> “Performance, efficiency, and functionality are generally regarded as important goals or aspects of engineering or physical design.These are goals that tend to have well understood metrics and criteria. What about the role of beauty, aesthetics, and visual impact in design?”

Horst J. Schor, Donald H. Gray, *Landforming* (2007)

Avalanche defense structures in Iceland

Stóri-Boli, deflecting dam, in Siglufjörður, N-Iceland. An informal path to the mountainside.
(Photograph, Eiður Páll Birgisson)

Abstract

One of my main notions from my research on mitigation measures against avalanches in Iceland is two folded. On the one hand it relates to the aspect of scale and harmony; where the scale of the protection dams is the same as the natural context they are implemented in. On the other hand new types of connection between the natural- and the anthropogenic landforms take shape. Where the hidden brutality of avalanches has more profound visualisation through the formal language of the defense systems.

My personal interest comes from living in close proximity to anti-avalanche earthworks. As well as from the simple fact that they are enormously large, yet not necessarily appearing as invasive landforms from my perspective; But rather as engaging landscapes, that in some cases fit into the dynamic setting of natural and cultural patterns at a large scale.

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Spring 2021

Table of contents

First half of this booklet explores avalanche defense structures in Iceland. Their form and dimensions in relation to adjacent settlements. The second half contradicts existing practise by drawing out conclusion from former exploration.

Topics

1. Introduction // Backstory
Introduction to the main topic of this research.

2. Avalanche defense typologies
Classification of avalanche defense systems.

3. Exploration 1 // research on existing avalanche protection techniques
Such as avalanche dynamics, geometrical recommendation & location and configuration.

4. Construction methods
Construction examples diagnosed
through tracing past and present construction techniques.

5. Exploration 2 // the search for design freedom
Exploration done through series of sketches and 3d modeling

6. Project
The Village Wall

7. List of References

Iceland is an unusually dynamic country in terms of weather conditions. This means that Icelanders have to be prepared for a multitude of natural weather hazards. These natural hazards include snow avalanches, debris flows, rockfall and landslides. From the year 1901, more than two hundred lives have been lost in Iceland because of snow avalanches and landslides.

People in modern societies are becoming more concerned with safety, and authorities strive to ensure that settlements are protected. Due to high safety demands, the design of permanent protection measures has become more demanding than before.

Photograph, Haukur Sigurðsson

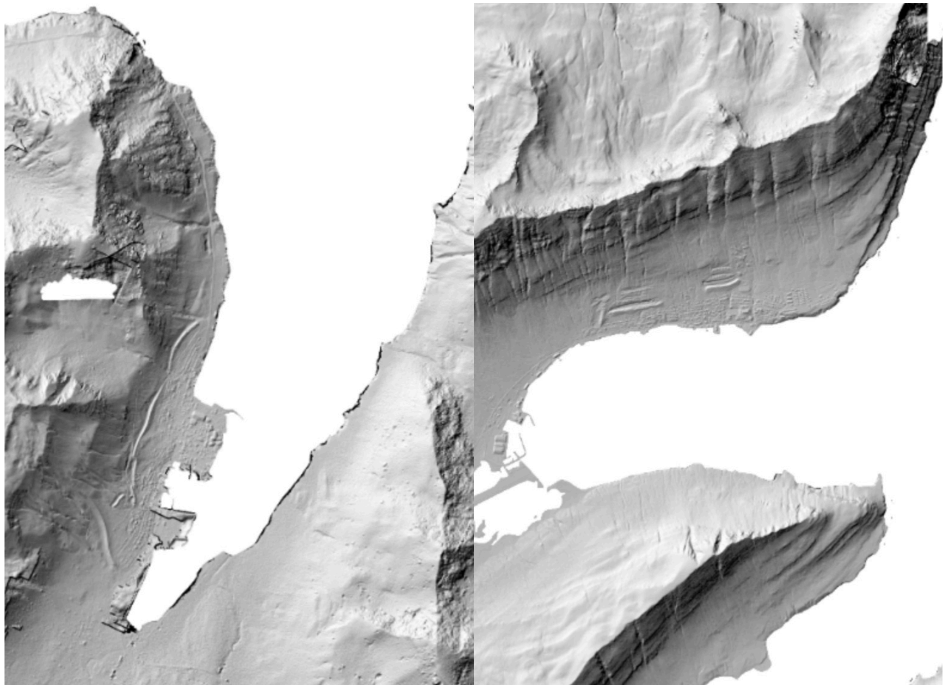
Photograph, Eiríkur Greipsson

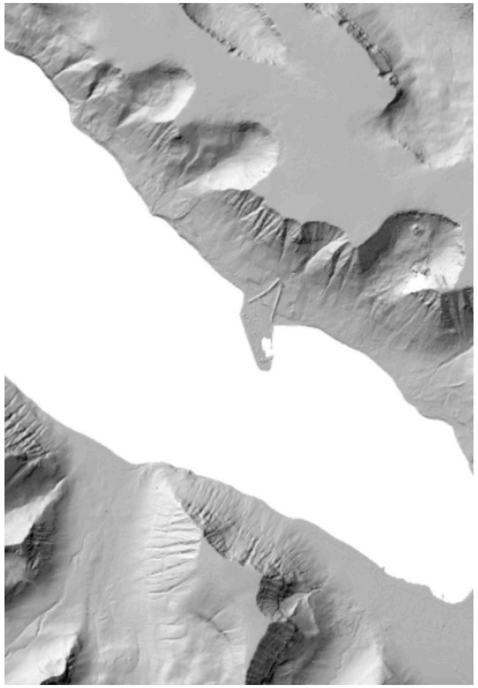
Photograph, Eiríkur Greipsson

Photograph, Einar Bjarnason

Photograph, Sigurður Hlöðversson

Photograph, Sigurður Hlöðversson





Areas of great danger are situated in glaciated valleys and fjords with a typical U-shaped cross section. The landscape is mostly composed of basaltic rock with angular and jagged forms and hillsides that have relatively long slopes and short decreasing gradient near the toe. These conditions can be found In the west, east and north of the country.

2. // Classification of mitigation measures

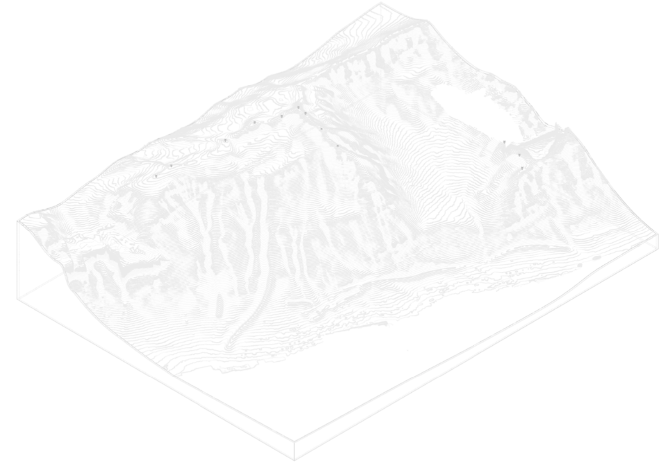
In Iceland protection measures for settlements can be divided into two categories -

Supporting structures: such as Anti drifting structures, snow bridges and snow nets; Placed In the starting zones of avalanches to resist the threat of avalanche occurring at the source.

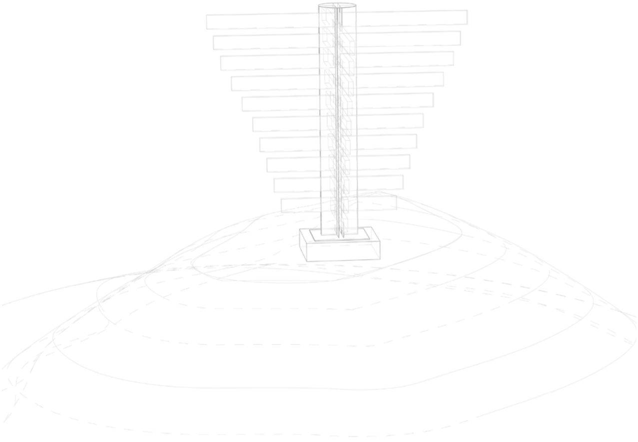
Anti avalanche earthworks: Such as deflecting dams, catching dams, breaking mounds and wedges; That are meant to either divert, stop or retard avalanches.

(Next coming pages include illustrations done by author)

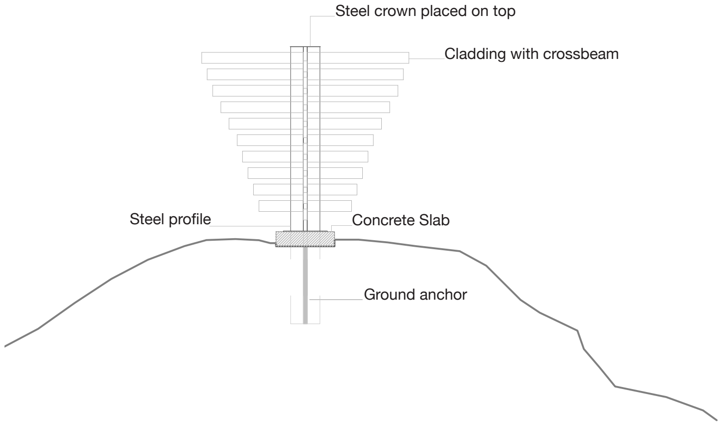
Typologies - supporting structures



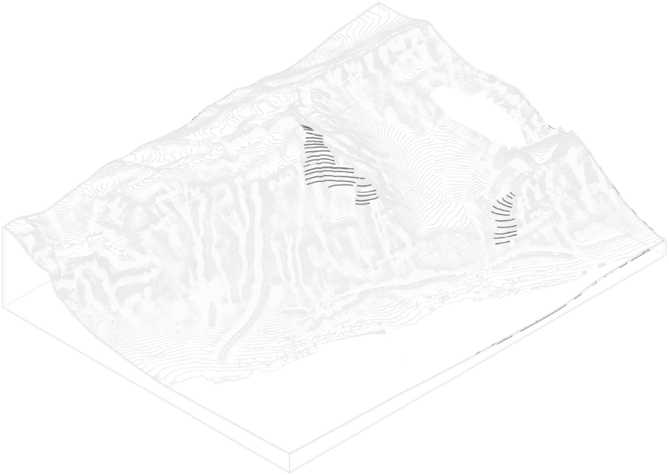
Positioning of the Anti - drifting structure / Where the slope to be controlled is bounded by a ridge known to form a heavy cornice, the uppermost structures should be positioned as near as possible to the foot of the cornice, without, however, coming to lie within the cornice itself. The structures should be dimensioned very generously to accept the large volume of snow and withstand falling sections of the cornice. In many cases, the mass of the cornice can be reduced by anti-drifting structures..



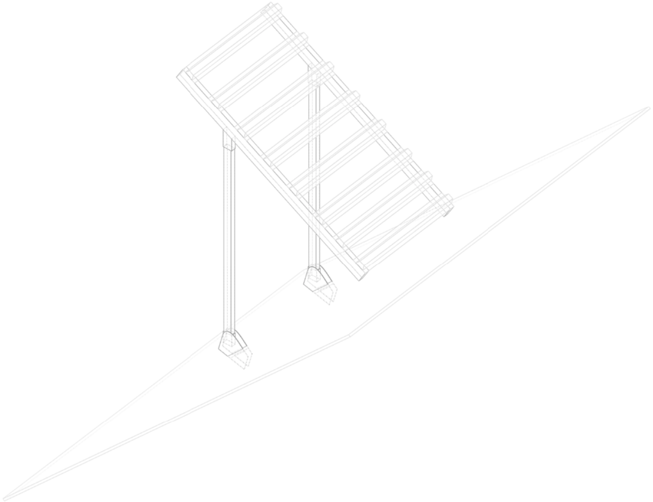
Anti - drifting structures / Walls, panels, fences, etc., exploit wind effects to control snow deposition with the objective either of preventing the formation of cornices, or reducing the deposition of snow in starting zones.



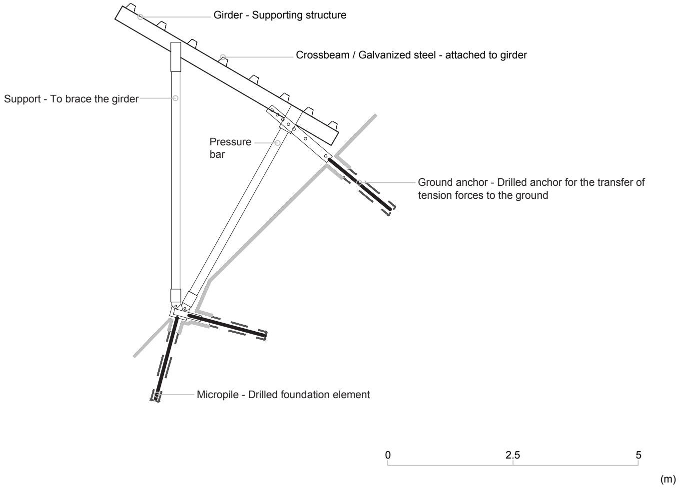
Anti - drifting structures / The placement of the crossbeams prevents snow from drifting in areas where its difficult to install supporting structures because of snow depth.



Positioning of snow bridges / The supporting structures are placed on hillsides where snow collection is high. Their function is to prevent snow avalanches from occurring at the source by keeping the snow in place.

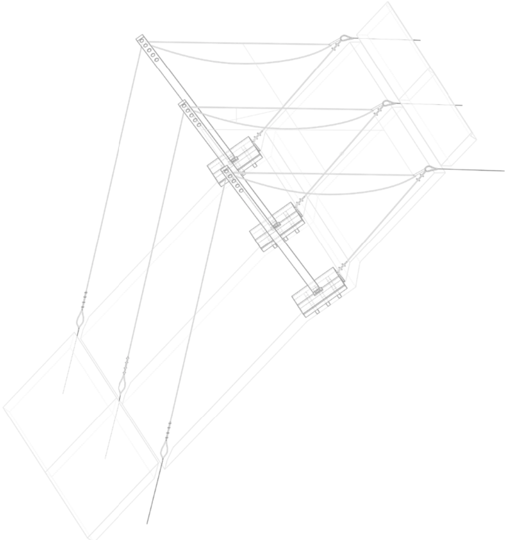


Snow bridge / The supported surface of galvanized steel cross beams arrests the creeping and sliding motion of a snow layer and holds it in place. The ideal value of the open width between the crossbeams is 250 mm.

