CROSS COURSE INSTRUCTION DOCUMENT

white
INDUSTRIES
SNOW CONSTRUCTION

CANADA
SKI CROSS

canada snowboard

Table of Contents

CROSS COURSE DESCRIPTION

A Cross Course is a race track that is built out of snow and is designed for 4 or 6 skiers / snowboarders to race together at one time. A well designed cross course has the adjustability to be used for both low and high ability users. Depending on the purpose and the ability level of the user a Cross Course can have banked corners, rollers or various forms of jumps within the course line. It can be constructed purely out of snow or the course can have an in ground structure completed to conserve snow volumes.

CRITERIA FOR SBX/SX RUN SELECTION

Gradients / Slope inclinations

- Ideal run gradients vary from 0 – 20 degrees.
- Consistent high gradient slopes ideally would be avoided. High gradients would be considered to be 15 – 20 degrees.
- Consistent low gradient slopes may cause low speed issues during snowfalls. Low gradients would be considered to be 0 to 5 degrees.
- The average ideal gradient should be between 5 - 15 degrees.
- A slope can have a negative gradient for a short duration, providing that the speed preceding the negative gradient is enough to carry the user through the particular section.
- Gradients above 20 degrees can be acceptable for short durations providing they are followed by lower gradients to control the speed of the user. Short steep slopes are often integrated into the design and used for jump landings.

Run Width

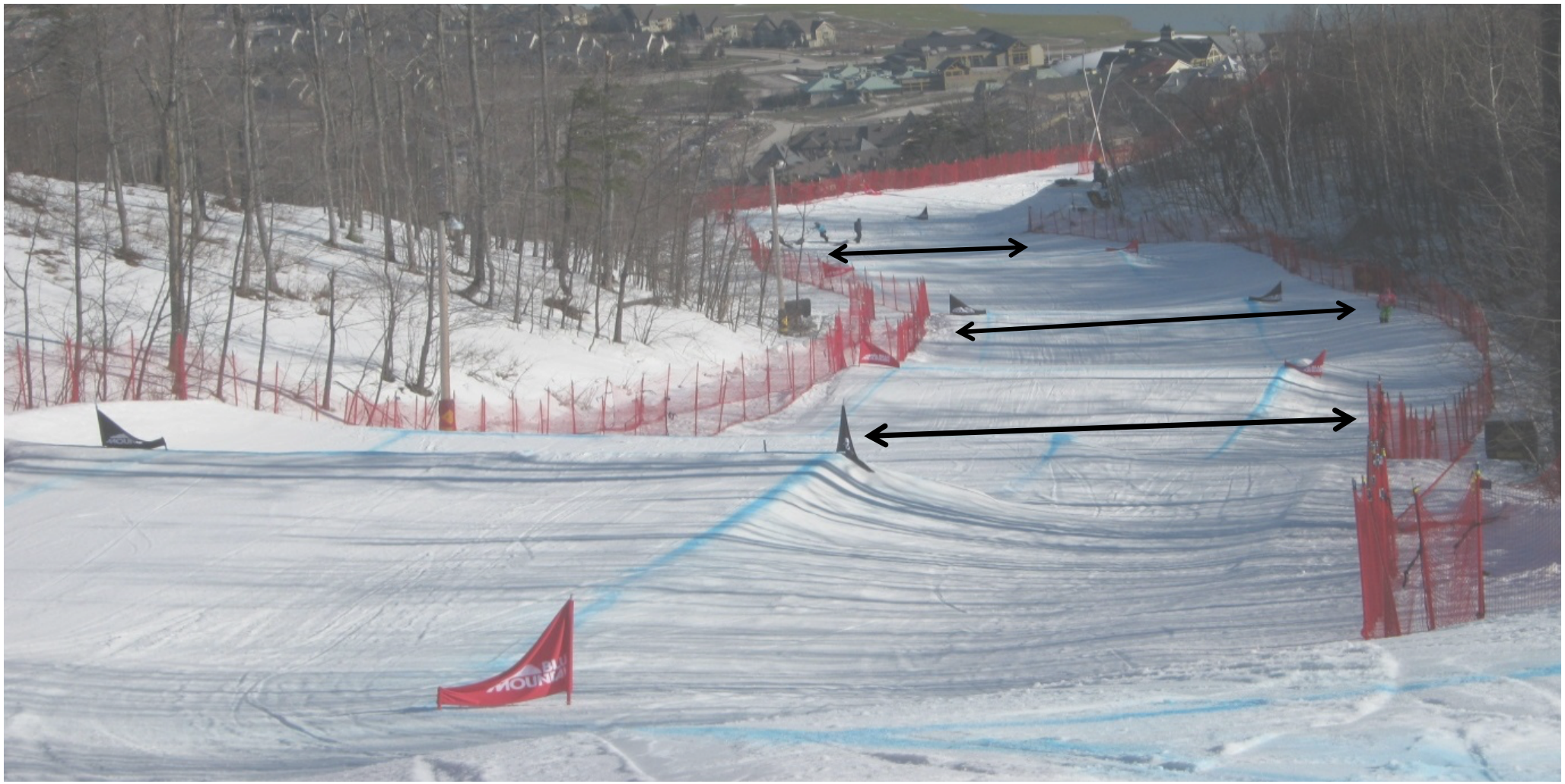
- Run width should be a minimum of 65 meters wide.
- Additional run width is needed as slope gradients increase. The additional run width allows the course to traverse the steeper slopes to moderate the course gradients.
- A run width of less than 65 meters is acceptable providing the slope gradients allow the course to run fall line for a period of time. The length of time running fall line would be determined by the inclination of slope. A slope gradient of 5 degrees or less would allow the course to run fall line for a longer period than that of a slope with a slightly higher gradient. Slopes beyond 8 degrees usually run fall line only to transition into a jump landing.
- Essentially the flatter the slope the narrower the run with can be.
- Run width will effect safety installation and recommendation. See safety recommendations within this document.

The picture below shows a slope with undulating features that is over 65 meters wide. It had steep pitches for potential jump landings and flat benches for potential banked corners.

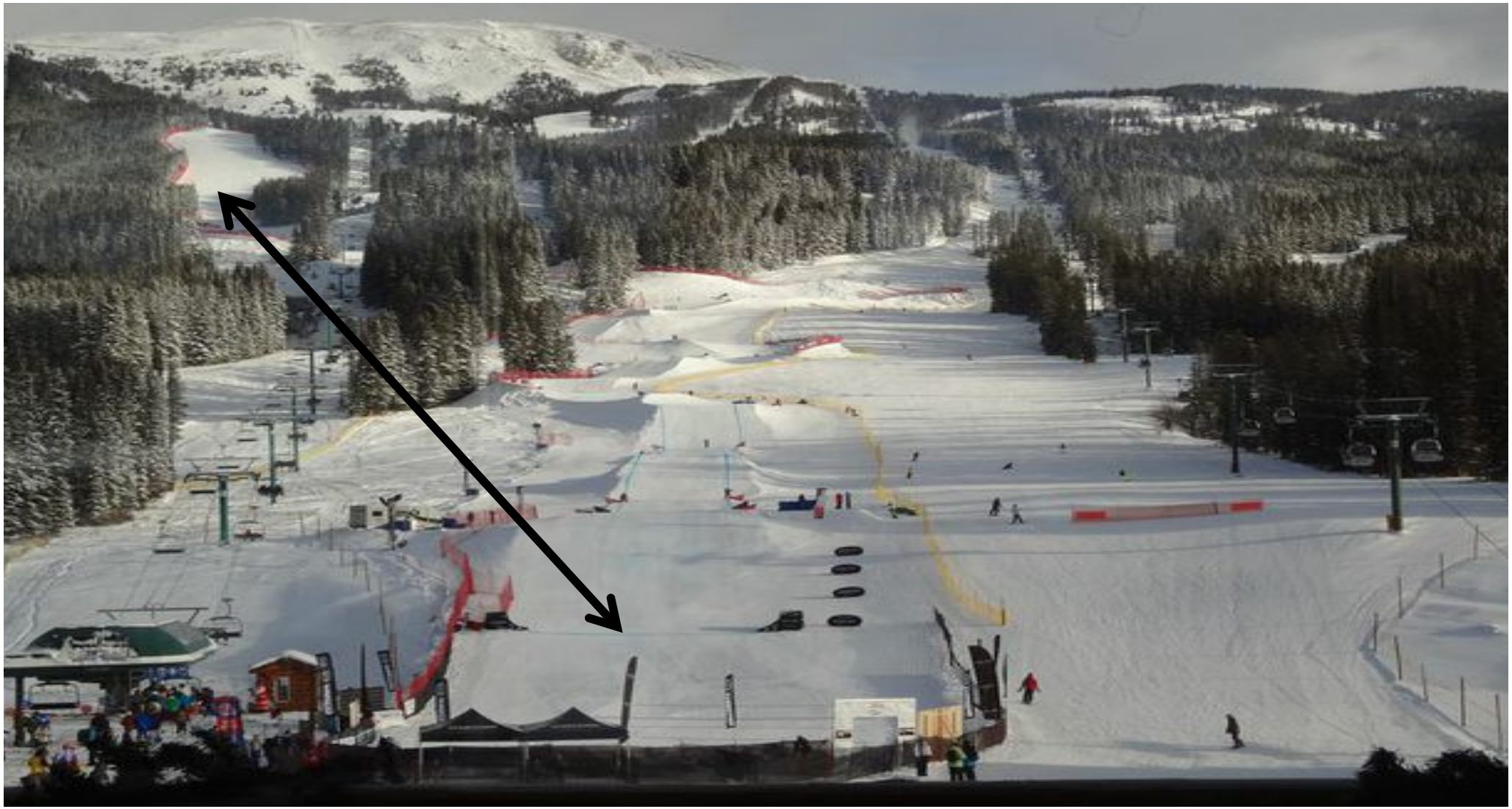
The run below is less than 65 meters wide with a low slope gradient. This allowed the course to run fall line for a short duration with safety installation.

