles or sticks) to keep people from punching through. If you have the time, create a mud room around the entrance outside for storing gear, changing clothes, etc.

3. *Slip-form igloo*: at least two people and a kit required. It's best to use freshly-fallen snow with a crew of four and go start-to-finish in one continuous session - the walls will settle a tiny bit overnight and the previous day's pole length will no longer work. With snowshoes stomp a level, circular platform that is at least 66" larger than the interior diameter that you desire. Bring along a large grain shovel with a plastic pan and sweep loose snow with a single motion – or transport large chunks of more-settled snow - into a huge pile very nearby (about 500 cf will eventually be needed). Move the snow as little as possible to reduce age-hardening. During construction, the shoveler should use a collapsible shovel with the longest handle available (for example, the Life Link Alpine Pro) to "work" each shovelful so that it has no lumps just before pouring into the form for the packer. (A good technique is to rake down a vertical face with the front edge of the upside-down pan, scraping about an inch of snow off the face with each quick stroke, until you have enough for just one shovel-full, then turn the shovel over and take the loose pile you've just made.) You can make a form of your own, and if you use an Ice Box (see grandshelters.com) igloo kit, follow the instructions carefully, and start with a 3-block ramp and spiral from there all the way to the top. But you can also make each course complete, starting each with a steep ramp and trimming the whole course at a uniform inward angle when it is complete. There are four viable alternatives for the peak: (a) Follow the kit instructions all the way – often slow and frustrating. (b) If you brought a big saucer sled (or some kind of folding dome pan) when you reach the point where the sled/pan can fill the opening from below, support the sled/pan with hands and a

center pole while helper(s) on the outside pour loose snow gently on the sled/pan and lightly tamp in lifts to create a mound – very quick and fool-proof. (c) When you reach the point in the kit instructions where the outside panel of the slip form has to be removed, use a snow saw to level the top course and lay *Flat-blocks* (see #5 below). (d) When this same point is reached, use short vigas like the *Roundhouse* below (a design that helps prevent sagging….somewhat). Leave any ceiling supports in place while you cut an entrance door – either from the inside or the outside - then relax and replenish while the dome hardens; make gear lockers around the outside, a kiva, etc. Finish with an entrance tunnel. Comments: can be built anywhere with (almost!) any type of snow, but requires skill and patience; best to have a tall person inside packing; get snow from a completely undisturbed area; seamless, requires no chinking. You'll know with the first block or two in the first course if the snow is suitable for a *Slip-form*; if not, abandon the effort *immediately* and make a different kind of shelter.

4. *Tilt-block igloo*: built from the inside; site prep same as the *Slip-form*, with a large quarry next door. Place a colored stake to represent the center of the shelter, coming in the desired radius + 10" (wall) + 18" (entrance tunnel) from the platform perimeter. If you're right-handed, lay up in a clockwise direction, starting opposite the future entrance. When the wall has completed the fourth course, you can cut out an entrance opening just big enough for access or to push block through if there is an outside worker. Note: The leading block in the top courses has a tendency to fall in – even if you reduce the size of the blocks toward the top - unless the person inside keeps a hand on it. Unlike the *Flat-block* approach below (where you can take a break after a course is complete), the Tilt-block forces you to keep going without much delay. Therefore, either have three people (one to quarry, one to carry and one to construct) or quarry all the block that you'll need before you start to build the igloo to minimize delay if there are only two workers.

There are two basic construction methods, and each involves creating a ramp from the floor to the top of the blocks in the first course so that all following courses will "spiral" up this ramp.

> *3-point method*: Cut the first block from the leading upper corner to the mid-point of the trailing side so that, when the two pieces are laid end-to-end they create a 2-block ramp. Adjust the block length so that no joint lines up with the joint in the course below, set each block on edge (even on the first course) and trim the block below and the sides so that there will be support/contact at *only three points* when the block is tipped inward. Use loose snow as mortar, and "sinter" (bond) each block by blowing/spraying on the contact points and tapping it. As you go, gently fill in the gaps between blocks with chunks of snow and then lightly tamp loose (sticky!) snow over the outside surface for strength. Cap with a block (resting it and cutting away till it drops into place) or the saucer sled, dome pan, vigas, etc.
>
> *full-contact method*: Cut the bottom of the first course blocks at an angle so that, when the block is set in place, the bottom is in full contact with the floor. As you place the next block, also tilted in at the same angle, use the saw and bevel square

to cut both blocks so that the cut is radial and points at the center stake and the new block is totally stable. When you've completed the first course, cut a ramp that goes from the leading top end of the last block (or at least a block that is halfway around) all the way to the bottom trailing end of the first block. Adjust the block length so that no joint lines up with the joint in the course below, sinter the vertical joints by spraying one side lightly with water (keep the small bottle inside your jacket) and rub snow into the cracks as you go. The bevel square can be helpful to cut blocks outside before setting in place.