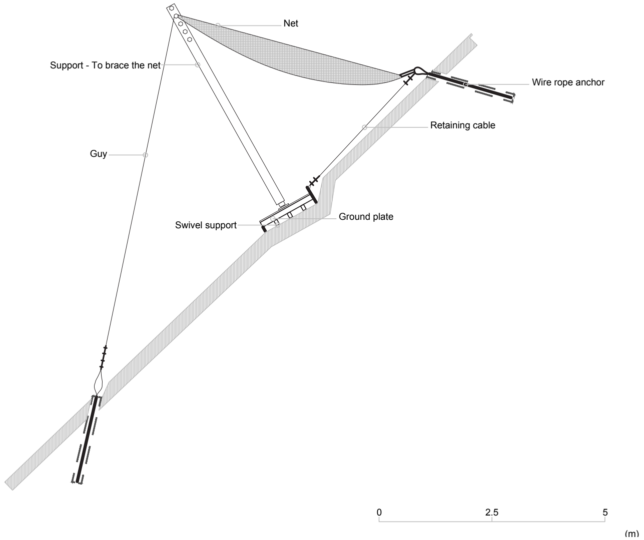


Snow bridge / Supporting structure with pressure bar, where the lower foundation consists of a micropile and ground anchor, and the upper foundation of a ground anchor.

Positioning of snow nets / The flexible supporting structures are placed on hillsides where snow collection is high. Their function is to prevent snow avalanches from occurring at the source by keeping the snow in place. The supporting surface is to a certain extent able to follow the movement of the snow layer.

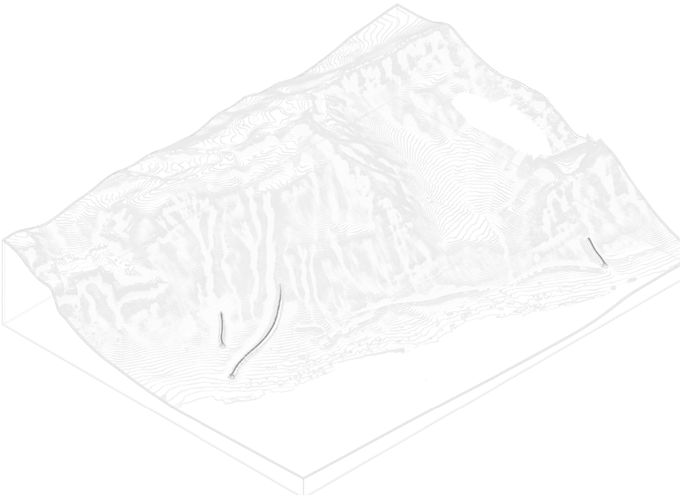


Snow net / To ensure an adequate braking effect in low-cohesion, moving, snow, the nets can be covered either with wire netting having a mesh width of 50 mm or an open 'patchwork' of metal sheeting, fine-mesh wire netting or similar materials. In these cases, a side length of the cover materials of 200 to 250 mm is recommended.

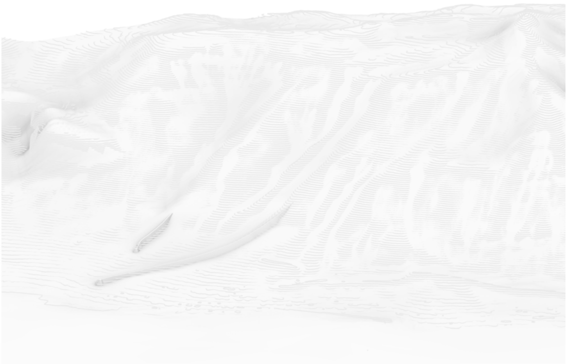


Snow net / Snow net anchored with two wire rope anchors and a ground plate. The ground plate is secured using a retaining cable

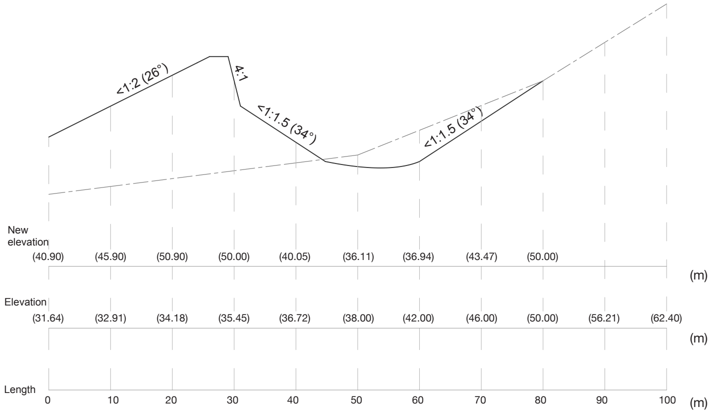
Typologies - Anti-avalanche earthworks



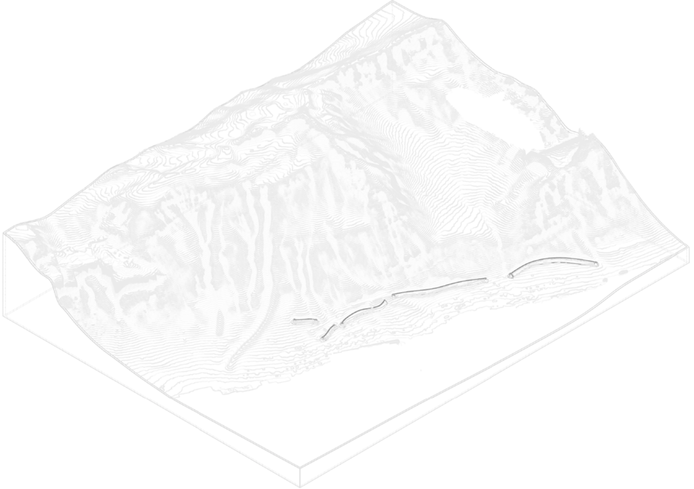
Location of deflecting dams / An optimal deflecting dam is built in steep terrain and adjusts the course of an avalanche without a substantial reduction of flow speed, thereby avoiding deposition of masses along the dam wall and maintaining the effective height for subsequent events.



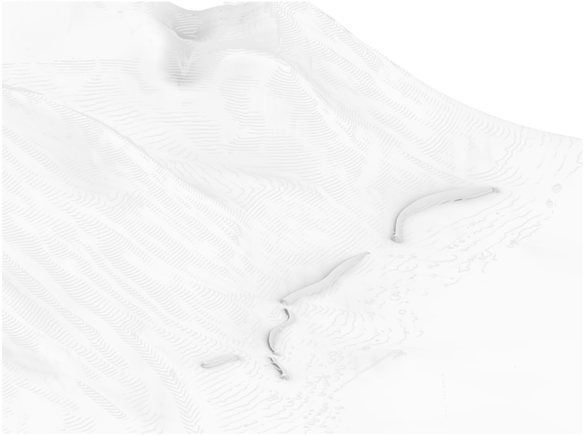
Deflecting dams / guide the avalanches away from the risk zones. They are considered the second most effective defense against avalanches.



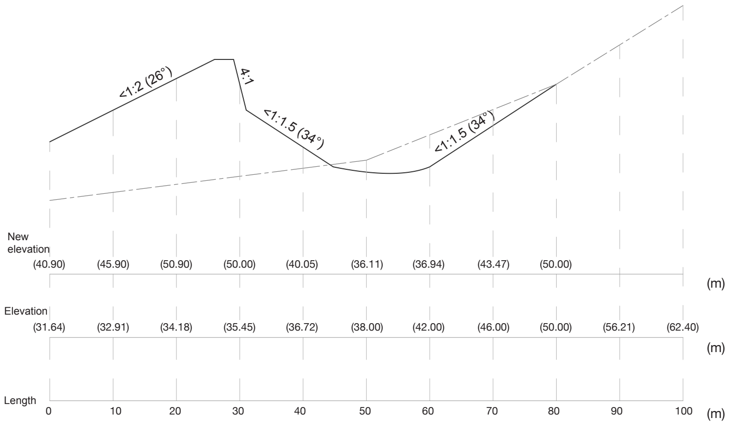
Deflecting dams / The easiest way to control an avalanche is to guide it along a gently curving channel. Recommented channel width is not less then 50m with an ideal inclination of 1:1.5 on both sides.



Location of catching dams / The effectiveness of catching dams is dependent upon a location near the lower end of the run-out zone of the avalanches. They are usually steeper and taller than deflecting dams.

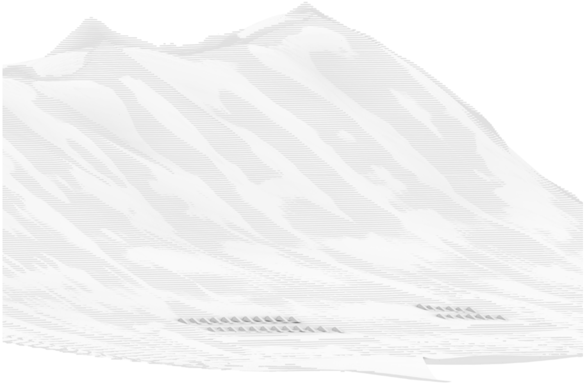


Catching dams / are intended to stop dense avalanches completely before they reach objects at risk. They are placed perpendicular to the direction of the slope. where there is insufficient space for deflecting dams.

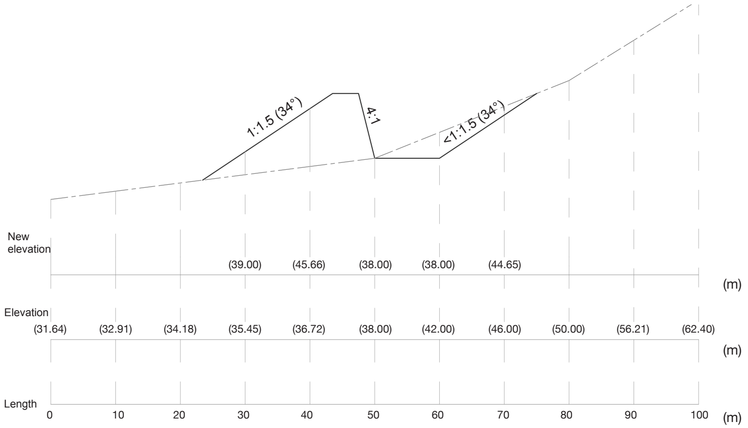


Catching dams / have steep up-stream face that is usually composed of reinforced earth, It is considered to bring more effective resistance.

Braking mounds / break the avalanche force down and are usually used in combination with other defense structures. They are widely used for protection against dense, wet-snow avalanches.



Braking mounds / are used to retard avalanches by breaking up the flow and causing increased dissipation of kinetic energy. There is not much observation evidence for the effectiveness of braking mounds for natural avalanches, but laboratory experiments with granular materials indicate that they can reduce the speed and run-out distance of avalanches.



Braking mound / Typical longitudional-section of braking mound; showing desired heights and angles.

The criteria for avalanche dams geometry are based on the concepts of supercritical overflow and flow depth downstream of a shock. They are formulated in terms of a description of the geometry of the terrain and the dam and an analysis of the dynamics of the flow of avalanches against dams.[1]

The design possibilities vary in scope and depend on sufficient materials that are certified bygeotechnical scientists. Many different types of materials are used for avalanche deflecting and retaining dams or walls, depending on what is foundto be the most cost-effective solution in each case. The construction materials normally consist of:

- loose deposits: rocks, gravel, sand, and/or
- reinforced earth, or
- concrete.

(Next coming pages include illustrations done by author)

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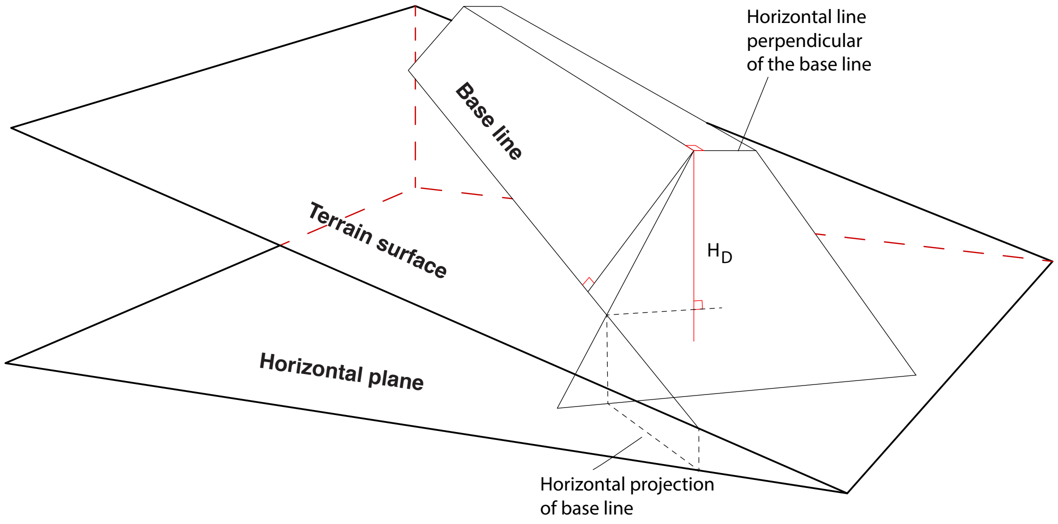
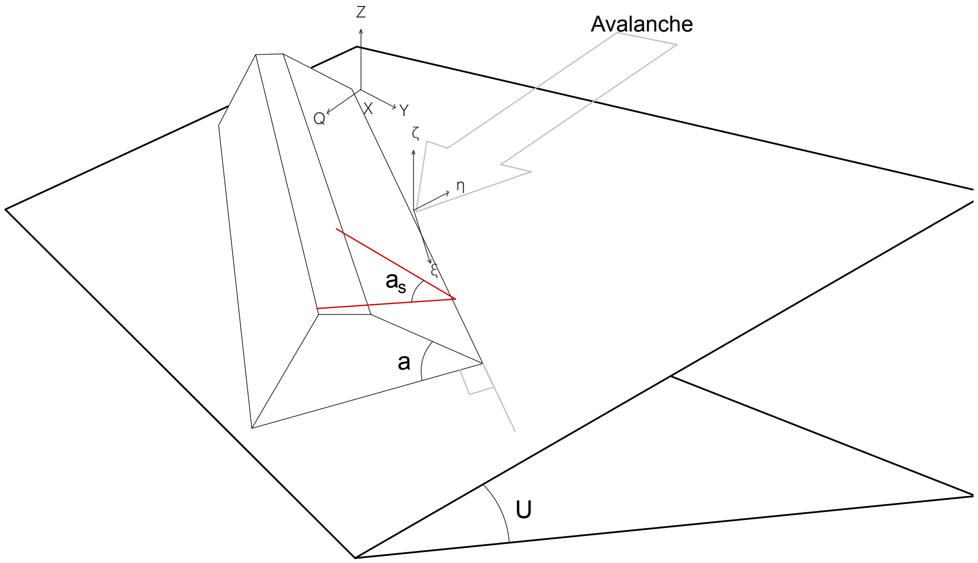
[1] (Karstein Leid, 2008).