Vertical Drop

- 100 meters minimum
- 220 meters maximum



The picture below shows an example of a large scale (World Cup Course) with 190 meters vertical drop.



Level of Courses

There are 3 different levels of courses, beginner, intermediate and advanced

Beginner Course

- Average speed should be lower than that of an intermediate or advanced course this can be controlled by the location and length of the start section.
- The course should have a good flow and a mixture of banked corners and rollers both large and small that are spaced well and easy to absorb.
- Ideally suited for families and lower level riders
- Ideally suited for low level users and competitions.
- Would not have jumps are abrupt obstacles within the course line.
- Is easily maintained with a snow cat by doing single passes down the course each evening from top to bottom.

Intermediate Course

- The average course speed would be slightly higher than that of the beginner course. This can be controlled by the location and length of the start as well as the gradients throughout the course.
- Ideally suited for intermediate to advanced skiers and snowboarders.
- Is well suited for intermediate level competitions.
- The course should have a good flow with a mixture of banked corners, rollers, and intermediate sized jumps.
- The course would require additional time to maintain the features present on the course.
- A well designed beginner course could be easily modified to resemble an intermediate course. This can be done by elevating the start section to increase the speed leading into the course. With any additional speed the features found within the course would also need to be modified from the easy to intermediate level.
- Adversely an intermediate sized course can easily be detuned to resemble a beginner course by decreasing the course speed and adjusting features throughout the course to fit the lower ability user group.

The pictures below show 3 examples of intermediate courses and features.

Advanced Course

- The course speed is greater than that of the beginner and intermediate course.
- Ideally suited for advanced skiers and snowboarders.
- Constructed mainly for high level competitions.
- The course would have a good flow with a mixture of banked corners, rollers, and a variety of different sized jumps.
- Extensive maintenance is required to maintain the features on a nightly basis.
- An advanced sized course once constructed can easily be detuned to resemble an intermediate or a beginner course by decreasing the speed and adjusting its features.

The 3 pictures below show examples of advanced courses and features.

Ideal Slope Characteristics

Start Section

- Ideal start length is 100 meters or longer.
- Minimum start length is 85 meters.
- For an intermediate or advanced course the start section would ideally be a maximum of 17 degrees. At 17 degrees the start section should be no longer than 85 meters in length. Start section length may be increased as slope inclination decreases.
- Start length and slope angle are critical to setting an ideal speed for course use. An ideal speed is where the user is able to negotiate the course comfortably and maintain a consistent speed moving over features placed within the course.
- For lower inclination slopes it's preferable to have start section lengths of 100 meters or greater.
- The start section would ideally be straight and level from side to side enabling the athletes to remain flat based and separated from one another.

An example of a long low gradient intermediate start section

An example of a short high gradient advanced start section

The Course

- Would have an average grade of 7 – 9 degrees when constructed on low gradient slopes.
- Would have an average grade of 9 – 11 degrees when constructed on higher gradient slopes.
- Would be constructed to match the level of the user group.
- Would control the speed of the user.
- Wouldn't run fall line on steep slopes with the exception of where a steep slope is being used as jump landing.

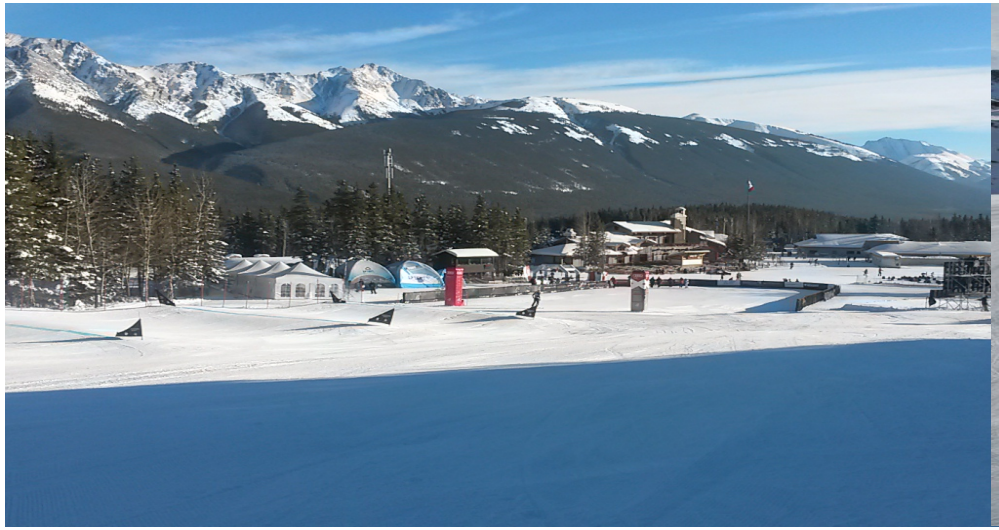
An example of an intermediate course with its features

An example of an advanced course with its features

The Finish Section

- Ideal set up would have the user running straight for a minimum of 60 meters before going off the final feature.
- The finish area would be flat in character and be a minimum length of 60 meters in length. The finish area should allow the athlete to come to a controlled stop. Ideal gradients of 0 – 3 degrees.
- Length of the finish area would increase as the speed of the course increases. Maximum of 75 meters.
- Finish areas are ideally 30 meters wide or greater. Width would increase as course speed increases.
- The finish line and its structures would be located 30 meters from the point of landing of the user.

The pictures below show 2 examples of finish areas:



The Ideal Slope

- Would have a start section that is between 6-14 degrees and be 100 meters or more in length.
- Would have a start section that runs fall line with the slope.
- Would be a slope wider than 65 meters in multiple areas.
- The slope would have a variety of gradients.
- The slope would be level from left to right (not hanging) and be clear of any debris that would interfere with construction.
- Would allow for the course to meander in many directions.
- Would have a straight section that is over 60 meters long before the final feature.
- Would have a finish that is 0-3 degrees and is over 30 meters wide.

Characteristics of each Course Section

Staging area (For event purposes only)

- Ideally be flat and level.
- Can be located beside or above the start area.
- Minimum measurements of 20 meters wide x 15 meters deep or a shape that is equivalent to these measurements.
- Large enough to accommodate all athletes and support crews for the particular event to be held.