Here are dimensions from the inner face of the wall to the center stake, in 2" intervals measured vertically from the floor for an 8' interior diameter dome with an interior peak height of 66 inches. From 2-26" high = 47.5; from 28-32" high = 48; at 34" = 49; at 36" = 49.5; at 38" = 50; at 40" = 50.5; at 42" = 51; at 44" = 52; at 46" = 53; at 48" = 54, then eyeball it from there. To check your progress, leave the center stake in place and use a knotted string line to measure the distance from the stake to the top edge of a block as you spiral around. If you want to make the igloo bigger or smaller, draw the profile on graph paper – assume a maximum feasible interior peak higher of 72" - write the dimensions from wall to center stake and laminate it. Finish with a short entrance tunnel. Comments: the classic Inuit home; goes up quickly with high-quality blocks and good teamwork. Dig out an area in front where people can sit and take off/put on their gaiters and boots.

5. *Flat-block igloo*: built from the outside. Av-probe and prepare site the same as *Tilt-block.* Place a colored stake to represent the center of the shelter, coming in the desired radius + 10" (wall) + 18" (entrance tunnel) from the platform perimeter. Put one colored stake at the end/center of the future tunnel trench and the other stake one radius-length on the opposite side of the center stake, then stretch a string line from the end stakes running over the center stake. Make a deep vertical cut along this line all the way from one end stake to the other, removing the center stake temporarily and replacing it. Then make vertical cuts as long as, and 10" on either side of, this line and quarry 18-20" long block from the trench starting at the entrance face and stopping no less than 6" before reaching the center stake. (Make the bottom cut as deep as you can and then carefully cut the block height later when it's lying on its side.) Remove the end stakes and use one of them with the string and center stake to scribe a circle with your desired radius (this will be the interior face of the igloo), and make a deep vertical cut all the way around the circle. Quarry 10"-wide blocks that range from 18-24" long from the interior until you've excavated the entire circular floor. Fill in the entrance trench to the top with chunks/blocks to make a temporary support wall for a 10" wide wall and lay a 20" block flat with the 18" dimension to the interior, centered on the trench and work away in both directions. Make sure that the top of each course is level, and cut each block to length to overlap joints. It is essential to complete each course before starting on the next so that the blocks form a "ring" that cannot fall inward. You should get four 8"-high courses up with 10" wide walls, but will have to cut blocks with a different width (see profile below) and rotate them 90 degrees on all the higher courses to create counterbalance and keep the block from falling in until the ring is complete – then trim the outside later. For the highest courses, try using the bevel square to make the radial cuts before setting in

place. Eventually you'll reduce the opening to the point where it can be finished with a couple of extra-large blocks. Before leaving on the trip, use a sheet of graph paper to draw a profile of the igloo and measure the overhangs for each course. Recommended block dimensions (for 8" courses, showing width-times-length in inches – width is radial, length is perpendicular to the radius) for an 8'-diameter igloo with roughly the same profile as the Tilt-block profile above: courses #1-4 = 10x16; #5 = 12x18; #6 = 16x18; #7 = 22x18; #8 = 18x18". Toss and lightly tamp a mound of snow on top and finish with an entrance tunnel. Comments: see *Slip-form* options for the top; requires solid block; uses more block but less skill than the *Tilt-block* approach; locate in total shade to make it last as long as a S*lip-form*; won't be as quiet inside as a *Slip-form* until the next snowfall; if the snow is not deep enough to excavate the floor, then build on a platform like the *Slip-form*.

6. *Mason's Cave*: Suitable for a deep wind-packed snow drift (not a cornice) or a very steep, well-consolidated (maritime snow) slope; best to have a team of 3 people, each with a shovel and saw. Av-probe, pick the deepest spot and, standing at the bottom of the slope where your entrance will be (for a drift, start at the flank so that the back wall will be parallel to the prevailing wind direction that created the drift) reach up and scratch out vertical lines with the saw tip running straight downhill 16" apart. The far-left and far-right lines should be 32" farther apart than the intended interior diameter of your shelter. Make deep, truly-vertical cuts, sawing down-slope, along these lines. Starting a couple of feet uphill from where you stood, cut across the slope with the saw perpendicular to the slope (not "vertical") and shovel out the fluffy side. Then move the cut up the slope 16" and make bottom cuts for courses that will be 8-10" high. Set the best blocks near the bottom of this initial quarry and put the softer ones off to one side – if blocks shear along cleavage lines (between storms), sort them by thickness. Keep going until you have a back wall that's at least 5' high, then use the shovel and saw to make the back wall smooth and vertical (plumb). Now, with the saw angling in and down, cut the outline of a generous arch – leaving at least 16" between the peak and the surface of the snow above and at least 16" at the bottom on either side for the flat-block half-dome in front - and cut/pry away blocks and chunks from the back wall (to make either a rectangular or semi-circular floor extension), and set these off to the other side. Level and stomp down the interior till you have a semi-circular foundation in front of the back wall with the desired radius. Scribe the half-circle (should be 16" in from each side of the initial cut), make an entrance trench and fill it temporarily where the 16" wall will cross over. From the inside, lay up your best block (insetting each course - see *Flat-block* and laying block sections) in the half-circle until you reach the maximum height that you can step over. Pack snow between the circular wall and the side walls of the initial quarry. Then step over and work from the outside until you've completed the half-dome that encloses the shelter. Chink and rub the exterior and put the vent pipe high on the lee side. Cut a door and make an entrance tunnel then go inside and bevel all the insets and rub down to prevent dripping. Make a gear locker and cooking area wind walls with the back-wall chunks, and toss what's left around the uphill side of the built dome to keep people from punching through. Comments: much drier and probably a lot stronger than a mole's cave; can be built solo with an interior layout like the Tunnel Dome - see this done in fast-frame on a steep, high-moisture slope at snowsaw.com/movies.