Geometric identity for vertical dam

$$HD = \frac{\cos\psi - \sin Q \sin\psi \cot \alpha}{1 - \cos 2 Q \sin 2 \psi} H$$

$$H = hr + hs$$

H - Run-up height, measured for dams onsloping terrain.

hr - Run- up of the avalanche above the snow cover.

hs - Snow depth on the terrain.

HD - Vertical dam height measured in a

Q - Deflecting angle of the dam

a - Angle between upper dam side and

ψ - The slope of the terrain.

If the right-handed Cartesian coordinate system with ξ, η and ζ as the coordinates such that the ξ-axis is aligned with the downstream axis of a deflecting dam, the η-axis points in the direction normal to the dam axis in the upstream direction, the ζ-axis points in the direction normal to the terrain, and the origin moves along the dam axis with speed u1 cosQ (see Figs. above). It is easy to show that, for supercritical flow over the dam, the dynamics in the (ξ,η,ζ)-coordinate system are exactly equivalent to normal flow with uniform velocity u1 sinQ towards a catching dam. This fact may be used to recast the criterion for supercritical flow over a catching dam for flow against a deflecting dam (see Jóhannesson and others, 2008).

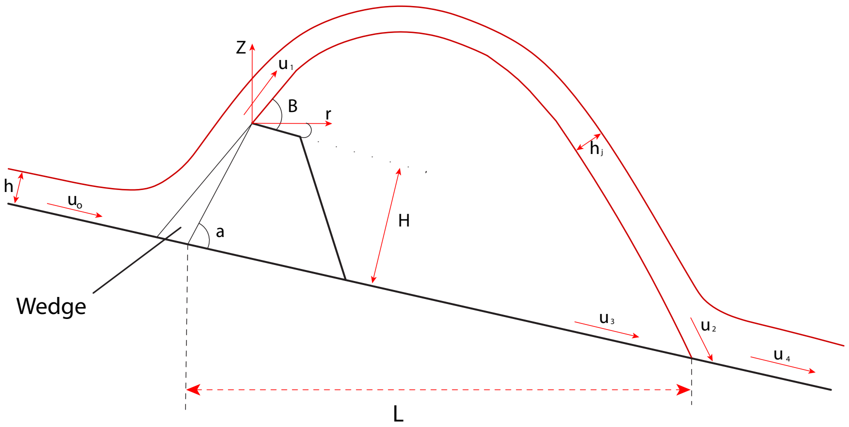
The design procedure for catching dams and braking mounds is highly influenced by the inclination of the up-stream dam sides which should be steep, location and configuration in the terrain should be planned carefully.

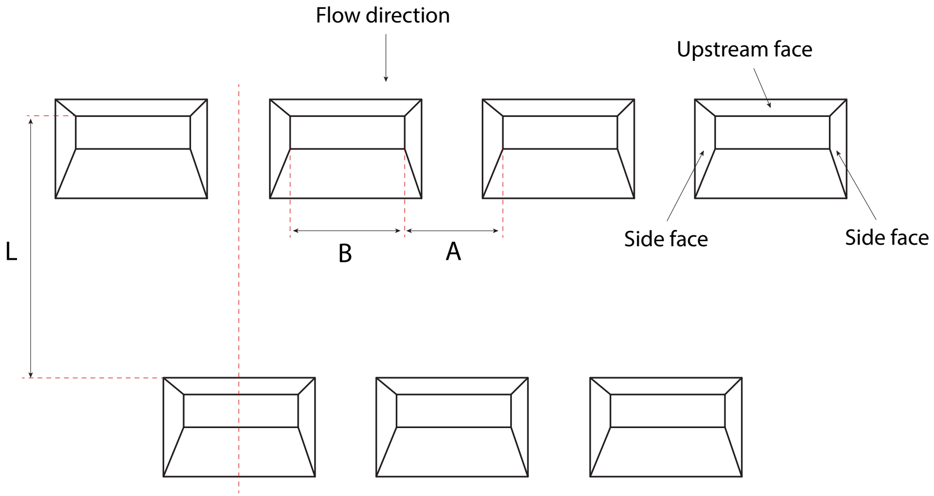
Braking mounds, in Neskaupstaður, east-Iceland.
(Photograph, Sigurður Hlöðversson)

Photograph, Sigurður Hlöðversson

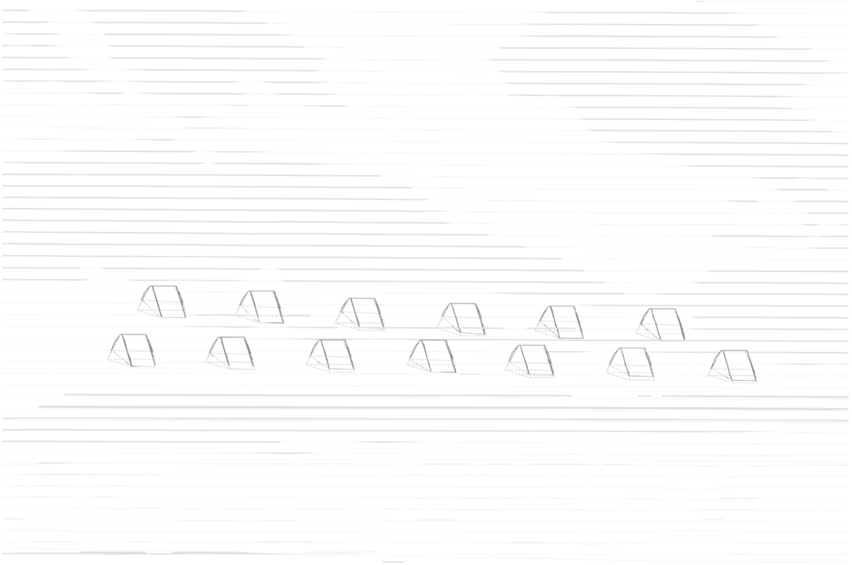
Photograph, Sigurður Hlöðversson

Braking mounds break the avalanche force down and are usually used in combination with other defense structures. They are widely used for protection against dense, wet-snow avalanches. Laboratory experiments with granular materials indicate that they can reduce the speed and run-out distance of avalanches. [1]





B is the top breadth of a mound and A is the distance between the tops of two adjacent mounds. A should be similar to or shorter than B, and B should be similar to the height of the mounds, H, above the snow cover. The figure is adapted from Hákonardóttir and others (2003c).



A schematic diagram showing the result of hydraulic experiments and their implications in context of snow avalanches by using braking mound as a upstream mound face. The figure is adapted from Hákonardóttir and others (2003c).

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[1] Hákonardóttir, K. M., A. J. Hogg, T. Jóhannesson and G. G. Tómasson. 2003c. A laboratory study of the retarding effects of braking mounds on snow avalanches, Journal of Glaciology, 49(165), 191–200.

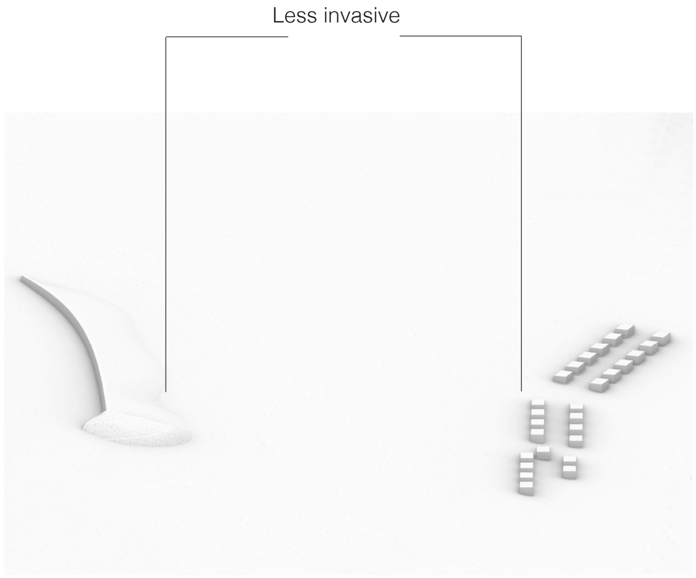
Photograph, Ingvar Erlingsson

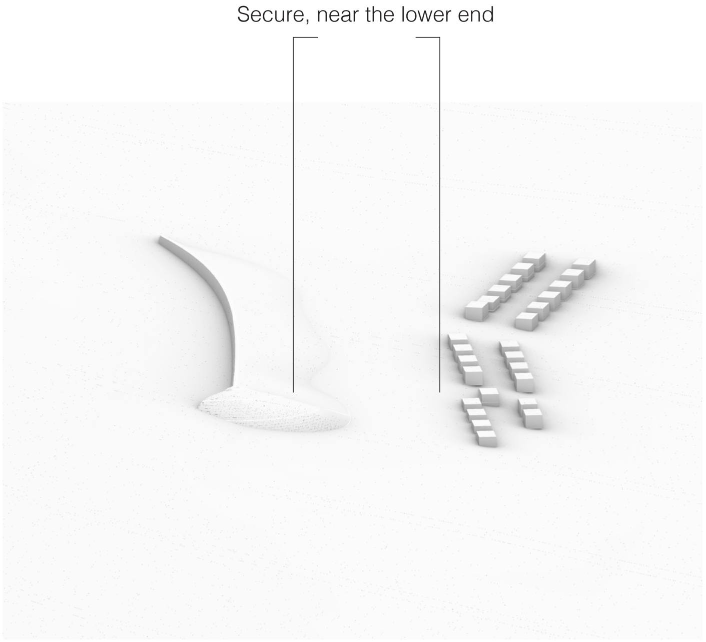
Photograph, Ingvar Erlingsson


Photograph, Ingvar Erlingsson


Photograph, Ingvar Erlingsson

The construction approach of cathing dams is to optimise the height and length of the dam, and therefore the costs, it is of importance to locate the dams far down the avalanche path. This is also an important issue concerning the construction itself, as it is usually cheaper to carry out the construction work on flat ground instead of on a steep mountain slope.[1]





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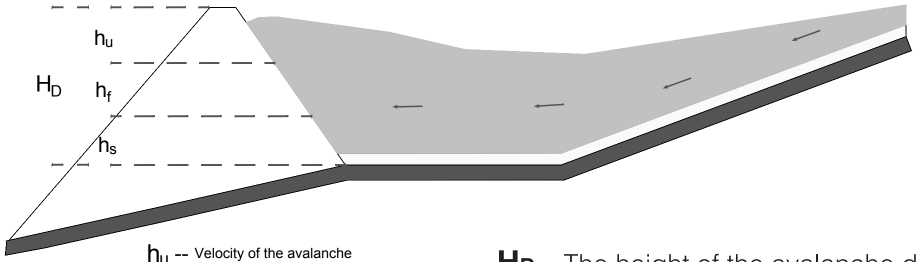
[1] Barbolini, Massimiliano & Domaas and others. (2009). The design of avalanche protection dams Recent practical and theoretical developments. (p) 118.



h_u -- Velocity of the avalanche
h_f -- Thickness of flowing dense core
h_s -- Existing snow layer
H_D-- Dam height

H_D - The height of the avalanche dams,

$$H_D = h_u + h_f + h_s$$

For Catching dams --

$H_D = h_u + h_f + h_s$ **$h_u = u2 /$**

u - The velocity of choosen avalanche

g - 9.8 ms -

λ - empirical parameter /
to reflect the momentum loss value,
usually 1-2

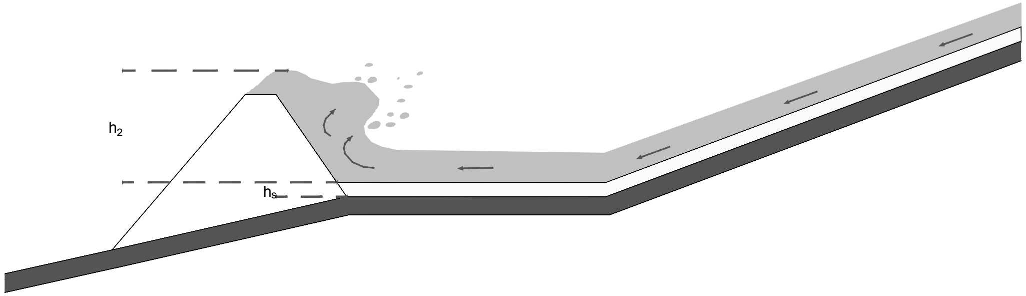
For Deflecting dams --

$H_D = h_u + h_f$ **$h_u = (u \sin Q)$**

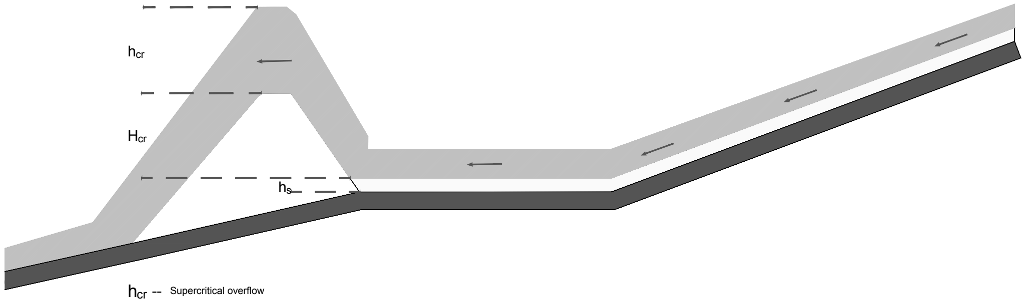
Q - Deflecting angle

g - 9.8 ms -

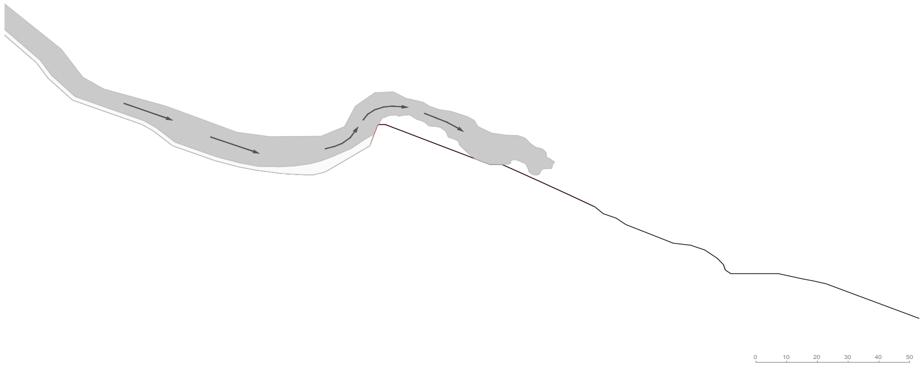
λ - empirical parameter /
to reflect the momentum loss value,
usually 1.