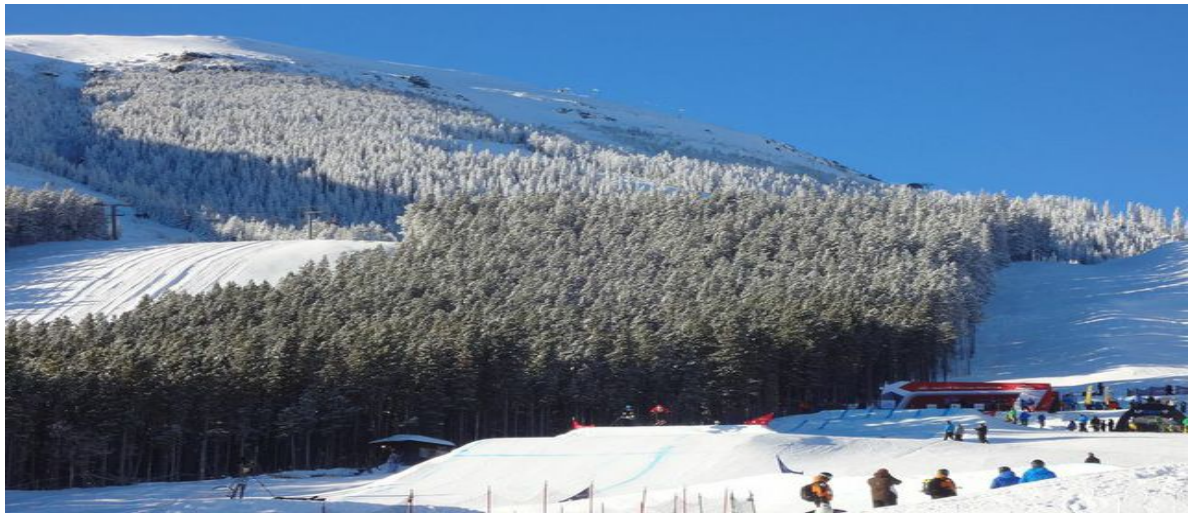
Start gate area

- Flat and level to allow for start gate placement
- Deep enough to allow athletes easy access into the start gate from behind.
- Wide enough to allow for start structure / branding etc.
- A typical start area would be a minimum of 12 meters wide by 5 meters deep.
- Additional room would be needed for larger scale events with larger structures.
- A wider start area is needed for six person heats.

Start Section

- Would have a minimum of 2 features before the first corner to separate the athletes.
- All the features should be in line and spaced appropriately with each other.
- The start gate and all the start section features should be in line with the first corner.
- The outside lane in the gate should be lined up to the most outside race line into the first corner.
- Fast start sections ideally would be followed by a low gradient slope after the first corner to control the users speed. Alternatively, a series of corners spaced appropriately could be used to control the speed of the user.
- For high level courses different feature options can be used to control the speed of each user through the start section. Having steep transitions out of the start on higher level courses helps lower the overall speed. With gradients and length of slope being equal, if rollers were put in place of the steep transitions additional speed would be generated.
- When the starting speed of a course is low steeper transitions can be constructed.

An example of an advanced start section with multiple features before the first corner.



First Corner

- Would have the athletes turn no more than 90 degrees. This would decrease compressional forces on the athletes as they travel through the corner.
- Ideally have a good shape to allow for easy edging thus resulting in less compressional forces on the user.
- Would be of appropriate size to accommodate all the athletes at one time.
- Would have a smooth transition at both entrance and exit.
- Corners that carry on for long periods (hang/dogleg) are not ideal. Turns such as these will lead to the athletes bunching together in one area of the track.

An example of a short start section with a large open first corner less than 90 degrees.

Second Corner

- Would be an appropriate distance away from the first corner in relation to the speed of the user.
- Ideally would turn the user in the opposite direction of the first corner.
- Would be in line and connect well with the first corner.
- Be of an appropriate size to accommodate all the athletes at one time.
- Can be a full wrap around corner providing it is large enough to accommodate all the athletes.
- Would be of appropriate size to dissipate compressional forces put on the user.
- Would be a full arc corner and not just a slight bend. This will keep the user from bunching into one area of the track.

An example of a second corner close to the first corner but large enough to accommodate all the athletes at one time.

Third Corner

- Ideally the third corner would turn the user in the opposite direction of the second corner.
- Would be in line and connect well with the second corner.
- Would be a full arc corner and not just a slight bend. This will keep the user from bunching into one area of the track.

After the third corner to the finish section

Design and Construction from the third corner to the finish section can be up to the builder / designer's discretion providing it follows the basic construction principles.

- Ideally the features on course would match the course speed resulting in a good course flow. The faster the course is the larger the features would need to be (excluding single roles which would become smaller as speed increases)
- Would allow for space to follow each corner. This would allow for the user to set up or become flat based before encountering another feature.
- Would have features that are in line and aligned with each other in the direction of travel.
- Ideally would have crash zones between features thus reducing impact dangers if a fall was to occur.
- Would have space in between features to enable the user to travel comfortably from one feature to the next.
- Would have jumps or rollers that match the speed and characteristics of the course.
- Landings would be of appropriate size to the takeoffs. Landings would match the speed of which the user is travelling. Long landings are the most ideal in any situation. Try to avoid concave depressions at the bottom of landings.
- Features that have smooth transitions and edges are most ideal. (excluding the start area where speed is low and controlled)
- Attempt to use features suitable to the slope characteristics. Each feature on course is unique in relation to where it is placed on course
- Whenever possible maintain a clean venue with the course and surrounding areas being clean and smooth.

Constructing a SBX / SX Course

Snow & Snowmaking

- Snowmaking ideally would be present to build a large scale SBX/SX course.
- For a small scale SBX/SX course natural snow would sufficient depending on annual snow depths.
- Natural Snow can be used for large scale events where annual snowfall and depths are proven to be sufficient.
- Snow depths required to build courses varies greatly on the terrain in which they are to be built. If the slope is steep and not cleared well of brush, rocks and other debris the snow requirements will be substantially more than if the run is of a lesser gradient with a smooth surface.
- Snow volumes also depend on the features desired within the course. Ex. A small roller would take less snow to construct than a large jump.
- Snow requirements will be less if the course and its features are built to suit the natural terrain.

For a large scale course such as a World Cup snow volumes are calculated as follows:

- The below depths are based on a run that has a smooth surface that is free of rocks and debris.
- The below depths are based off an average slope width of 65 meters.
- The below amounts are the recommended depths that would be required to build a large scale event. (World Cup or Equivalent)
- Snow quantities required vary as the slope gradients increase or decrease.

Degree of Slope	Snow Depth Required
0-8	1 meter
8-14	1.2 meters
14-22	1.5 meters

For tracks that are smaller in size the snow amounts required would be proportionally less to match the size of course desired.

Summer Ground Work

- Summer ground work can greatly decrease yearly course construction and maintenance costs.
- Summer ground work increases safety by decreasing the amount of steep ledges and drop offs formed from piling snow to build features.
- A course should be proven to work before committing to ground work. A consultant should be brought in to design a course that will be both safe and fun for the user. Before committing to earthworks an assessment should be made of the site where the course is to be constructed. The type of ground where the course is to be constructed will have a great effect on costs involved.

Prince George, Canada Winter Games 2015

Before Construction

After Construction

Time, Snow and Venue

These three principles each play an equally important role in a successful build.

Time

- Allow yourself enough time to build the course.
- If the amount of time to build is not sufficient look at other options such as shortening length of the course or having a more open section within the course running line .

The amount of time it takes to build a course depends on the amount of snow available and the characteristics of the chosen venue.

Snow

- With insufficient snow volumes building a challenging and safe course will be difficult.
- Resources could be wasted due to excessive snow farming and other measures.
- Adversely with too much snow machinery and resources could also be wasted.

The amount of snow required to complete a build depends on the characteristics of the chosen venue.

Venue

- The venue really plays a large role in the amount of time you need to complete the build as well as the snow amounts.
- A venue that has ideal slope characteristics for Cross Course Construction will take less time and less snow to build.
- A venue that does not lend well to Cross Course Construction will take more time and more snow to construct.

The characteristics of the venue will affect the amount of time and snow it will take to complete the build.