7. *Digloo*: two people required. At a site suitable for either a *Mason's* or *Mole's Cave*, toss more snow down from above and pack the area with skis/snowshoes. One person digs a hole smaller than 3' (or the saucer sled if you brought it) in diameter straight down in the middle, and begins to bell out the sides when about 2' down, then gets into the hole and continues to carve out an interior dome while standing on a pillar of snow and going as far as possible while still tossing the snow out the hole. Use the saucer sled or tilted large blocks on edge to cap the hole and cover this with tamped snow. Then the outside helper digs out the entrance on the downhill side and both finish carving the domed interior, at which point the ceiling can be reduced to less than a foot under the cap. Finish with a short entrance tunnel. Comments: more lifting to dig out, and only slightly drier, than a mole approach. Flag around the outside to keep people from punching through.

8. *A-frame solo*: You'll need a bivvy for this one. Av-probe and stomp a level quarry 4' wide that runs across the slope (if any) at least 10'. Add snow and compact in lifts if you can't make the quarry at least 3' deep. Using the stakes and string line, make four deep, cuts with the saw perpendicular to the slope, 8" apart, centered on the long axis of the stomped area, going from the entrance end to about 12" in from the opposite end. Starting at the entrance end, cut blocks that are <u>at least</u> 20" long and at least 12" deep, and set these aside. When you reach the far end, deepen the trench as much as you can – it will give you more headroom and get you closer to the actual ground level for warmth - then bell out the sides a little for more space, piling all the loose snow from this step on the surface next to the trench on both sides. The roof will be an A-frame made of pairs of long (20"+) blocks that tilt in to support one another. So cut a 3x3" (45-degree) shoulder off the bottom and top edges of two blocks and set them in place so that the shoulders both meet at the peak and are firmly packed in the loose snow at the sides. Trim the rear and front sides of this first pair and build a flat block wall on the rear end that touches the roof pair and projects up past the two roof blocks, and trim it back to the same profile. Finish laying up pairs of roof block till the tunnel is long enough for you and a pack, then create an entrance with an inclined face for your door tarp. Cover the roof with lots of loose snow and tamp it with your shovel. Comments: a fast, but very constricting, solo shelter; can be converted into a *Tunnel Dome* solo if you have the time; for two people, make the stomped pad 22' long and make two tunnels, using the space between for a protected kiva or a modified *Tunnel Dome 2* if you have the time; use extra block to make a fridge and gear locker. Flag to protect.

9. *Casita*: a rectangular floor plan for 2-3 people. Conceal 17 straight vigas – each 3-4" in diameter and 86" long – well before the snow falls (and hide them in the spring for re-use). Make a platform at least 12x16' with the 16' length perpendicular to the slope – the entrance will start 20" in from the 66" end on the downhill long side. Come in 3' from the downhill side of the platform and lay out a trench that is 66" wide and 120" long, squaring it up by making the diagonals equal. Set another string line 20" in from the 66" end closest to the future entrance (to define both one side of the entrance and a gear bench that you will <u>not</u> cut into for block) and make a cut beside that string from the uphill trench line to the downhill edge of the platform. Move the string line 10" toward