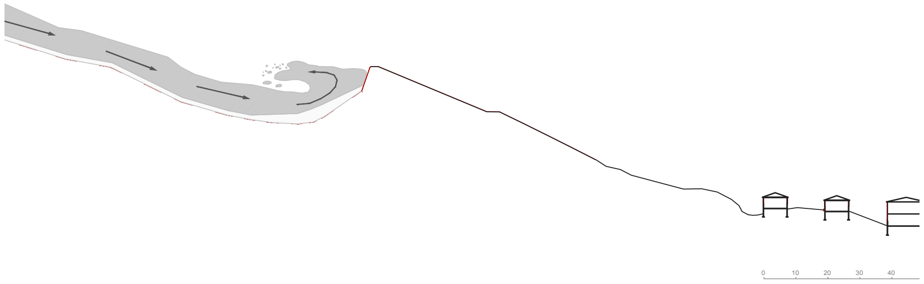


h_2-- Flow depth down-stream of the shock
h_s -- Existing snow layer

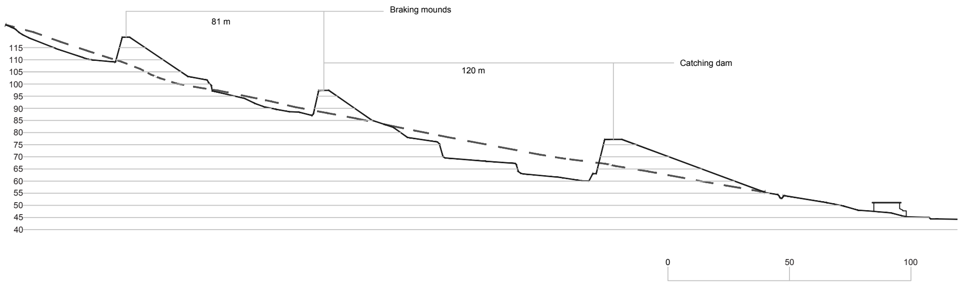


h_{cr} -- Supercritical overflow
H_{cr} -- Critical dam height



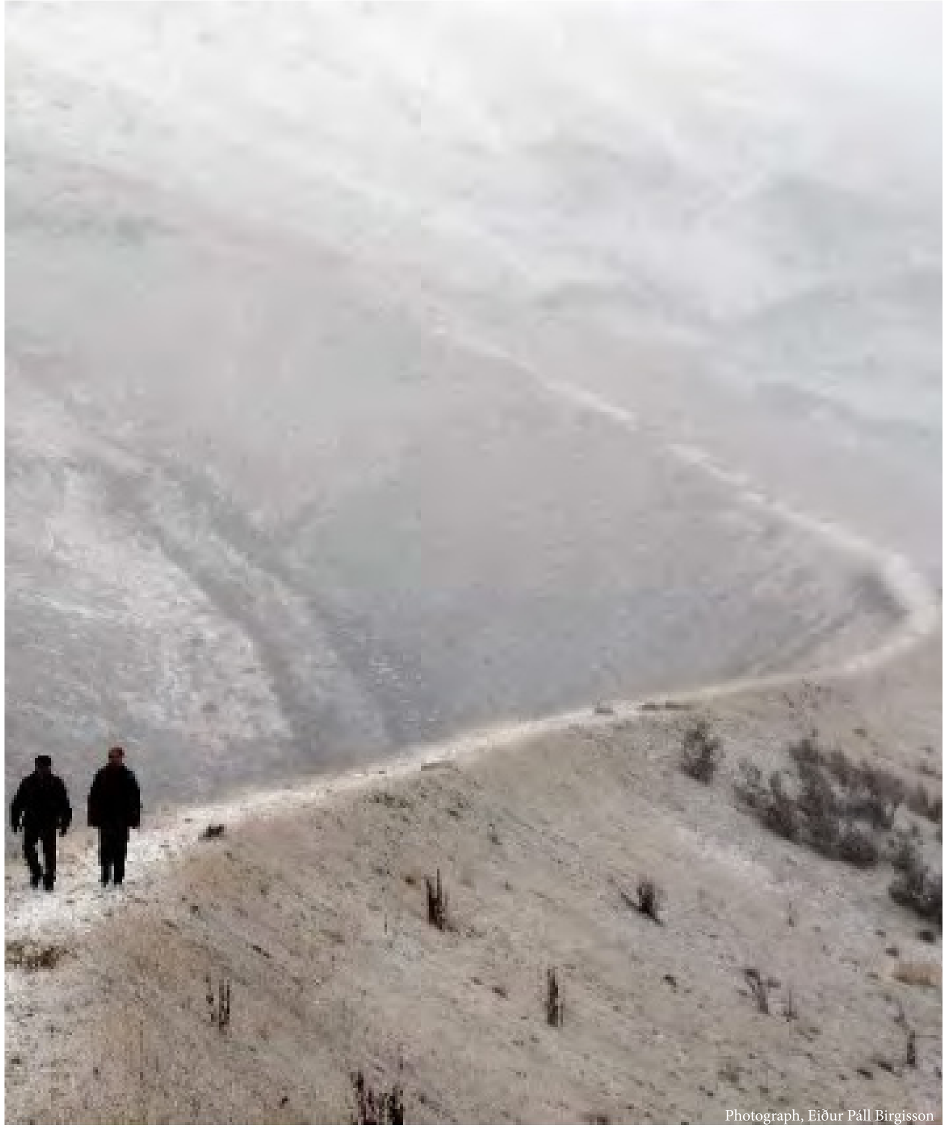


There are many examples of high speed avalanches overtopping catching dams. The effectiveness of catching dams is therefore dependent upon a location near the lower end of the run-out zone of the avalanches.



A vertical section of a A combined defence structure system consisting of two rows of 10m high braking mounds and a 17m high steep catching dam has been constructed above the town of Neskaupstaður in eastern Iceland.

Photograph, Steingrímur Kristinsson



Photograph, Eiður Páll Birgisson

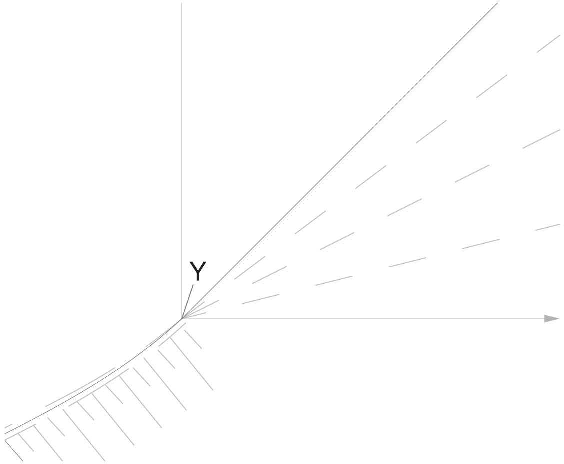
Although a clear interrelation exists amongst protection dams; effective dimensions do vary depending on the location and function. For Deflecting dams; factors like existing slope inclination, proposed direction of the dam axis and deflecting angles form the basics of the design.

An optimal deflecting dam is built in steep terrain and adjusts the course of an avalanche without a substantial reduction of flow speed, thereby avoiding deposition of masses along the dam wall and maintaining the effective height for subsequent events. The easiest way to control an avalanche is to guide it along a gently curving channel. However, this often requires a very long dam along a steep talus. [1]

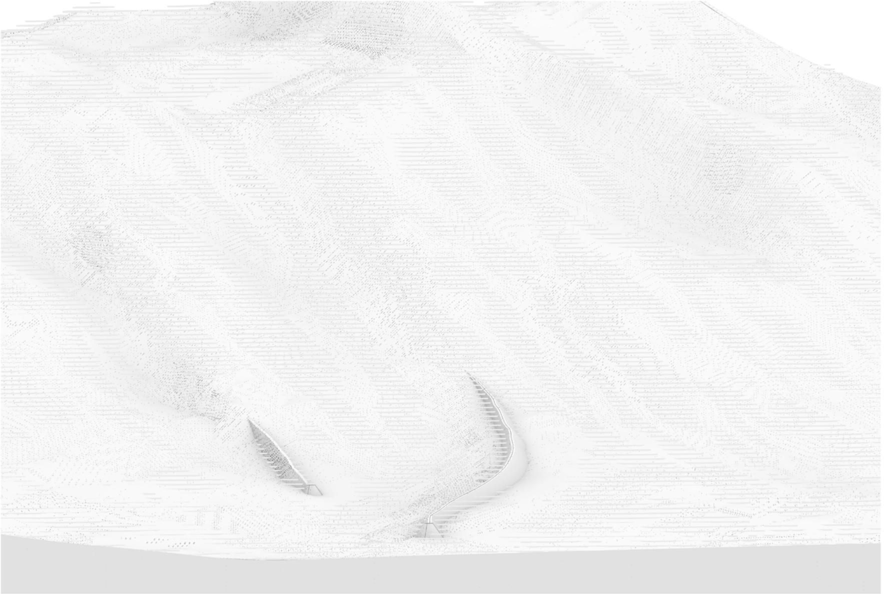
---

[1] Domaas, Harbitz & and others. (2009). The design of avalanche protection dams Recent practical and theoretical developments. (p) 39.

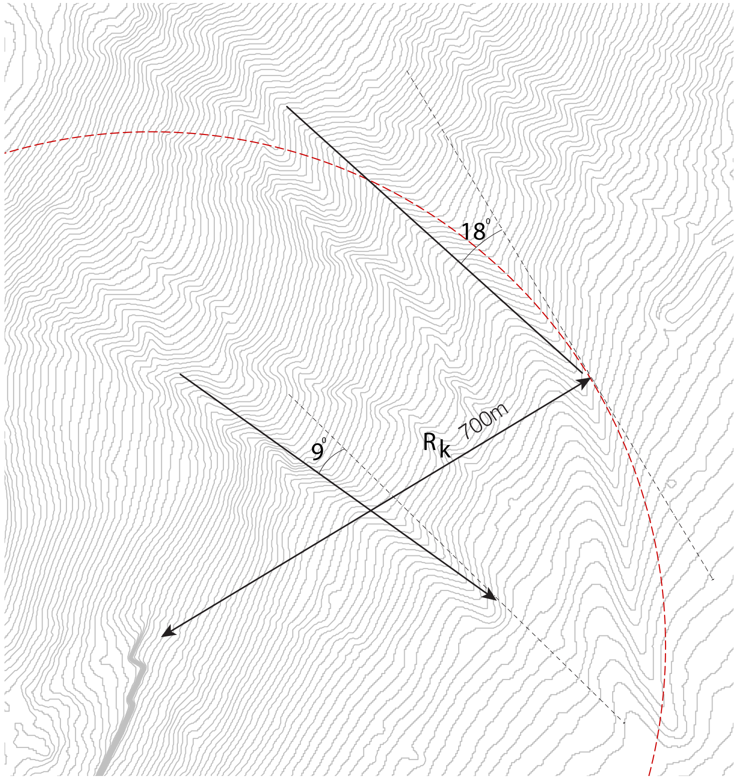
An optimal deflecting dam is built in steep terrain and adjusts the course of an avalanche without a substantial reduction of flow speed, thereby avoiding deposition of masses along the dam wall and maintaining the effective height for subsequent events.



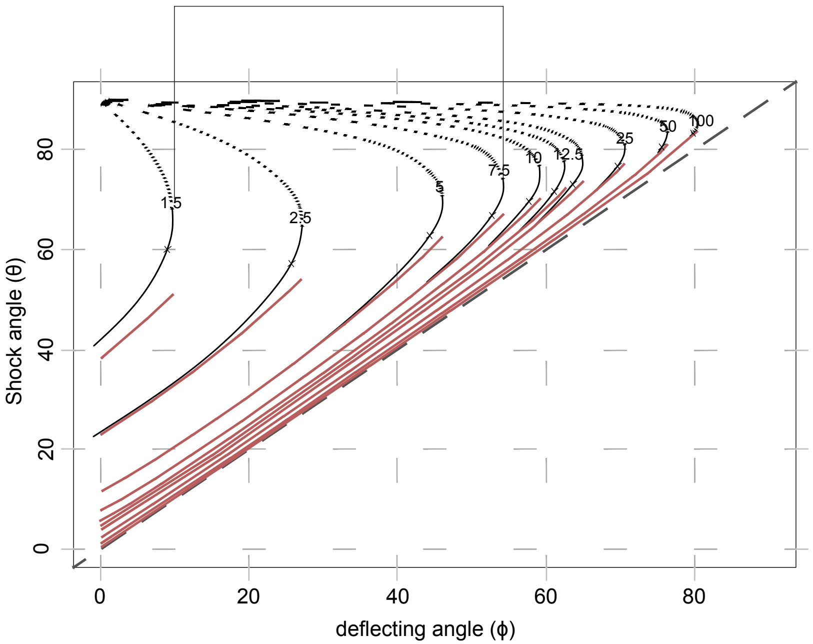
The global stability of a dam in steep terrain may easily be insufficient if the dam axis does not approximately follow the steepest descent of the terrain.