Effects of weather

Due to the effects of weather and snow conditions the course over a period of time has the ability to increase in speed or decrease in speed by 25%.

Speed increases from:

- Thawing of the course and freezing.
- Snow crystals bonding and becoming denser after course use and repeated grooming.
- Type of snow used during construction. Snowmaking versus natural. Wet versus dry.
- Amount of course maintenance completed.
- The time of day which course maintenance is completed and
- Grooming techniques used.
- Slope maintenance procedures using salt, fertilizer, water injection.
- Seasonal factors such as temperature, humidity and sun exposure.

Speed decreases from:

- Snowfalls.
- Amount of course maintenance completed.
- The time of day course maintenance is completed.
- Grooming techniques used.
- Seasonal factors such as temperature, humidity, sun exposure.

Safety

Safety Considerations

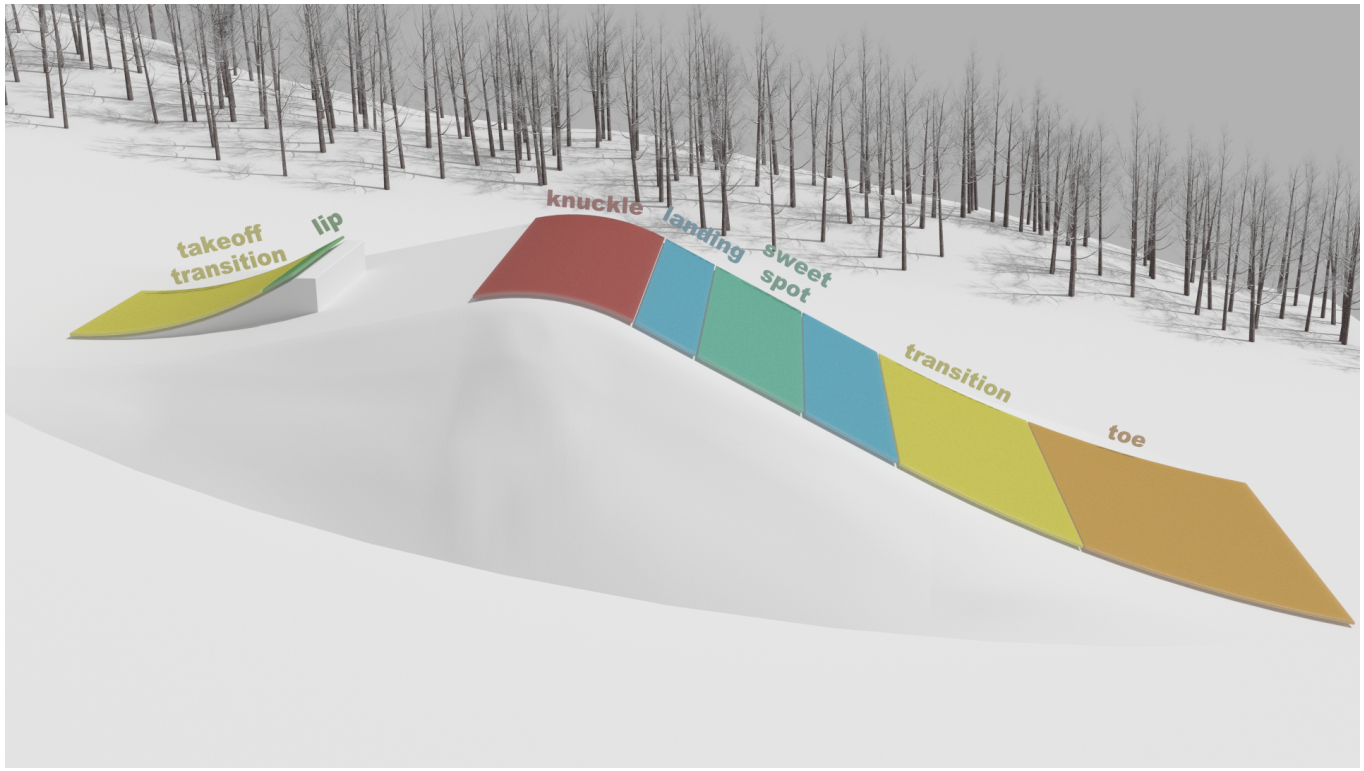
- Safety installations in front of objects.
- Safety installations on corners.
- Sharp edges on features.
- Alignment of the course away from fixed objects.
- Locate jump take offs after and away from dangerous objects.
- Clean up debris around the course line.
- Crash zones.
- User set up time before and after take offs.

Course Features

** TO BE EDITED

General Info

A feature will generally consist of the following areas:



Difficulty Rating:

Each feature is given a difficulty rating, which will help you decide what features should be included in your course. This important thing to note is that although a feature may be considered good for a beginner course does not mean it cannot be included in a more advanced course.

Beginner Features

Banked Corners

Placement
Can be placed anywhere there needs to be a direction change.
Speed Range – All
Difficulty – Beginner to advanced
Ideal traits and best practise for constructing corners:

- Create fun and excitement for people of all ages and abilities
- Match the speed of the user and dissipate any compressional forces upon the user.
- Smooth open radius throughout.
- Smooth transition at the entrance and exit.
- Be large enough to accommodate multiple users at one time.
- Creates the direction of travel for the user.
- If the bank is to be used for competition purposes there should be enough room to install B nets for safety on the top of the corners. Ideally 45 -70cm.