the middle (that is, away from the 20" gear bench) and make another cut, then move it another 10" and make that cut. Starting at the downhill platform edge, cut 16" blocks from this 20"-wide trench all the way to the uphill perimeter. Then move the string line repeatedly another 10" in the same direction (away from the gear bench and staying completely within the trench perimeter this time) and keep cutting 16" blocks till you reach the 66" end opposite the gear bench. Fill in the entrance trench to support a 10" wide wall and center a 20" block on it, then level the interior floor as needed. Remove the perimeter string line and lay one course of a 10"-wide wall around the entire perimeter, starting at the corners and filling in the middle. Working from the outside, add courses and inset the front and rear (120") walls (but *not* the 66" side walls) just a little (no more than one-half inch on each course) toward the interior to add shear strength. [As a reminder, this is the strongest pattern for the block wall at the entrance: start the second course with two 24" blocks that meet over the center of the entrance, the third course with a 24" lintel block also centered on the future entrance opening and the fourth course with two long blocks that meet over the door center and so on.] Build up the walls until you reach 4'-6" of headroom on the uphill/rear wall and 5'-6" on the downhill/front wall, then add blocks to the side walls so that you can cut a shed roof slope from one to the other. To define the slope perfectly, notch your straightest viga fully into the top of the front and rear walls next to each side wall and use the top as a guide when cutting. Then remove the viga and cut the front and rear walls in a matching slope by eye to make a plane for the roof deck. (Remember: it's much easier to remove snow than to add it.) Lay *all* the vigas in place, evenly spaced, alternating big and small ends, and notch them so that they don't protrude above the tops of the side walls and tamp loose snow all along the tops of the walls. Cover the entire roof plane with really long, 7" thick blocks on the flat, end-to-end, laid at right angles to the vigas, starting at the low rear wall and working up the roof slope. When necessary, cut the entrance (one side lines up with the gear bench) so that someone can go inside to reach through the gaps and help position/trim the roof decking. Put a vent hole at each corner, high on the entrance wall, toss lots of loose snow on the roof and tamp in lifts, then build a short entrance tunnel and polish the inside. As a final step, toss and compact chunks, partial blocks and loose snow against the outside of the uphill wall for support. If the snow is not deep enough to excavate the floor, then build on a platform like the *Slip-form*. Comments: uses about the same amount of snow as the *Chalet*, *Roundhouse* and *Barrel Vault*; not as strong as a *Quonset* with the same floor area and peak height, but the shorter vigas are easier to find and transport.

10. *Motel:* an easy extension of the *Casita*. Lay out a 66"x 120" trench in line with the existing *Casita* and make another unit that shares a common (66") end wall, keeping in mind that every end wall must have either a gear bench or the undisturbed platform for support. Comments: extremely efficient way (16% less snow than a *Casita*) to add space if you already have a *Casita* next door; live in one "unit" while you add another; each new room, of course, requires another stash of vigas; cut a single block out of the common wall for communication between rooms; best location is on the north side of an east-west line of high evergreen trees.

11. *Chalet:* a variation of the *Casita*, with a gable roof and a short-side entrance; you'll need 22 vigas 86" long. Start with the *Casita* plan and put a roof peak 66" above the floor directly over a point that is 80" from the end opposite the gear bench, then cut slopes in the long walls down to 54" on either end using a straight viga as a guide when sawing. Center the entrance on an end wall by cutting through the middle of the gear bench. Comment: fits nicely onto a much steeper slope at the cost of losing some gear bench space; if necessary, you can build this entirely from the inside – for the roof, lay up vigas several at a time, starting at the down-slope wall, then lift, set and cover the decking blocks course-by-course as you move toward the peak.

12. *Split-level*: a *Chalet* rotated 90 degrees to fit onto a steeper slope of 10-30% (that is, 5-16 degrees). You'll need a spray bottle and 22 straight vigas 86" long. Select a site where you won't be taken out by skiers, snowboarders or avalanches, and begin by av-probing and, starting from the side that will be your entrance, make a level snowshoe path going across the slope 12' long for the shelter platform. Continue that same path another 35' feet for a quarry. Standing on your path, tamp the slope on the uphill side along the shelter section with one snowshoe until it firms up; leave a space of 2' for mortar snow, then do the same thing for the quarry area. In both areas, reach up and scoop more snow down on the retaining wall and tamp it, trying to make it more solid and vertical. Step around from one end of your path and sweep snow down from uphill to make a level area (for both quarry and shelter) that goes from the retaining wall into the slope about 8' horizontally, then stomp this, and the retaining wall from below, until the area is very firm and level. Now go around below the shelter platform and make another snowshoe path 6' downhill (center-to-center) from the first path and repeat the process, except when it comes to sweeping down snow from uphill, cut into the upper retaining wall vertically all the way across until you reach solid, compacted snow, and use those chunks to build up the lower level until it's 16-24" below the upper level. [If possible at this point, leave the site untouched for a day or two to allow the snow to age-harden fully.] Set a string line perpendicular to the slope and trim up the face of the shelter retaining wall to make it clean and vertical, taking off as little as needed and being careful not to break the corner off. Then chamfer the corner with a 45-degree cut that goes about 2" in and down, rub the beveled corner smooth and spray it down with cool water. Outline the interior by staking an upper level sleeping area that's 66" wide, centered on your stomped area and going from the retaining wall face 80" in the uphill direction. Then lay out the lower level for gear and circulation with the same width and running 40" downhill. Quarry block for the lower level with surface cuts 16" long and your desired height wide and at least 14" deep (for an extra wide wall). When you lay them up, put the good (quarry surface) face to the interior and the bottom (ragged) face to the exterior. Build up the three lower level walls till the tops project just above the upper floor, then trim so that the top is level with the upper floor and rub down. Lay one course around the entire perimeter, and put a 16", stabilizing "buttress" block outside and at right angles to each side wall with its downhill face lined up with the vertical face between the levels. When you start the next course, overlap all four corners and the buttress walls, then fill in and keep going, insetting each course a small amount (no more than 1/2"), until the uphill wall is 30-36" high. Then build up the downhill, side and buttress walls till the downhill wall is no more than 54" above the lower level. Then