On the upper part of the talus, the dam may need to be very wide due to the steepness of the underlying terrain.

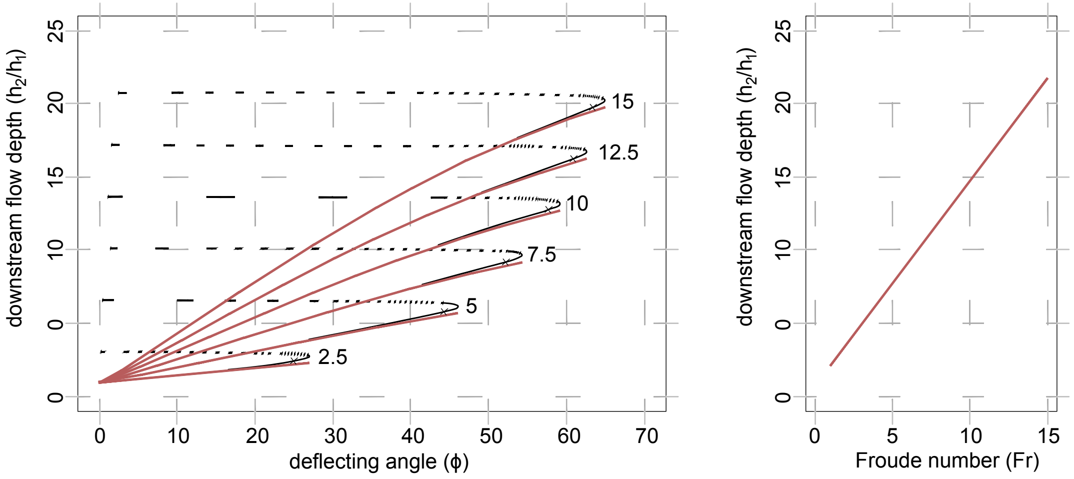


Studies on deflecting dam, Arrows indicate flow direction. The dotted lines show the local direction of the dam axis, and the dash dotted curve is a circle fitted to the dam axis of the dam,
representing the curvature (Figure adapted from Jóhannesson and others).



Relevant design extent for deflecting angle

$$\phi_{max} = \frac{\pi}{2} - \frac{2^{3/4}}{Fr^{1/2}} - \frac{2^{1/4}}{6Fr^{3/2}} + 0\left(\frac{1}{Fr^{5/2}}\right)$$



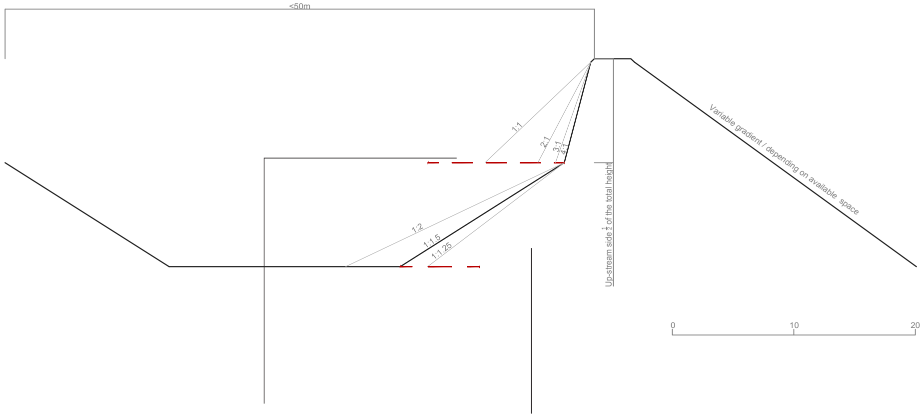
The ideal oblique shock solution lies between Fr > 2.5 and deflecting angle, somewhat below boundry between the weak and strong shocks represented in the diagram above. Chute experiments with granular materials indicate that an attached, stationary shock may perhaps not be maintained for deflecting angles close to the theoretical maximum, Qmax. It is recommended that deflecting dams should have deflecting angles at least 10° smaller than Qmax.

Diagram to the left -- Flow depth downstream of an oblique shock for a deflecting dam as a function of deflecting angle,Q, and Froude number, Fr. To the right -- Flow depth downstream of a normal shock for a catching dam as a function of Froude number. The curves for the deflecting dam are labelled with the Froude number and the x-symbols show the values of the deflecting angle at which the flow downstream of the shock becomes critical.

4. // Construction methods

A dam is most commonly constructed of natural soils found at the dam site or in the vicinity of the dam. A dam built in mass balance has a clear economical advantage.Mass balance means that excavation is done just above the dam, and that all excavated masses are used in the dam fill. The fill volume may then also be reduced, as the effective dam height is the sum of the fill itself and the depth of the excavated area. When dealing with earth fill dams, and especially with dams in which fine-grained materials are used, the following points must be asesed:

- quality of the earth materials,
- treatment of organic material in the ground,
- design of the dam,
- design of the excavation area,
- water, drainage and erosion protection.[1]



Material usage/choose for stable inclination

Inclination for up-stream faces	Inclination for lower foot of the dam
4:1 - Reinforced earth, geotextiles	**1:2 -** Fine-grained cohesive material.
3:1 - Dry walls with rocks	**1:1.5** - Sand and gravel.
1:1 - 1:1.25 - Loose layered rocks	**1:1.25** - Coarser frictional material

Fine-grained cohesive materials will not be stable with inclinations steeper than 1:2. For sand and gravel, the maximum steepness of the dam sides should not exceed 1:1.5 (34°). For coarser frictional materials a stable inclination of the dam sides is up to 1:1.25 (39°).

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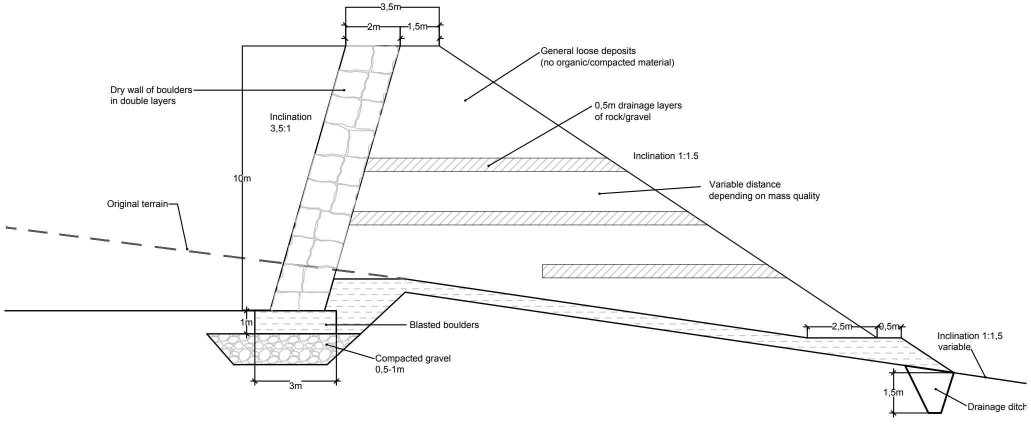
[1] Karstein Leid. 2009. The design of avalanche protection dams Recent practical and theoretical developments. (p) 120.)

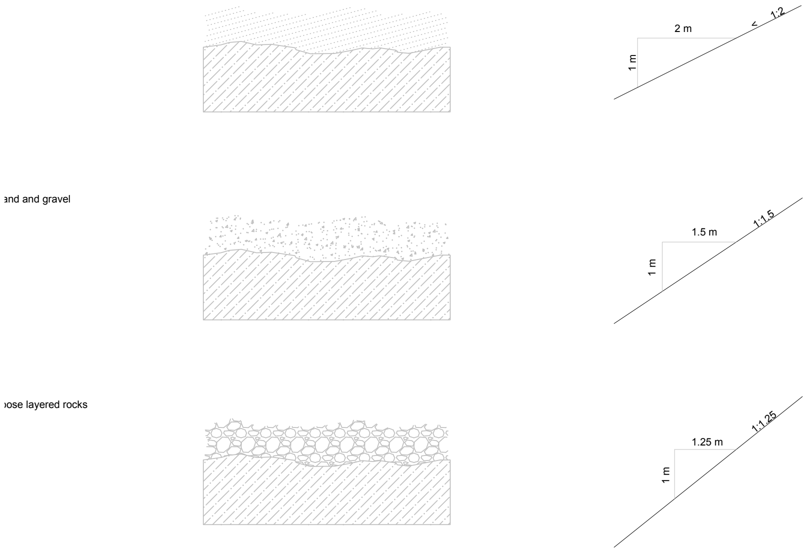

Photograph, Mats Wibe Lund


Photograph, Sigurður Hlöðversson



A Principal sketch of dry wall

A common practise is to make a horizontally layered construction with alternating coarse-grained and fine-grained layers. The thickness of the layers should not exceed 0.5 m, and they should be levelled out and compacted by heavy machinery.



The sides of the slopes must be gentle enough to ensure stability of the earth masses along the cut, and should normally not be steeper than 1:1.5. Coarser deposits (gravel, boulders) are stable up to 1:1.25, and if clay and silt make up for most of the cut, the inclination should not be steeper than 1:2.

A principal sketch of a dam with a dry wall, showing a horizontally layered construction with alternating coarse-grained and fine-grained layers compacted by heavy machinery.
(Figure adapted from (Karstein Leid, 2008).

Construction systems for earthdams

Dams in Iceland are mainly constructed of fill-material from excavations of soil or blasted bedrock at the construction site. The intended lifespan of the structures is 100 years. These systems must be easy and simple to erect, have good compatibility with the existing soils, as well as good durability.[1]

The systems usually consists of two major components, on the one hand the facing unit and on the other the soil reinforcement. Both components can be made either of steel or synthetic material or both. Concrete can also be utilized for facing units, but has only been used for low guiding dams or channel walls. Most common combination is of a rock wall that is contained by mesh of heavily galvanized steel.

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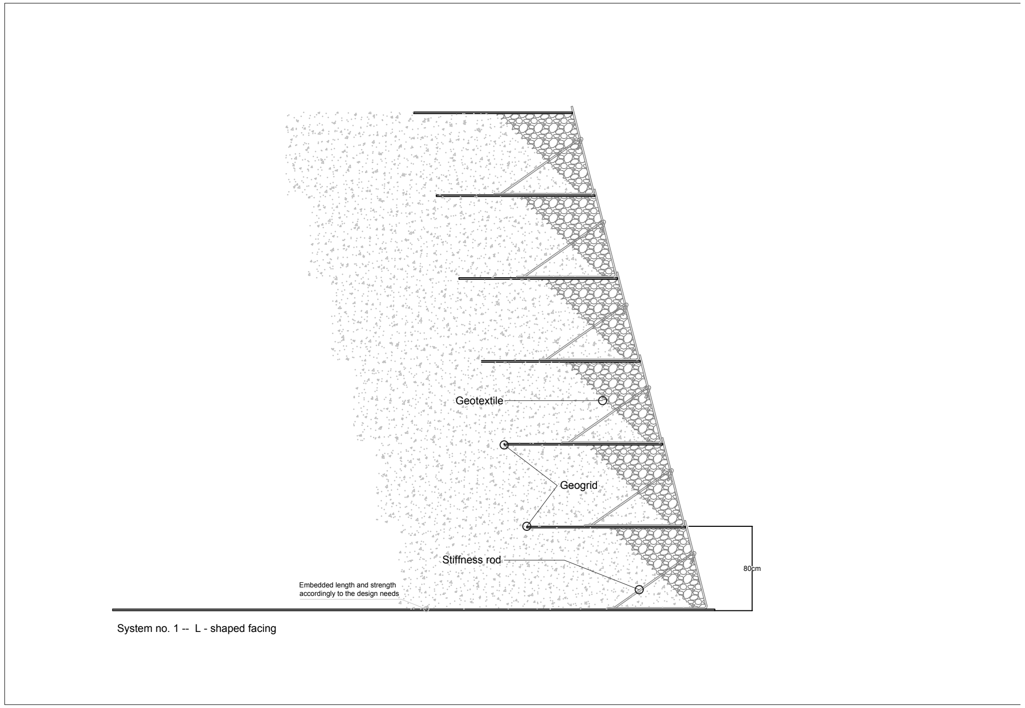
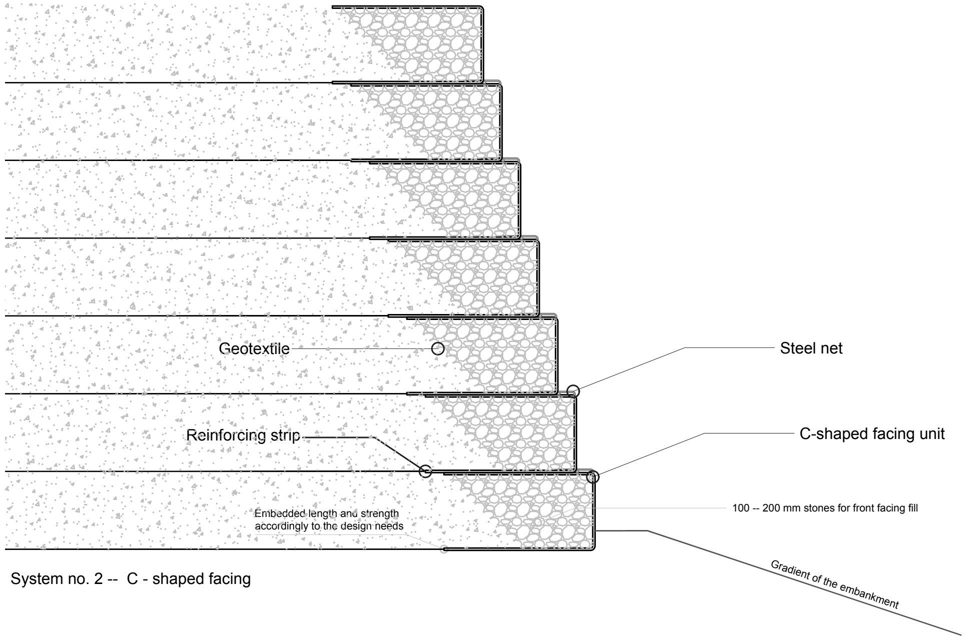
[1] Indriðason and Hákonardóttir, 2019. Experience and evaluation of reinforced soil systems in catching dams in Iceland 1998–2017. International Symposium on Mitigation Measures against Snow Avalanches and Other Rapid Gravity Mass Flows Siglufjörður, Iceland, April 3–5, 2019, 108-116.