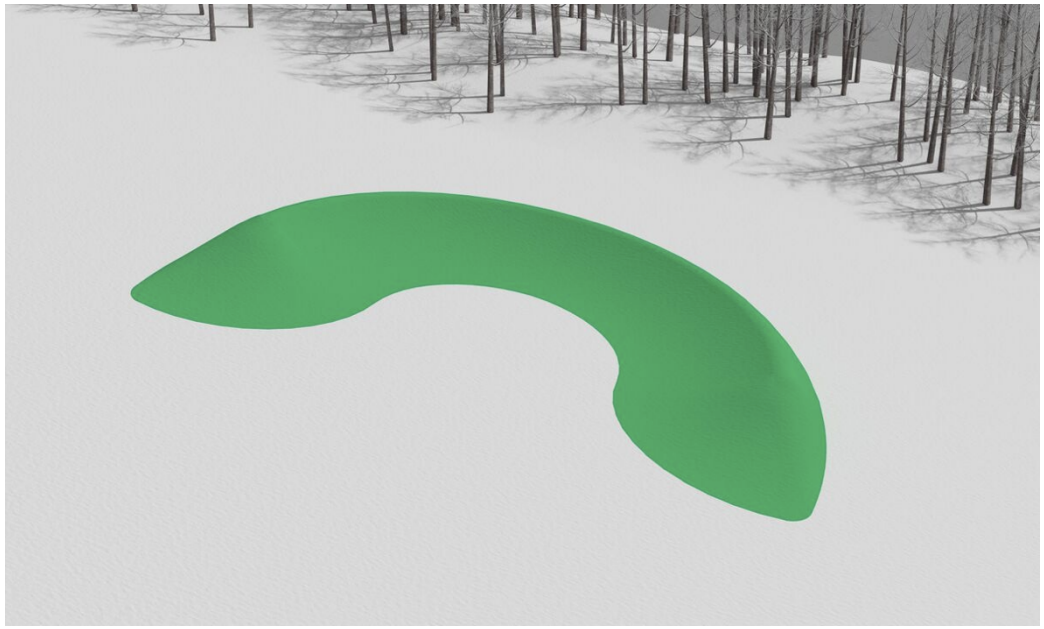


Table Top

Placement

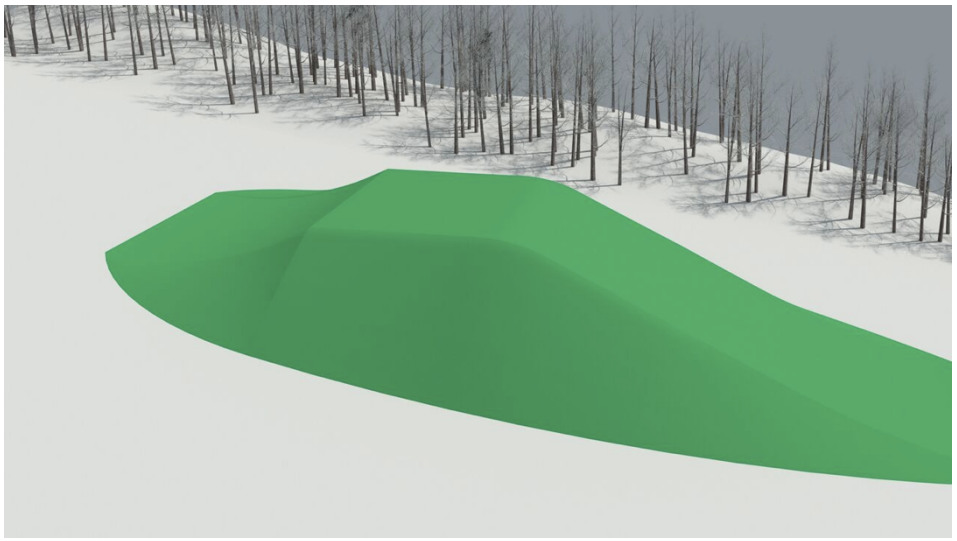
- Flat – medium gradients
- Consists of a take-off, flattop and landing

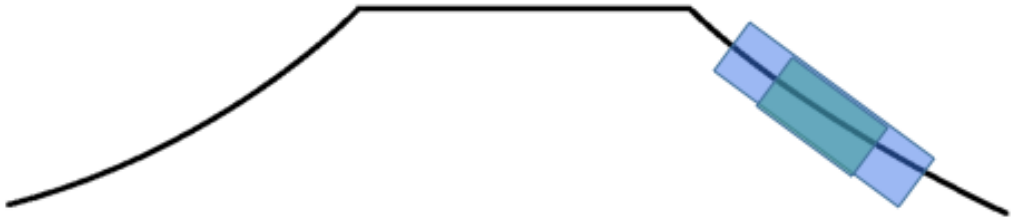
Speed Range - Slow to Med

Difficulty - Beginner to advanced

Notes:

- Safe jump when implemented correctly into a cross course.
- Not ideal in high speed situations unless it's placed on a break over of a steep slope to increase landing length.
- Table tops built on flat or low gradient slopes would ideally be used at lower speeds due to the inability to create a long landing.
- When a table top is built on a medium gradient slope the landing zone lengthens while the takeoff length tends to becomes smaller. In some cases if the table top was built on slopes with a greater inclination it would have the ability to accommodate higher speeds.
- Take off angle should match or be slightly less than the landing





Single Roller

Placement

- Can be placed anywhere on a cross course.

Speed range- All

Difficulty – Beginner to advanced

Ideal traits and best practise for constructing rollers:

- A roller can be used as a cornering feature
- The size of a roller should be proportional with the speed travelled by the athlete.
- As speed increases a single rollers size should decrease.
- Can be consistent in shape from left to right or built higher from one side to the other.
- Would have consistent ramps on approach and exit of the roller.

Intermediate Features:

Corner Jump

Placement

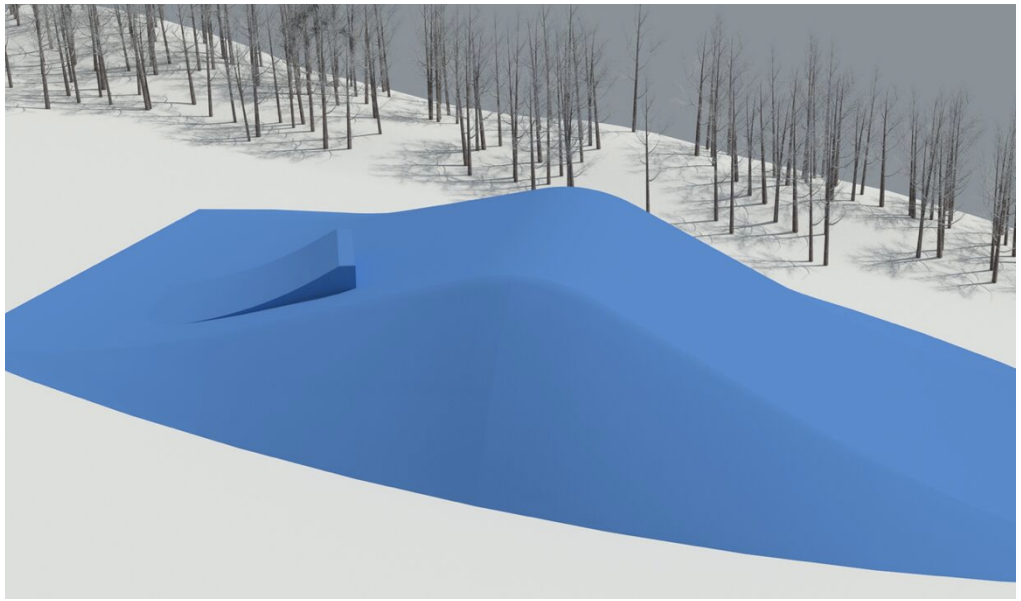
- Medium gradients.
- Consists of a take-off that is set at slight angle to a landing. A flat deck.

Speed Range - Med

Difficulty- Intermediate to advanced.

Notes

- Works great in areas where there is a break over or a slope undulation.
- Ideal for areas that require a slight change in direction.
- The jump and the landing have to be aligned well to allow the user to use full width of the take-off.
- The landing should be significantly wider than the take-off.
- Can be constructed in many different ways. Step up, step over and step down.
- See step up, step over or step down for construction principles.



Double Rollers

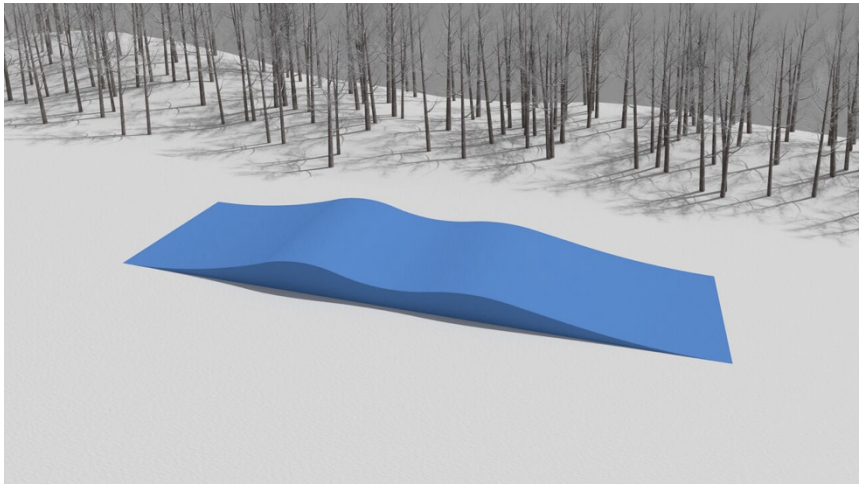
Placement

- Placed on low gradients.
- Consists of two rollers in a row.

Speed ranges- Slow to Fast.
Difficulty – Intermediate to Advanced

Ideal traits and best practise for constructing Double Rollers:

- Size of rollers would be proportional to the speed travelled.
- Distance between rollers would be proportional to the speed travelled.
- Shape of the front roller (Take off roller) would be constructed to enable the user to clear the set distance to the second roller (Landing Roller).
- The landing roller would have a transition that matches the takeoff roller.
- The approach (front face) of the landing roller would be constructed in a manner that would allow the user to still maintain forward momentum if they were not able to clear the distance between the two rollers.