build both side walls to reach a peak that's either 54" higher than the upper floor or 72" above the lower floor (whichever puts the peak higher) and is lined up directly over the face between the two levels. Cut an entrance door into the lower level with one side about a foot away from the wall between levels and notch the peak viga firmly in place. Use a straight viga as a guide (or stake string lines) and cut identical gables from the peak viga to the four corners. Lay up the first several vigas parallel to the downhill wall on the entrance side of the peak and, starting at the downhill wall, cover them with full block and tamp loose snow on each course as you go (someone may have to stand on the upper floor level with snowshoes to tamp the middle of the top). Then repeat the process for the uphill side of the roof. Put roof vents under the peak and make a short entrance tunnel. Comments: More potential than most flat sites for privacy and a grand view from camp; see if you can find the rounded shoulder of a ridge or the lee side of a knob directly below a grove of protective evergreens with deep drifts of snow. The vigas in this design (untested as of this writing) might encourage condensation drip with heavy use; a remedial strategy is putting six eye screws (corners and peaks) and stringing a custom-sized tarp to divert the moisture to the uphill and downhill walls.

13. R*oundhouse*: A lot like the *Casita*, but… round, and needing vigas of different lengths. Stomp out a large quarry and cut out a circular floor trench and a 20" wide entrance trench on the downhill side, then level the floor. Lay up courses, with a very small amount of inset toward the interior, until you have the desired ceiling height for the rear wall (4'-6" is recommended). Lay up more blocks around to the front (a foot higher) and saw, by eyeballing, a sloped cut from the peak over the door to the opposite point on the circle. Then set/notch the vigas in place with the biggest, longest one at the diameter parallel to the tunnel axis, with, say, 4" of space between. Cut the entrance so that someone can go in to help place block on the roof and deck the roof over with long, full blocks laid at right angles to the vigas. Comments: if this is built for 5 or 6 people, then use vigas that are 5-6" in diameter throughout. When making your viga stash, scribe a circle with the desired floor radius on the ground to represent the *outside* of the 10" walls and lay the poles out to cut them to size, then lay them out again when you make the shelter in the winter. If the snow is not deep enough to excavate the floor, then build on a platform like the *Slip-form.*

14. Qu*onset.* For 2-3 persons. Stash 8 straight vigas, 3-4" in diameter and 11'-4" long. Stomp the quarry, lay out and mine a 66" x 100" sleeping trench and 20" gear bench (see *Casita*) and temporarily fill in the entrance trench. Now you have to make a decision relating to interior peak height. The structure itself will have an interior peak height of 44". So if you want to create the typical interior peak height of 66", you'll have to add 22" using the depth of the sleeping trench and/or the height of a vertical wall around its perimeter. (If you need to build a vertical wall, follow the instructions for the *Barrel Vault* below - including the "buttress" end walls and "bond beam"! - with small insets on the *side* walls so that you end up with an opening that is no less than 60" wide, and take the "slope-point" measurements from the top of the vertical wall). At the front/entrance end, lay up a 10"-wide wall that goes from one side of the trench to the other, up to about 16"-18" above the surface of the quarry (or the top of the built-up vertical buttress wall). Lay a viga outside this wall running beside the trench with the viga end 2" in from the

outside of the wall. Build a similar wall at the opposite end so that it, too, is 2" past the end of the viga, creating a nice interior gear bench. On the outside of each end wall insert two small pointed sticks of wood (or colored plastic) to mark symmetrical "slope points". For the first course, these should be 14" above the quarry surface (or top of the built-up vertical wall, etc.) and 56" apart – then cut a straight, "roof slope" line going from the trench (or vertical wall) corner through the two points; remove and save the sticks. Make the same cut at all four corners and trim them by eye to be identical. Cut the roof blocks for a 10" thick roof and 18" (or more) in length – the width (that runs along the wall) will be determined by the depth of the quarry. Pick four good blocks and set them in loose snow with the bottoms beveled to sit on the quarry surface, long dimension up and flush with the outside of the end wall and rub the joints. Then notch out (for your smallest) vigas so that they fully support the inside face of each top, and cut the top of each corner block on an inward angle that will support the next course *and* "aims" at the center of the viga. Fill in each side, rub the joints and trim the tops at the same inward angle. Now build up the front and rear walls enough to support the second course, place the slope points at 27" above the quarry surface and 42" apart and repeat. The third-course slope points should be 38" above the quarry surface and 22" apart and the side-by-side peak vigas will be 44" above the quarry surface (with your two largest vigas). Bevel the opposing fourth-course blocks so that they meet nicely at the peak. It's nice, but there's no need to overlap courses, because the vigas just hold the blocks in place during construction - the real strength of this roof comes from the parabolic arch itself. Cover generously with loose snow and tamp with shovels. Rub down the entire outer surface. Cut a door and build an entrance tunnel, and polish the interior. Comments: stronger, and sheds new snow better, than any other viga plan, but requires a little more snow (7%) than the *Casita, Roundhouse, Barrel Vault* and *Chalet*; the rectangular floor plan with a gear bench is also more efficient than a circular one; strong, fast and easy; you can hang things from the vigas if loops are put in during construction; if the snow is not deep enough to excavate the floor, then build on a platform like the *Slip-form.*