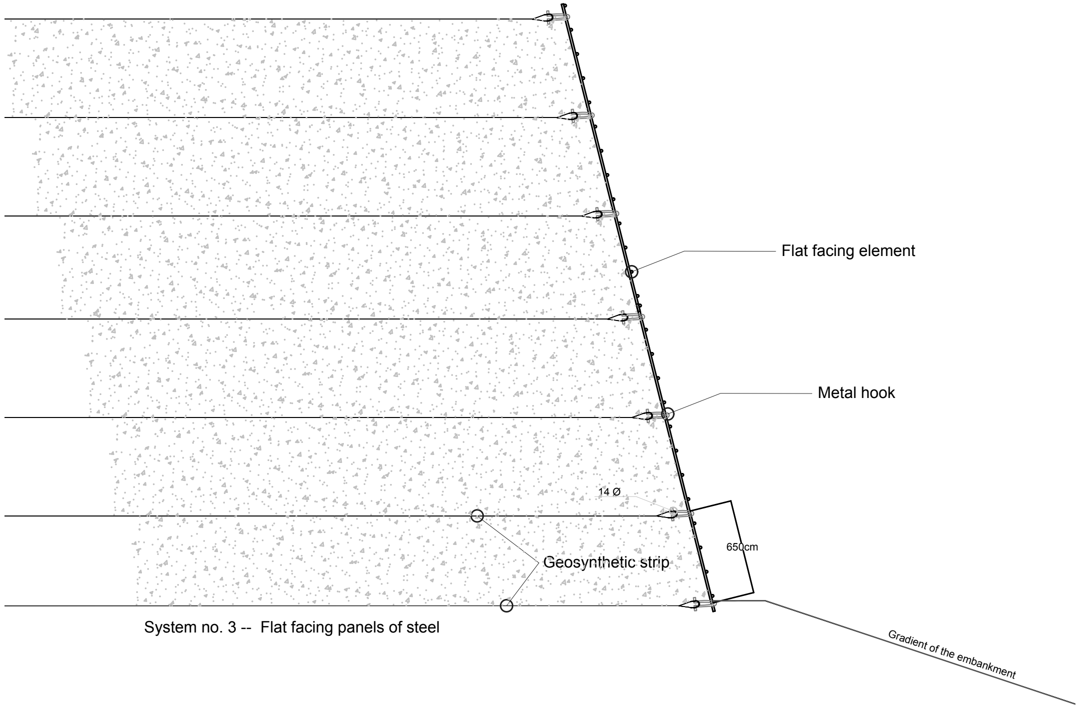


System 1.
The L - shaped facing units are placed on top of the geosynthetic reinforcement. Guiding rods are placed in front of the panels to secure the placement of the facing units.
A geotextile is placed between the stones behind the facing units and the fill.


Photograph, Kyle Mortara

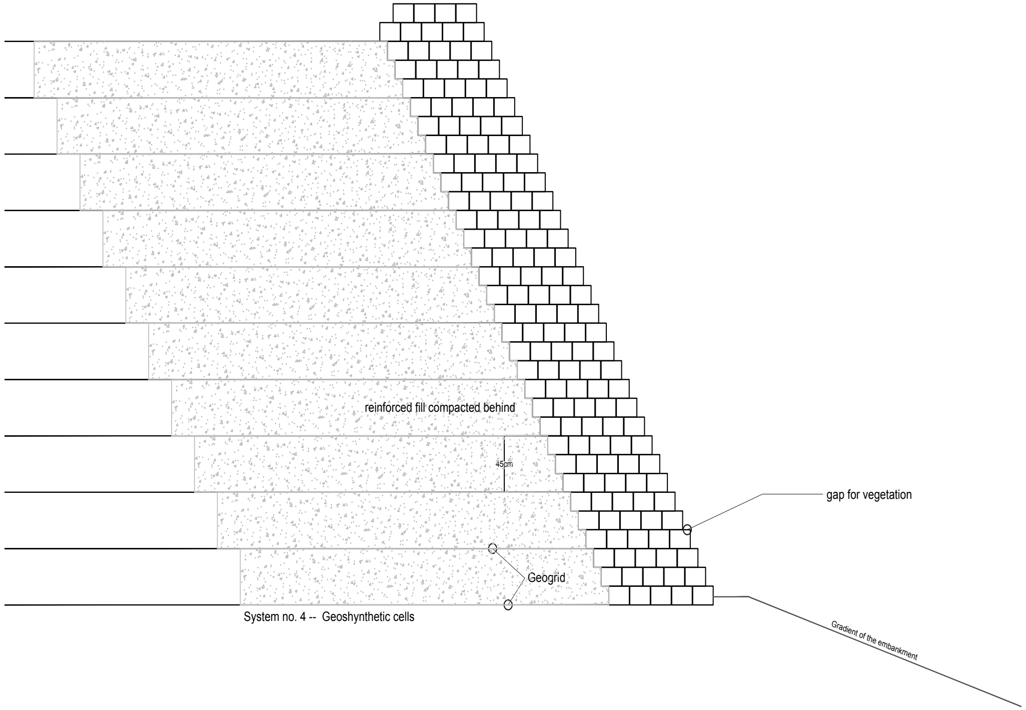


System 2.
C-shaped facing units are placed on a level grade with guiding rods in front of the units. Steel strips are then placed on a level grade and connected to the facing units with bolts. The reinforced fill is placed on top of the metal strips, extending almost to the front.



System 3.
Flat facing panels of steel are placed with the aid of a scaffolding system. Synthetic reinforcement strips are attached to the facing panel utilizing a special metal hook and tensioned.The reinforced fill is placed on top of the straps and the stones subsequently placed at the front.

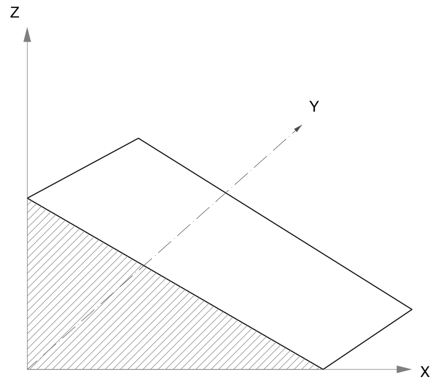

Photograph, Landmótun



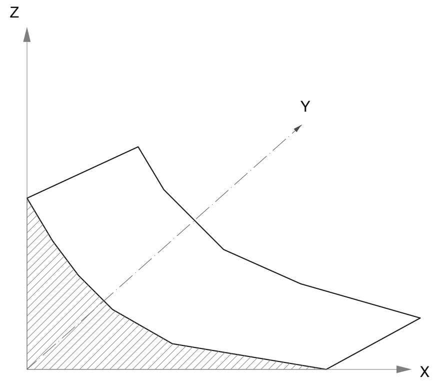
System 4.
Geosynthetic reinforcement is placed on a level grade and tensioned, Cells are placed and filled with soil and the reinforced fill placed and compacted behind it up to the level of the cells.
This process is then reiterated until the next layer of reinforcement is placed.


Photograph, Ingvar Erlingsson

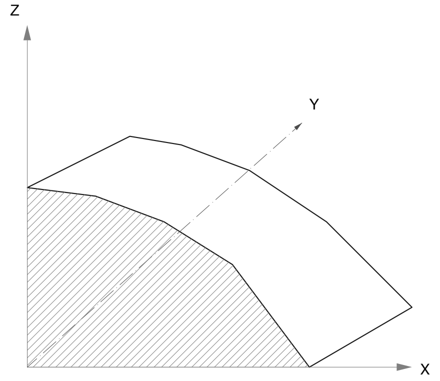
5. Exploration 2. // the search for design freedom



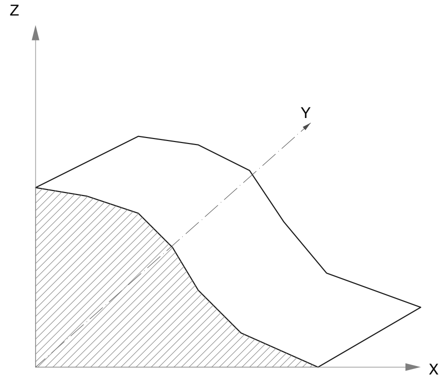
A) Planar slope



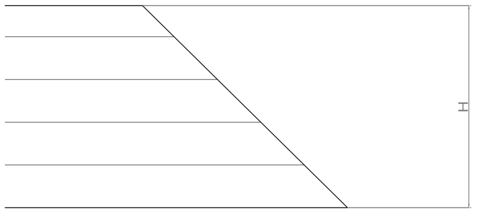
B) Concave slope

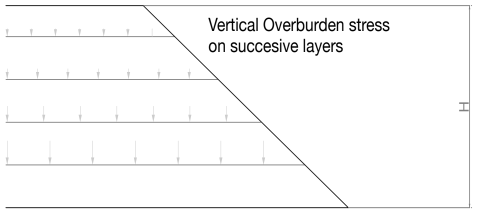


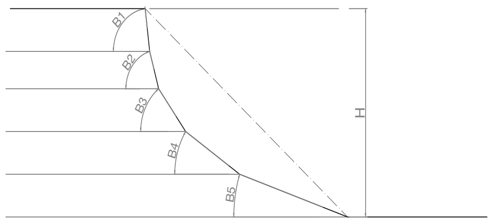
C) Convex slope

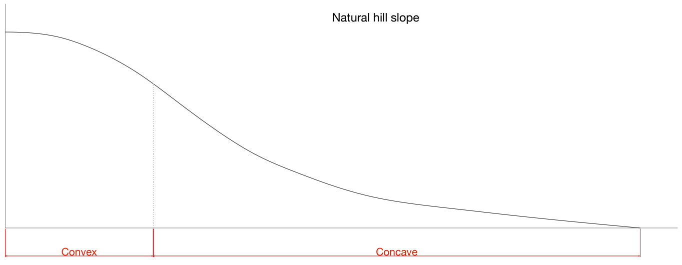


D) Compound slope









To conclude, the freedom is very much bound to the back facing sides of the earthworks; which in practice are usually convergent slopes with unvarying gradients. Shaped from the most common procedure, so called "cut and fill method". In present projects this procedure leaves us with a certain homogeneity in terms of surface treatment. Namely earthworks with oblong shapes, or planar slopes.

The latter exploration seeks out new ways of molding the protection dams on chosen project site. By using conclusions from previous phases to develop a geomorphological method to shape the earth works in a different kind of way than past and present practices have assimilated.

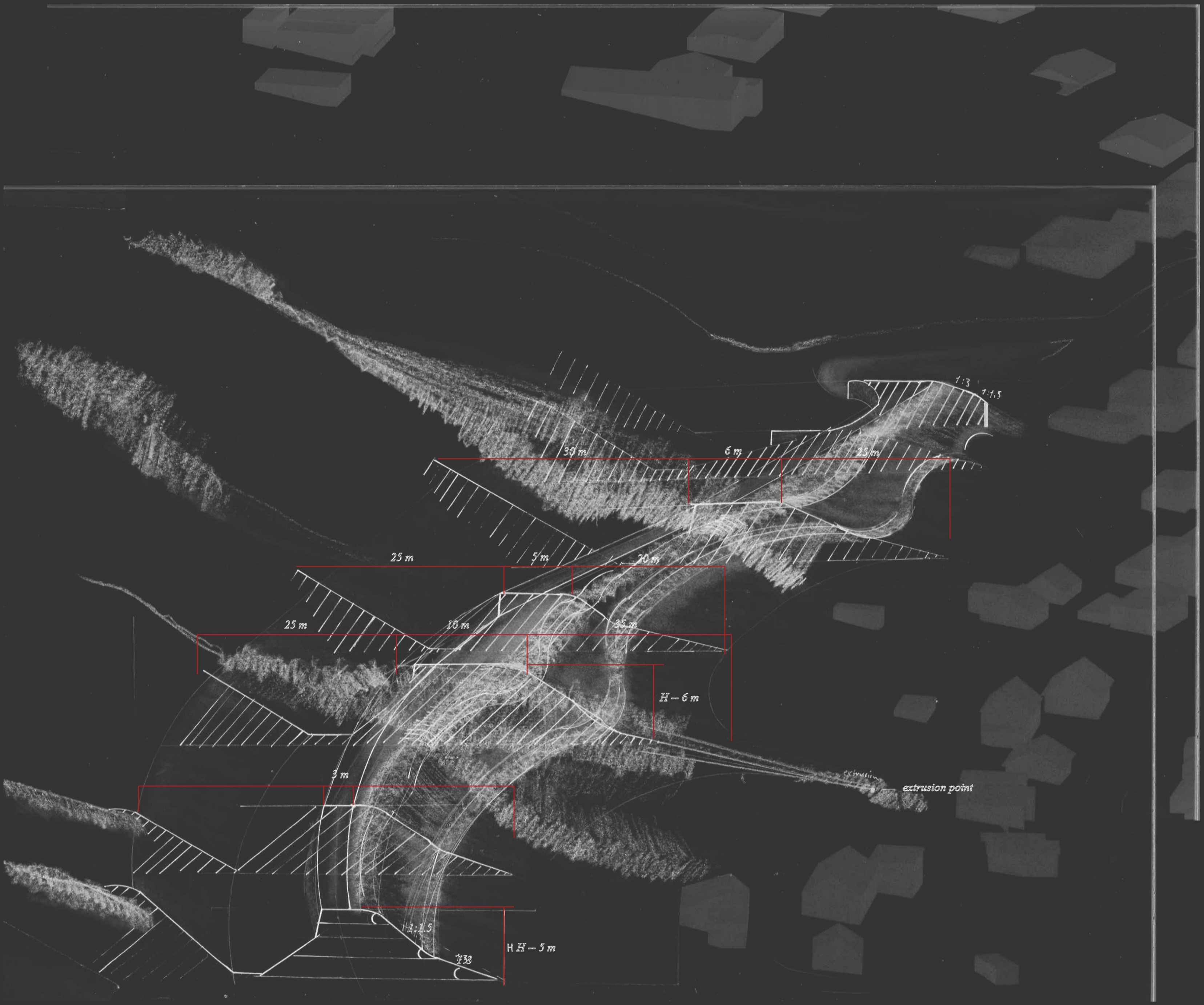
The drawing technique that is utilized in this project can briefly be described as follows; Each dam is dissected into profiles (cross section) that are attached to the dam leading axis, where each slope profile gets special treatment driven either under the influence of avalanche geometry (pronounced and rigid shapes) or the ideal compound slope that leaves a surface that simulates a curvilinear shape.