Multiple Rollers

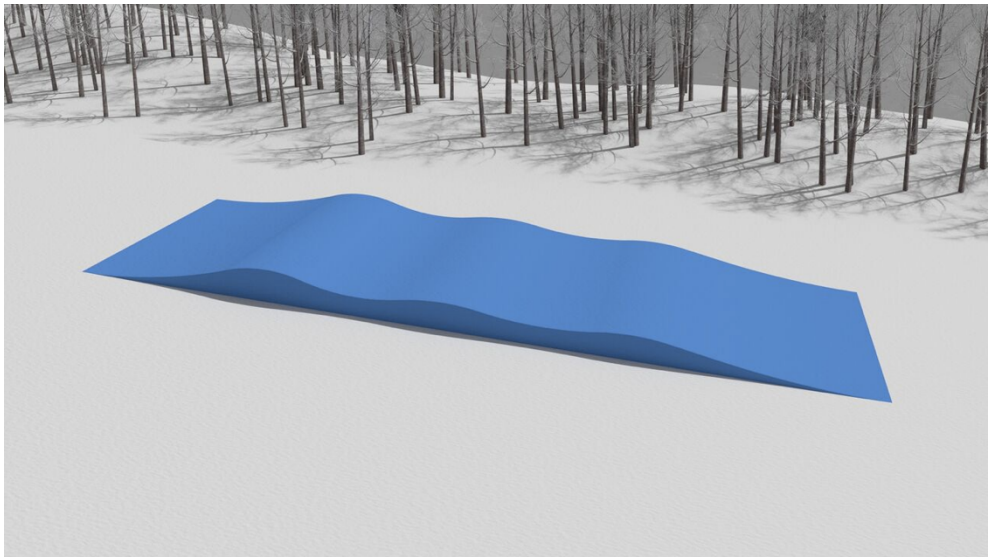
Placement

- Used on low gradients.
- Can consist of two or more rollers in a row.

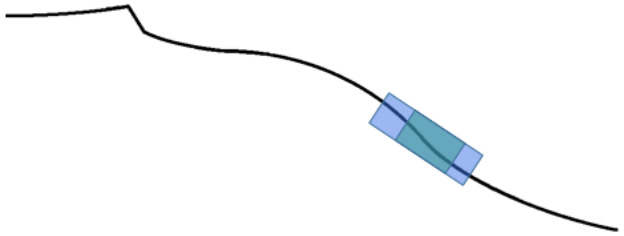
Speed range - Slow to Medium
Difficulty- Beginner to Advanced

Ideal traits and best practise for constructing multiple rollers or roller sets:

- Spacing would enable the athlete to ride at full speed without braking.
- Spacing can be consistent or staggered.
- Multiple rollers can be used as a cornering feature in the mid to lower section of the course.
- Size of rollers should be proportional to the speed travelled by the user.
- Approaches of Rollers (Roller Faces) can be designed with lesser of an incline to reduce impact forces.
- As the speed of the user increases the size of the rollers would decrease proportionately.
- As the speed of the user increases the spacing of the rollers would increase proportionately.



Step Down



Placement

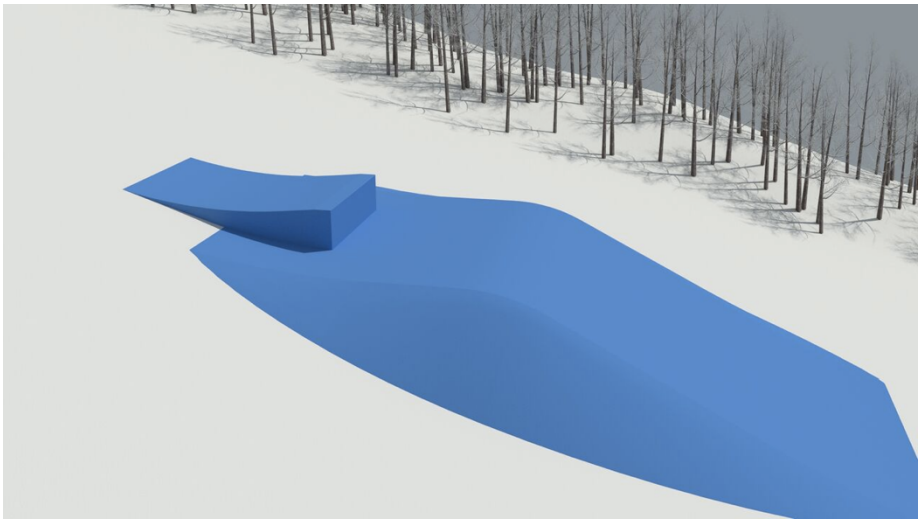
- Placed on medium to steep gradients.
- Consists of a takeoff, a flat deck and a landing zone.

Speed Range – All

Difficulty- Intermediate to advanced

Notes

- A great feature to use when a drop in elevation is needed and space is limited.
- Technical for the user to match transitions
- The takeoff varies between pointing slightly downhill to slightly uphill depending largely on slope gradient.
- The height of the takeoff will also vary do to slope gradients.
- The flat decks size will be proportional to the speed being carried by the athlete and the height of the takeoff.
- The landing should be of a steeper grade than that of the takeoff to create a comfortable landing.
- If set up correctly the user can pre jump the flat takeoff to correctly match their landing.



Step Over

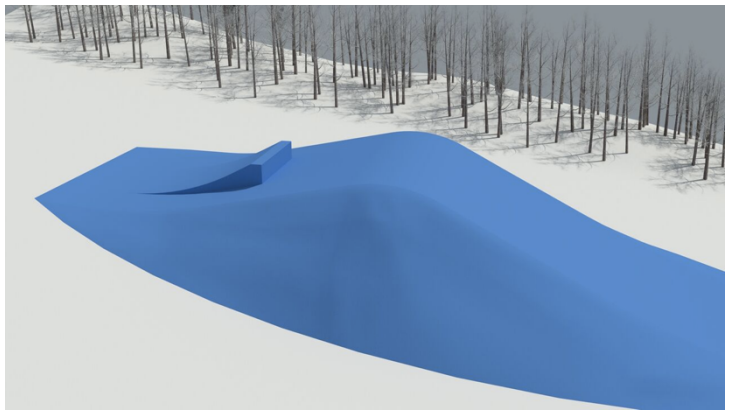
Placement

- Low gradient slopes
- Consists of a take-off and rounded pile of snow to create a landing

Speed Range - Med to High
Difficulty - Intermediate

Notes

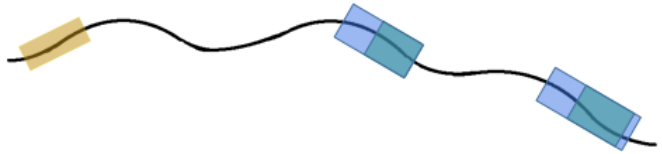
- Used more widespread now than any other jump.
- Can only be built on lower inclination slopes.
- To create the landing zone a rounded off pile of snow is formed where the user would travel uphill to reach the crest of the landing.
- Consists of a takeoff that is set into the uphill side of the landing zone. The height of the takeoff lip is anywhere from ½ way to ¾ of the way up the crest of the landing. This enables the athlete to air over the top of the landing zone essentially following the shape of the landing feature.
- One of the safest jumps that can be constructed.
- The takeoff angle would ideally be consistent with the angle of the landing zone.
- The landing zone should be made as large as possible. It will take more snow to construct the landing zone and take off as slope gradients increase.
- The takeoff angle should be consistent with the face of the landing to avoid any impact.
- With Step Overs there is a possibility for the athlete to overshoot and essentially follow the landing down. For this reason, as with all other jumps it is best practice to not have a concave compression at the base of the landing zone.