15. *Barrel Vault*: You'll need at least a dozen straight vigas 3-4" in diameter and 11'-4" long. Following the *Quonset* program, make a trench 66" x 100" and 20" gear bench and decide on your desired peak height (5'-6" is recommended). Two important features of The *Barrel Vault* end walls: (a) the lower portion will be a "buttress" wall that extends 30" past the side of the trench at all four corners, and (b) the upper portion will be semi-circlar with a radius/height a little less than half the width of your trench. Subtract the radius and trench depth from the desired interior peak height and build up the buttress end and side walls - with a small inset of about one inch per 8" course *just on the side walls* - to achieve that height on all four sides of the trench (starting each course with the corner overlaps, etc.) then trim the tops level. Lay up front and rear walls another 16-18", set a round metal stake (Easton 9" aluminum) at the top of the lower wall portion to mark the center of each semi-circular arch and use a string with loops formed at radius length and a second stake (REI blue 6") to scribe this section of a nice semi-circle on each end wall, then cut, holding the wall gently with one hand. Pick a good block and lay it, long dimension up, on a side wall leaning against the end arch, and cut a slope (chord) in the end wall arch so that the block lays flat against the slope cut. Remove the block and make the same cut at the other three corners and trim them by eye to be identical. Saw a

deep notch down the center of each side wall and pack your smallest, straightest viga as a "bond beam" into this notch to keep the walls from bowing out. Then drop all four corners blocks in place, setting in soft new snow, rub down and notch out for another pair of small vigas so that they do *not* project above the top of the corner blocks. Fill in each side, rub all joints and trim the tops at an inward angle to support the next course. Now build up the arches enough to support the second course and repeat, but this time put in *two* vigas – one to support the bottom and the other the top – for the second course. Continue in this fashion, but add a third (the largest) viga in between when you get closer to the peak and the blocks are more horizontal out; cut a door and bevel the keystone/peak blocks to drop in place. When you have finished the vault, build up the buttress walls on the outside to the top of the second course, trim these walls in a neat curve and rub down. Cover generously with loose snow and tamp with shovels; put the vent high over the gear bench and make a nice entrance tunnel. Comments: a roomier feel than the *Quonset* even though it requires less snow for the equivalent floor area and peak height; if the snow is not deep enough to excavate the floor, then build on a platform like the *Slip-form.*

16. *Tunnel Dome solo*: a palace compared to the *A-frame solo*; this design uses 8" courses; a bivvy is essential. Av-probe and select/make a flat spot with deep snow (at least 18" after compaction) and stomp out a rectangle that is at least 8x16', with the front entrance/face on an 8' side and the 16' dimension perpendicular to any slope. Put a colored stake at the mid point of each 8' side and string a line between them, then cut vertically along this line all the way from the face to a point that is 2' from the rear stake. Set the third stake on this line 4' from the rear stake to mark the dome center. Then make vertical cuts as long as, and 10" on either side of, this line to make the entrance trench and quarry 18-24" long block from the trench starting at the face and stopping no less than 6" before reaching the dome center stake. Use the tape/string and dome center stake to scribe a circle with a radius of 2' (the interior of the dome wall) and cut around the circle – note: you can leave one side of the trench intact as a sitting/gear bench if you think it will work - then quarry/excavate the floor area. Fill in the trench to the top with chunks/blocks to make a temporary support wall for a 10" wide wall and lay a long block flat with the 20" dimension to the interior, centered on the trench. Working with full block in both directions away from this first block, complete the dome (see *Flat-block* above for details) working entirely from the outside. (Here is a recipe for a Flat-block dome with a nice interior peak height before the floor is quarried out, showing the distance from block face to opposing block face for each 8" course: #1 = 48", #2 = 43", #3 = 38", #4 = 33", #5 = 25" and #6 = 15".) Finally cut the entrance profile by taking out the temporary support wall and the course above it, and build an entrance tunnel that extends at least 3' from the dome exterior. For a tunnel this long, you should start the second course with half-block to get proper overlapping. Push all the debris out, sweep the floor, then plaster and pat down. Comment: use the dome for sitting and eating, your sleeping pad will extend into the tunnel; use the *Tilt-block* method for the dome if you have excellent block *and* the skill; if you are short on time and the trench is deep enough, put an *A-frame* roof over the tunnel; the dome can be built like the *Roundhouse* if you have the vigas and want more room inside; if the snow is not deep enough to excavate the floor, then build on a platform like the *Slip-form.*