The notion of aesthetic quality in the contrast between the anthropogenic landforms and the natural context they are implemented becomes intriguing. Where the hidden brutality of avalanches has more profound visualisation through the formal language of the defense systems. This fine line between invasive and less invasive will be explored on the project site.

(Next coming pages include extract of illustrations from the exploration of the author)

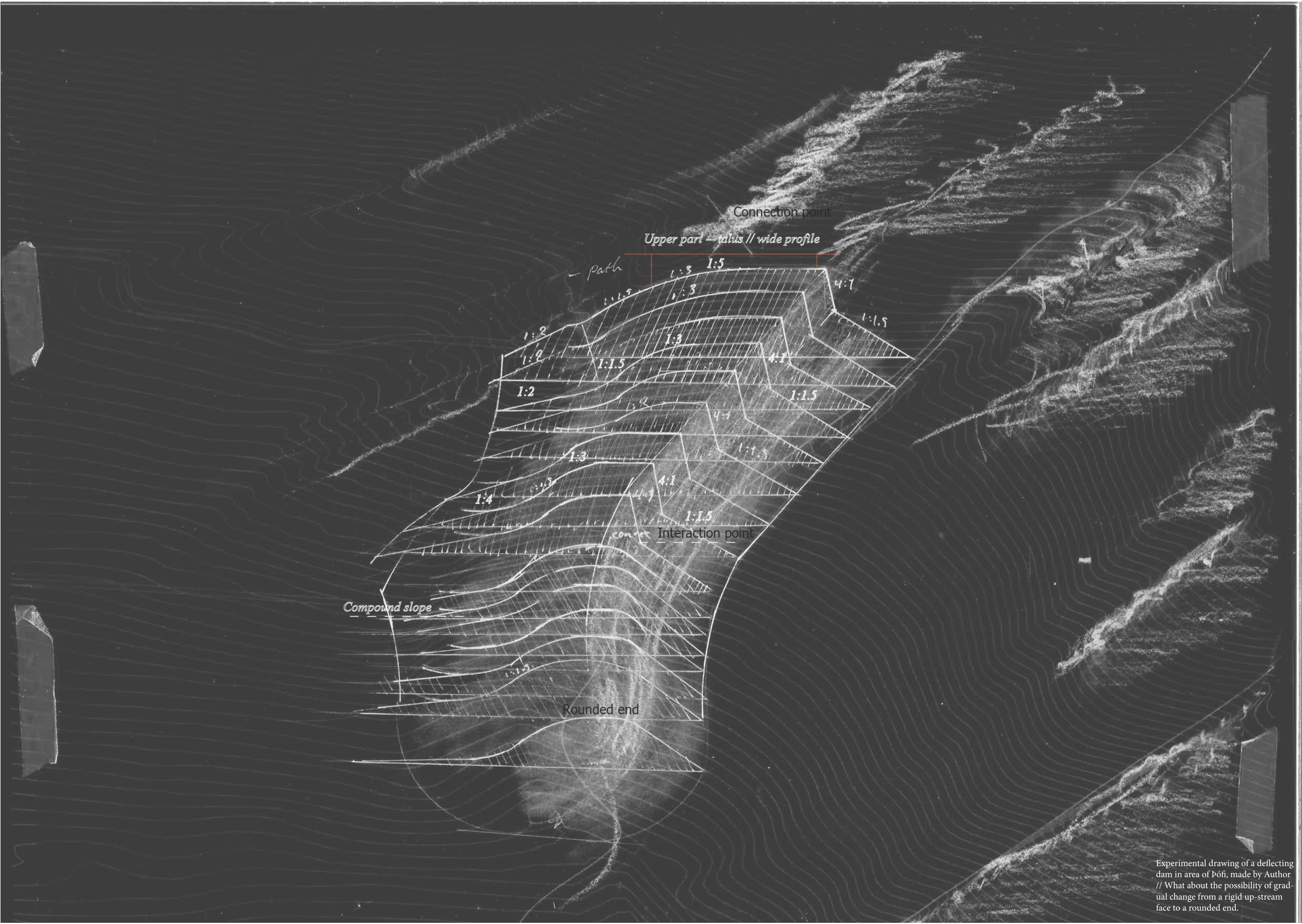
1. Site

Areal image, Landmælingar íslands

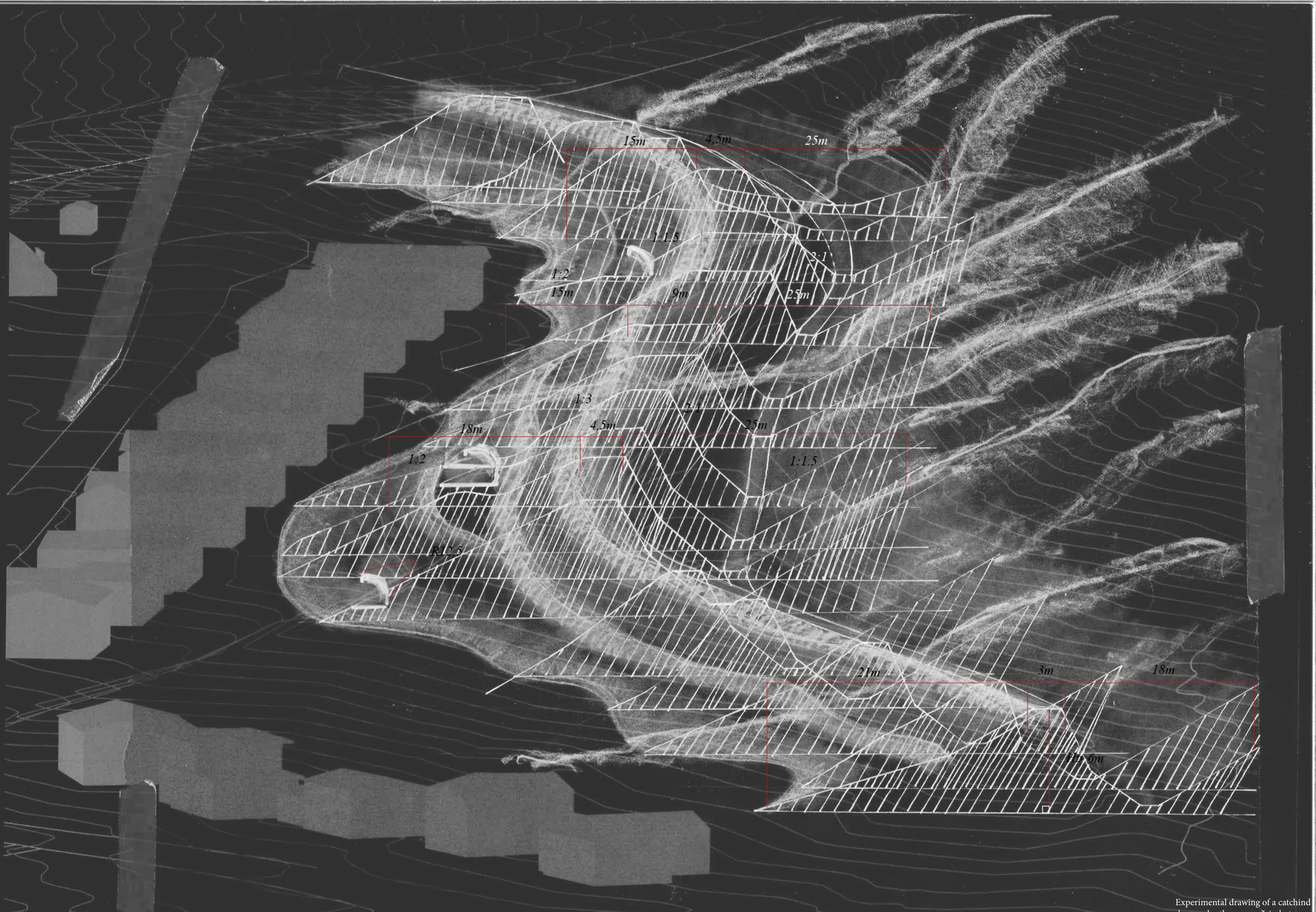


Experimental drawing of a catching dam in Svabbatún area, made by Author//By drawing out different slope-profiles along precise curvature, one begins to visualise, not just the down slope section but also the cross slope section.

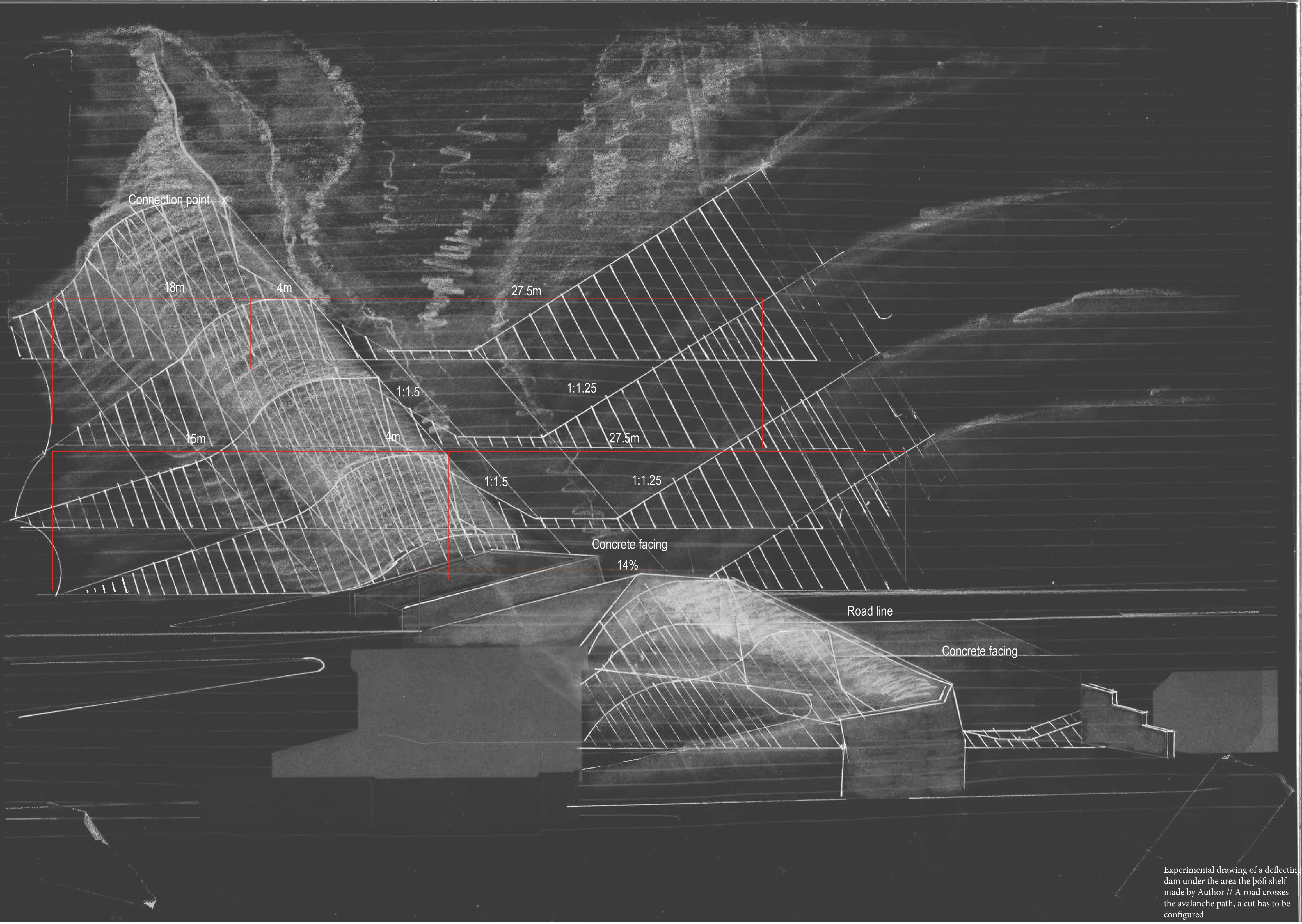
Experimental drawing of a triangular shaped dam under the area of Botnabrún, made by Author // A hybrid between the actions of retarding and deflecting.