Triple

Placement

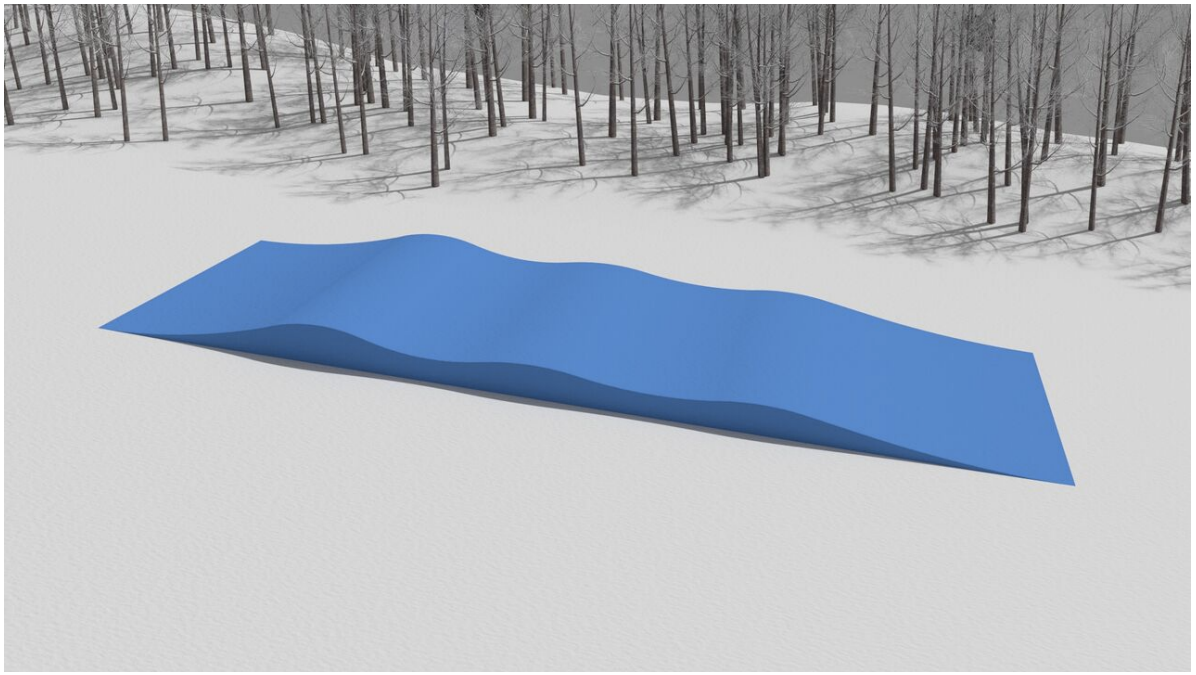
- Placed on low - medium gradients.
- Consists of two rollers and a second landing.



Speed Range - Medium to High.
Difficulty – Advanced

Ideal traits and best practise for constructing Triple Rollers:

- Would enable the user to double or triple.
- The first two rollers would be constructed much the same as a double set as described above. Following the first two rollers (double rollers) a sloped bench would be created that has a downhill profile. A transition would then be put in place after the sloped bench. This transition would be regarded as the landing of the triple.
- The short bench would be constructed with a downhill sloping profile. If the user was to land short of the triple landing this downhill profile would help minimize any impact forces and still allow for forward momentum of the user. It will also allow the user to absorb the impact and transition of the triple if they were to not make the full triple jump.



Wu Tang

Placement

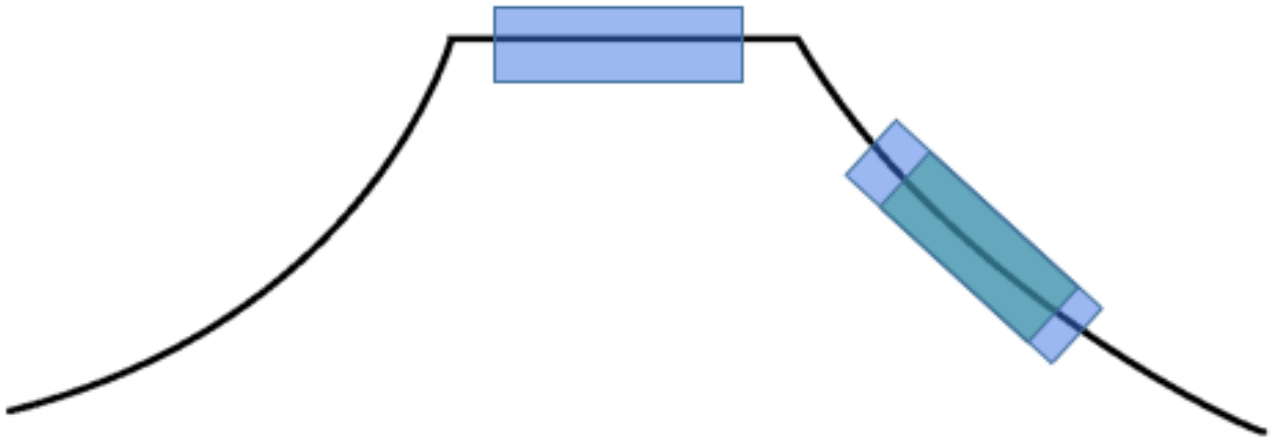
- Flat gradients
- Consists of a take-off, flattop and landing

Speed Range - Slow

Difficulty - Intermediate to advanced

Notes

- Used mainly in the start section where speed is low.
- Not ideal in high speed situations.
- Built to decrease users speed with compressional forces.
- Can be configured to be used as a step up or step down.
- Take off transition ideally would match or be slightly less than the landing transition.



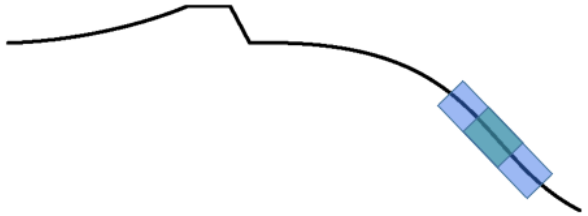
Advanced Features

Cheese Wedge Step Down

Placement

- Medium to steep gradients
- Consists of – Takeoff, flat deck and a landing

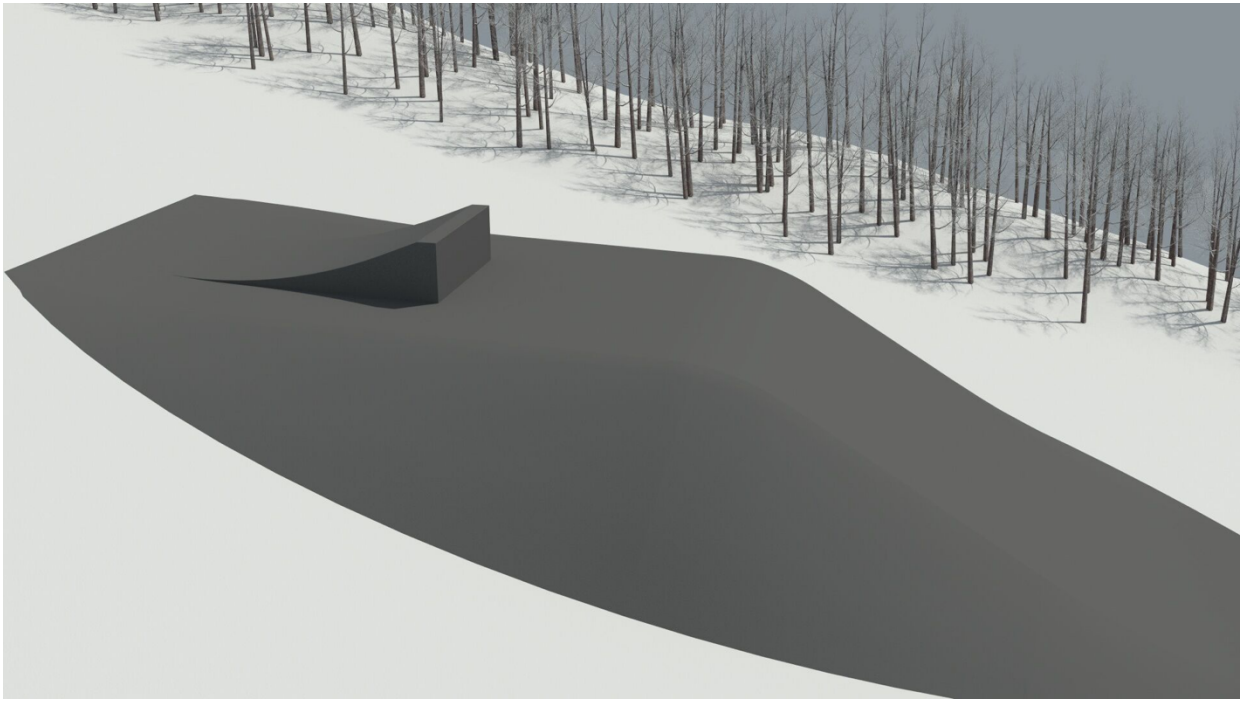
Speed Range - Med to high
Difficulty - Intermediate to Advanced