17. *Tunnel Dome 2*: for two people; 8" courses; bivvy's required. Stomp out a quarry, and set a colored stake to mark the dome center 7' in from the center of the entrance/face, and check to see that there is enough room for two sleeping tunnels, terminating 10' away from this stake with approximately 120 degrees of angle between them, pointing away from the entrance axis to form a "Y". Use the other two stakes to string a line from the center of the face, running over the dome center stake, to a point 30" past the dome center stake, and cut vertically along this line (remove and replace the center stake). Then make vertical cuts that are the same length as, and 10" on either side of, this line to form the entrance tunnel trench. Cut and remove 18-24" long blocks from this trench, starting at the face and ending no less than 6" before reaching the stake. Then use the center stake to scribe a circle with 30" radius (the dome interior) and quarry the entire interior – there is no room for a sitting like the solo version. Fill in the entrance trench to the top with chunks/blocks as a temporary support for a 10" wide wall, then cut 20"-wide trenches through the wall foundation for the two dorm tunnels (try to have equal wall segments between the three tunnels) and fill them in the same way. Lay the first course of block with the long dimension forming the inside wall, and a full 20" block centered on each of the three temporary walls, then fill in between these blocks. Working entirely from the outside (see Flat-block above for details), construct the entire kiva dome. Then make the entrance tunnel, go inside and cut the arches for the dorm tunnels at the cuts. Go outside and make the dorm tunnels with an interior that ends at least 6' from the outside wall of the kiva dome; bell out the lower sides if you want more space. For dorm tunnels this long, you should start the second course with half-block to get proper overlapping. Comments: high efficiency when two people work together on a small dome, then each makes a customized dorm tunnel; if you are short on time and the trench is deep enough, put an A-frame roof over the dorm tunnels; if 5' diameter seems too cozy for the kiva, make it just a little larger; stash your packs upright, and full of the gear you won't need during the night, at the end of the dorm tunnel and sleep with your chest/shoulders in the kiva for maximum comfort; do *Tilt-block* if you have excellent block *and* the skill; the dome can be built like a *Roundhouse* if you have the vigas and want more room inside; if the snow is not deep enough to excavate the floor, then build on a platform like the *Slip-form*.

18. *Emergency solo*: Have a bivvy sack for this one, too. Find a protected place with deep snow and stomp down an area that's 4' wide and 10' long going across the slope. Without delay, start at your entrance end and cut/dig out a 24"-wide trench down the center of your packed area getting down as close to the ground as you can and setting the chunks on the perimeter of the stomped rectangle. You'll now fill this trench with something bulky that you can pull out after covering with tamped snow. One option is to wrap your backpack (if it's a big one) in a tarp (5x8' Heatshield will work fine), and slide it out as you finish each section. The other is to fill three 55-gallon contractor trash bags with air - hold open the top end and scoop air in with swooping motion, then fill by blowing and seal by twisting the top, folding it once and wrapping with a sturdy rubber band. Lay the filler item(s) starting at the rear end of the trench (put the trash bags with the rubber band toward the door) and cover with snow, tamping with the shovel and lightly with your snowshoes to compact the snow, leaving the front end accessible, until

you have at least 24" of hardened snow covering the item(s). Note: If you're using a pack, slide it gently out from the accessible end and make the roof in stages; if using trash bags, deflate them before pulling them out. Let it sit for 15 minutes while you make a gear locker, wind walls, etc. Use the saw to trim out an arched tunnel and finish with an inclined entrance face for the door flap. Comment: Flag liberally with orange tape and trekking poles. If you brought them, the trash bags can serve as a door flap and ground tarp.

K. FABRIC SHELTERS

1. BD *mega-mid*: Stomp down a large level circular area of deep snow and set up a Black Diamond Mega-Mid tent with the center pole on a solid platform (like the pole pads described in the next shelter), then excavate around the interior to form benches, leaving the center column as a counter table. Comments: tent is very light; terrific feature for a group meeting area and/or you can sleep on the benches; use large dead men for the guys, keep the tensioners above the snow surface and tamp fully; take a much warmer bag than you would for a snow shelter.

2. *tarp for two*: This is my version of the winter shelter that's favored by NOLS. Get a new 12'x14' poly tarp with grommets and a sharp small, folding ("saddle") saw. Make two 12"x12" squares of ¼" exterior, painted plywood and fasten a little raised crib to hold a 3"-diameter pole in the center. Bring along eight snow stakes and tensioners, two lengths of ≥1/8" brightly-colored cord each 20' long (corner guylines), one length of the same cord 36' long (peak guyline) and two lengths 4' long (side guylines). Find some nifty way (like mini-biners or S-hooks) to clip the cords onto the grommets bring along the number you need based on a sketch of the shelter. At the campsite, find a level spot with lots of snow (shade is not important for any temporary shelter), stomp a quarry that is at least 16' long (the head-to-foot axis) and 10' wide. Find two poles 5' long and 2-3" in diameter at the base (maybe you wisely stashed them that summer?) and cut two V-grooves at least ½" deep in a cross pattern across the top to accept the guy cords. Center one plywood pad on the quarry near the edge at the "head" end, measure in toward the "foot" end 10" for a block wall and starting at that point cut 10x12x18" blocks (the deeper you can go in the quarry the more headroom you'll have) to create a sleeping area that is 60" wide and 90" long leading to a 20"-wide entrance trench on the main axis that extends 3' past the sleeping area. Lay the long dimension of the tarp, including the length of your clips, on this axis and position the second plywood pad. Find the center of each corner guy and tie a good knot (figure 8 on a bight?) on either side to keep the guy from slipping through the grooves at the top of the pole. While one person holds the head pole vertical on the pad, the other should put in the corner guys with dead man anchors - the corner guys should end up going into the snow about 12" from the side of the sleeping area. Do the same for the head end of the peak guy – it should go into the snow about 60" past the pole. With the pole holder putting a little tension on the peak guy to keep the head pole from toppling, repeat the process for the three guys at the foot platform. Keep the cord tensioners above the snow surface and tighten up the guys, then cover the pads with tamped snow, and let it age-harden, to hold the poles firmly in place. Fill the entrance trench temporarily where the foot block wall will be (see instructions for

the block snow shelters above) and lay up block walls (note: the walls can be either 10" or 12" thick) on the surface of the quarry at the head and foot end with the interior face lining up with the end of the sleeping area, stepping in the blocks so that the end walls go above the line of the corner guys. Then trim both walls carefully down to match (or be slightly above) the corner guy angle – you'll have to eyeball across the corner guys to get the walls cut properly. The tarp should lay on these end walls when it is fastened tightly to the guys. Attach the tarp to the guys, put in the two side guys with dead man anchors, and lay blocks gently on top of the tarp along both sides and up the gable ends. Cut out an arched doorway without a tunnel and cover it with a tarp; put vents at the peaks. Use the "front porch" to store gear and change boots. Comments: lots of headroom; you can cook in the front porch, too. Take a much warmer bag than you would for a snow shelter.

3. *4-season tent:* Bring a familiar, 4-season tent with external clips (if there are pole sleeves, they should be short), that does not have fiberglass poles and is sized for an extra person (i.e., 2 people occupy a tent rated for 3 persons). Put big pulls of 6"-long cord or 8"-long narrow webbing on all zippers and corner loops. Put the tent poles against your back inside the pack if it is very cold. Spray the interior surface of the fly with DWR to limit condensation buildup. Bring at least 12 snow stakes (either the curved aluminum ones sold by REI or Mountain Hardware X Stakes or SMC T-stakes), each with 3' extra cord (check out the "Glo Cord" at sterlingrope.com for guys) for each tent. Stomp a level tent area that is at least twice the floor area of the tent, till it bears your weight on foot; mark the tent floor corners and stomp down little depressions for each sleeping pad; create a sitting area with a 12-18" deep hole to put on boots near the entrance or in a vestibule. Set up tents with snow stakes at corners and snow stakes or branches in tamped dead man trenches (loop girth-hitched around middle of stake or branch, buried in snow and covered/tamped), and use *all* guy lines. Keep the cord tensioners above the surface of the snow. Put the low end into the wind and tension all the guys for maximum strength. If this site is exposed to the wind, build wind walls that are high enough to cut down the wind but not so close to the tent that they cause wind-borne drift to reach the tent – horizontal drift is typically 5 times the wall height. Wind walls should be 3' high and extend 2' past either side of the tent. Pile snow around the base of the tent that touches the tent and is about 3-6" inches high to block snow from blowing in. Unless you expect a storm, pile up and tamp snow 6-12" around the perimeter of the tent fly with someone pushing out from the inside, leaving some path for ventilation at both ends. But if you expect a storm during the night, try to dig deep trenches close to the tent, but away from the guy lines, so that snow sliding off the tent can fill up the trenches first. Place stuff sacks with gear around the insides for extra insulation. Comments: take a much warmer bag than you would for a snow shelter.

4. *tree pit*: Enlarge the natural snow hole under a large, healthy conifer and experiment with a tarp and roofing structures of various materials (vigas, branches, drift snow blocks, etc.) . Comments: a (single-wall?) tent might fit under a larger trees, but anticipate staking problems in frozen ground or heavily-metamorphosed snow; trees add protection and reflect back some of the radiant heat; pick a tree without (or trim away) dead branches that could fall on you; finding, preparing and GPS'ing the location of this tree in

the summer would be an excellent idea; the first spot to consider when making an emergency shelter because the tree can be so protective. Take a warm bag just in case.

L. REFERENCE MATERIAL

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