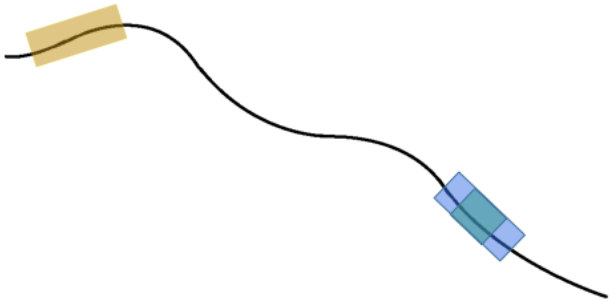
Notes

- One of the original jumps created.
- Should be placed carefully. If used incorrectly the layout of the cheese wedge jump has the potential to send athletes past the landing zone from high elevations. This is mainly due to the size of the takeoff and an athlete's ability and or inability to adjust to the takeoff
- A deck and a landing transition are constructed.
- The deck will reflect the amount of distance traveled from the takeoff to the landing transition.
- Both the deck and landing would be proportional in size to the speed travelled by the user.
- The deck would have a slight downhill grade to reduce impact.
- The knuckle where the deck meets the landing zone ideally would have a rounded off shape.
- The takeoff transition would reflect the speed travelled by the user. The takeoff transition would ideally be equal to or slightly less than that of the landing transition.
- The landing should be significantly wider than the take-off.
- The landing would ideally be as long as possible. The landing will have the ability to be much longer if it is placed on a steep slope. Alternatively, large quantities of snow will be needed to create the ideal landing.
- Ideally at the bottom of the landing zone there is no compression area present and that the transition out of the landing zone is smooth.

Cheese Wedge Step Down



Double Down



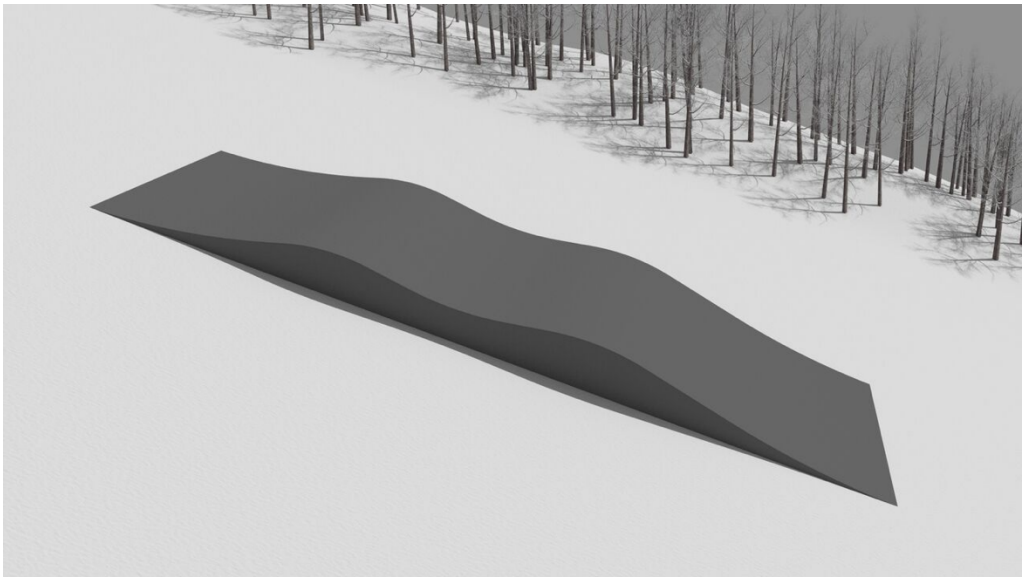
Placement

- Placed on low to medium gradients.
- Consists of two rollers, the second is at a lower elevation than the first.

Speed Range - All.
Difficulty - Intermediate to advanced

Ideal traits and best practise for constructing a Double Down:

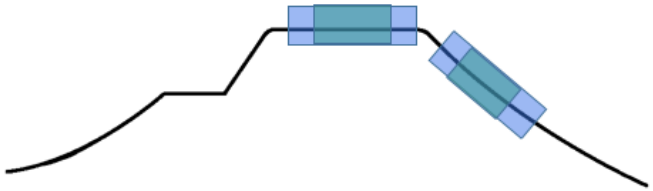
- Enables the user to jump while dropping in elevation from take-off to landing.
- The first roller of the double down is constructed similarly to the take-off roller of a double roller. Ideally the landing roller would be larger than the take-off roller increasing the size of the landing transition.
- The landing transition of the second roller would ideally match the transition of the take-off roller but would be longer in length.
- The approach (front face) of the landing roller would ideally have a downhill profile to minimize impact forces on the user if they were to not make the landing transition.



Step Up

Placement

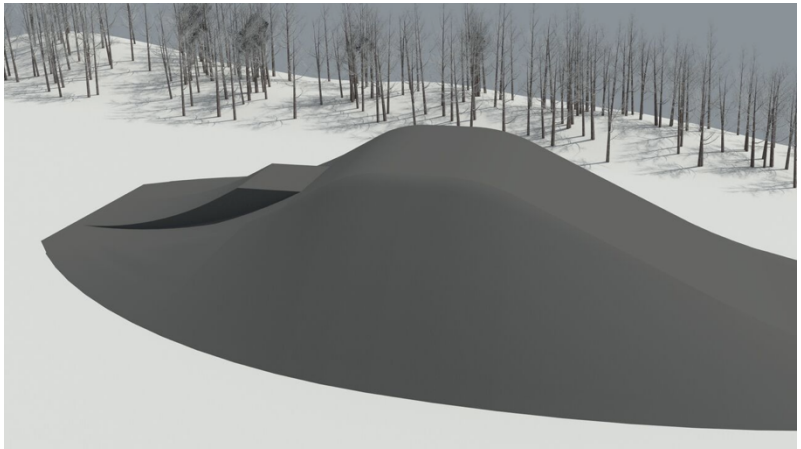
- Low Gradients, flat or uphill gradients.
- Consists of a takeoff, a flat section at the lip of the takeoff, a rising section and a flattop for a landing or a sloped landing.



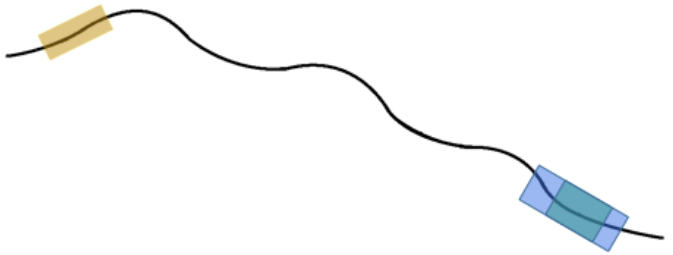
Speed Range - Medium to High
Difficulty - advanced

Notes:

- Slope gradient and users speed determine the quantity of snow to construct.
- A great feature to use when there is a rise in slope gradients.
- It's a good feature to use when course speed needs to be reduced for a period of time.
- The takeoff transition varies depending on course speed, the speed travelled by the athlete and the rise in elevation to the flattop.
- The takeoff would ideally be constructed in a manner that upon landing there is little or no impact.
- The flat section at the lip of the jump designates the forward distance the athlete will travel to reach the flattop landing.
- The uphill section ideally would match the takeoff transition to lessen any impact forces on the user.
- The rising section would determine the height of the step up.
- Whenever possible an alternate downhill gradient can be created after the flattop that would be used as a landing.



Triple Down



Placement

- Placed on medium gradients.
- Consists of one take off roller followed by two benched landing zones.

Speed Range - Medium to High.
Difficulty - Advanced

Ideal traits and best practise for constructing a Triple Down:

- Can be ridden in multiple different ways, enables the athlete to jump while dropping in elevation.
- The first roller is constructed the same as the takeoff roller of the double set. A flat is then created after the takeoff roller followed by the first of two landing zones. The first landing zone is usually the shorter one of the two. A second bench is then put in place to create the second landing zone. This second bench would have the same characteristics of the bench created in a triple. (Should have a downhill profile to reduce impact)