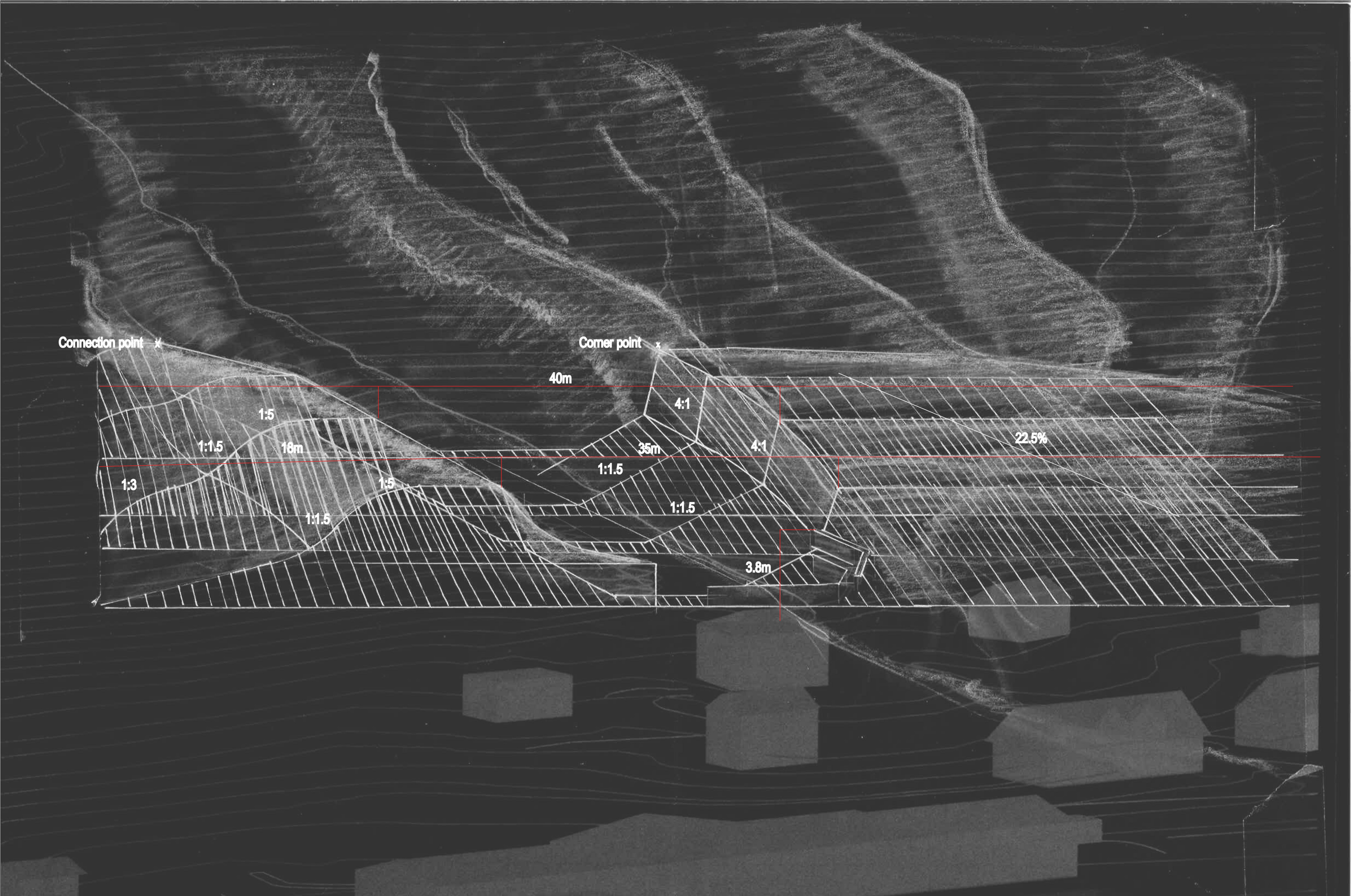
Experimental drawing of a deflecting dam in area of Þófi, made by Author // What about the possibility of gradual change from a rigid up-stream face to a rounded end.



Experimental drawing of a catchind dam under the area neðri - botnar, made by Author //



Experimental drawing of a deflecting dam under the area the þófi shelf made by Author // A road crosses the avalanche path, a cut has to be configured



Experimental drawing of a deflecting and splitting dam in the area under neðri botnar shelf made by Author // Intergration in close proximity to the settlement as to be configured.

The Village wall proposal partly addresses new ways of implementing an avalanche defense system for a small sea village in the east of Iceland. Furthermore it explores the relationship between form and function and aspects of beauty that are exposed from the making of the earthworks. Such as the contrast between prominent geometric shapes and the natural surroundings they are implemented in. As well as an interplay between convex and concave slope gradients that imitate natural slope conditions on the site.

Resulting project is a 2,5 km long defense system with 3,9 km of drainage channels. The Village wall itself is composed of catching- and deflecting dams, splitters and other hybrid deverting structures. That either stop or divert avalanches away from the settled area to retain bed loaders which dissociate the content of the avalanche, in this case - mud and water. Water is then led through the settlement and out to sea in sloping water basins. The designed waterways become a point of attraction for people to be and gather.

The water basins are made wide in order to facilitate gentle sloping with diverse vegetation cover. The hierarchy and succession of vegative cover is made in such a way that it can withstand a diverse rise in water level. Furthermore the water basins become passages not only for water but for people to walk through or to dwell in. The passage along the basin is attached both to towns existing infrastructure and newly proposed path system.

The resulting geometrical shapes of the dams offer new types of interactions for the local community. The undulating surface of the dam's back sides forms an enclosure where vegetable gardens and playgrounds are located. Here one could envision the back sides becoming the second garden space.

In some cases the structures are more rigid yet settled and reach high up the mountain side where access by foot is possible, providing great views over the fjord. Their prominent shapes and accessibility provide conditions for the local community to come up with various ideas for different occasions.

Network of paths, both hiking and cycle, are proposed. Sometimes the paths run on top of the structures providing scenic conditions for the hiker. Or along, fading into the existing path network. Here opens up for new types of possibilities, where a 2,5 km dirt bike track is built as an extension of the drainage channel berms.

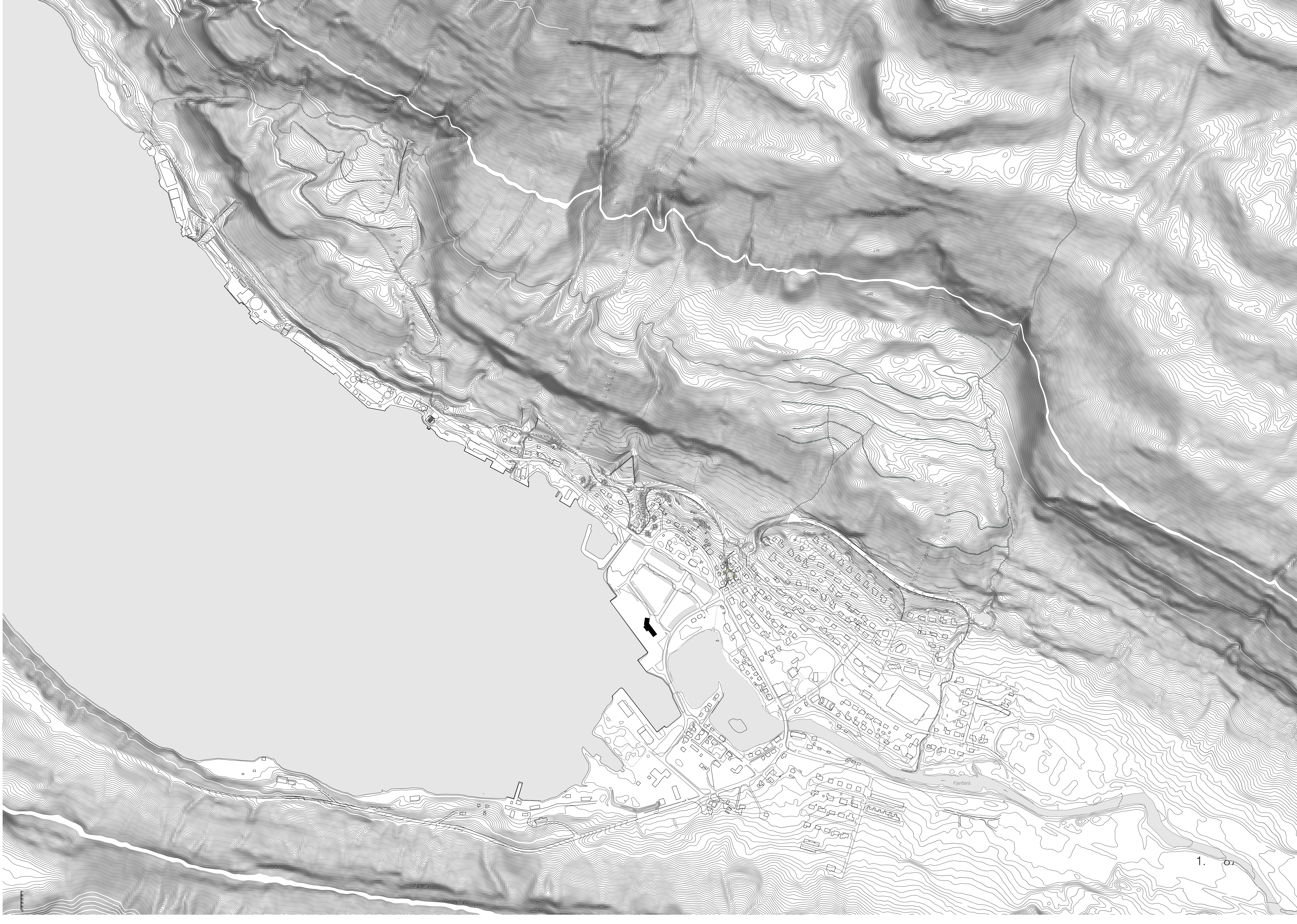
The soil reclamation will rely on two fundamental factors; first, the curvilinear down and cross slopes of the back facing sides, that will exhibit stable ground conditions that can more easily fight against the most common erosion factors in Iceland. Second, tight vegative cover composed of sowing mixes with native grasses and sedges that knit the surface cover together.

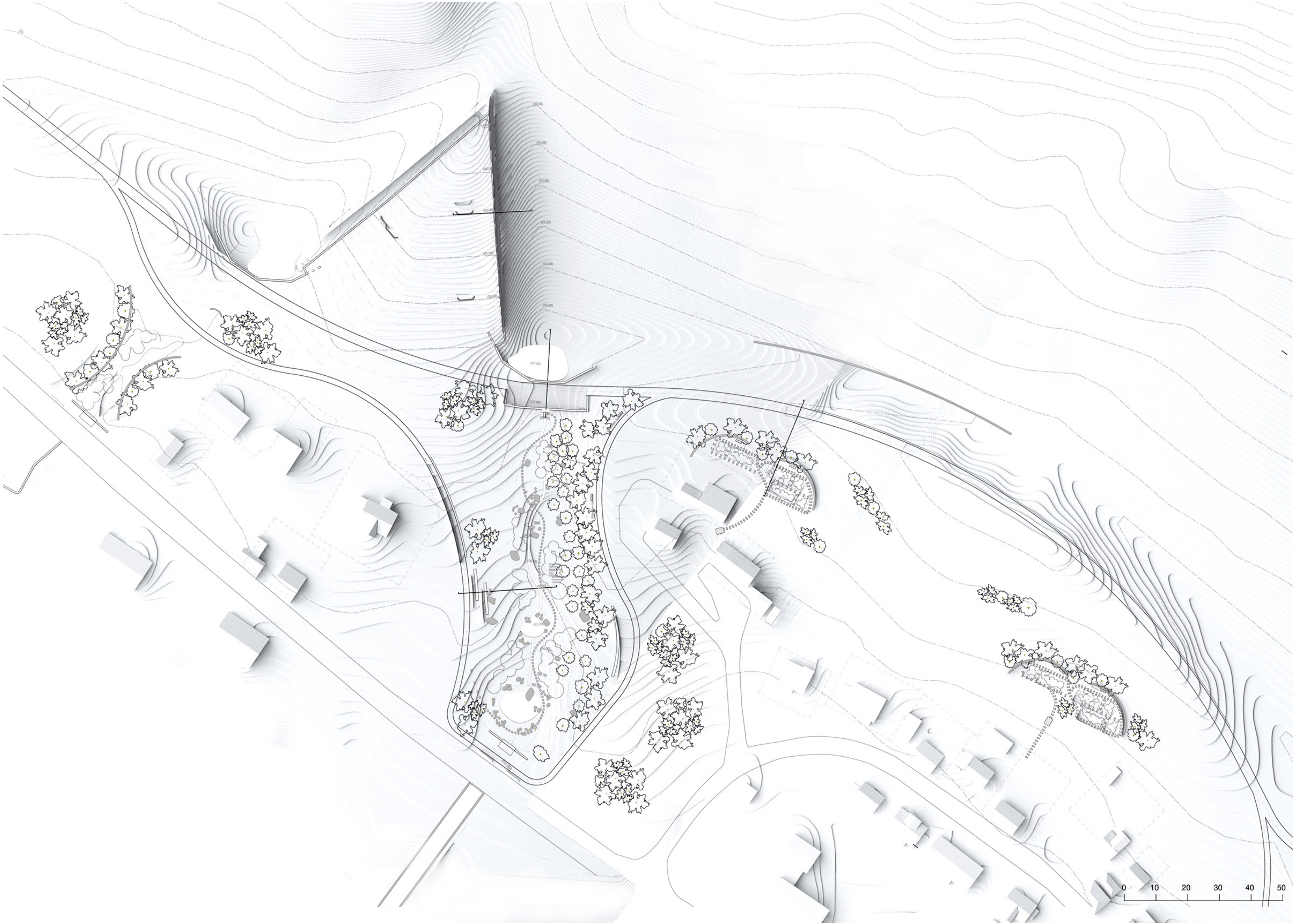
Robust shrubs and trees are suggested to form a net of groves that are adjusted to existing tree planting on the site. Here the implementation is not done by means of camouflage. But rather as an additive mix to the project proposal.

The interplay between rigid and undulating forms, between invasive and less invasive appearances is a constant thread throughout the whole project site. And moulds fine line of contrasting landscape features that surround the village of Seyðisfjörður. The Village Wall is an idea of a contemporary relevance of a fortification as public space.

A defense system against mudslides that becomes a fundamental link to the village chain.

There are few places in the world where a city's identity is defined by a wall as they were in medieval times. Not to mention as an identity for a small village.


Fjarðará
1.


(35.00)
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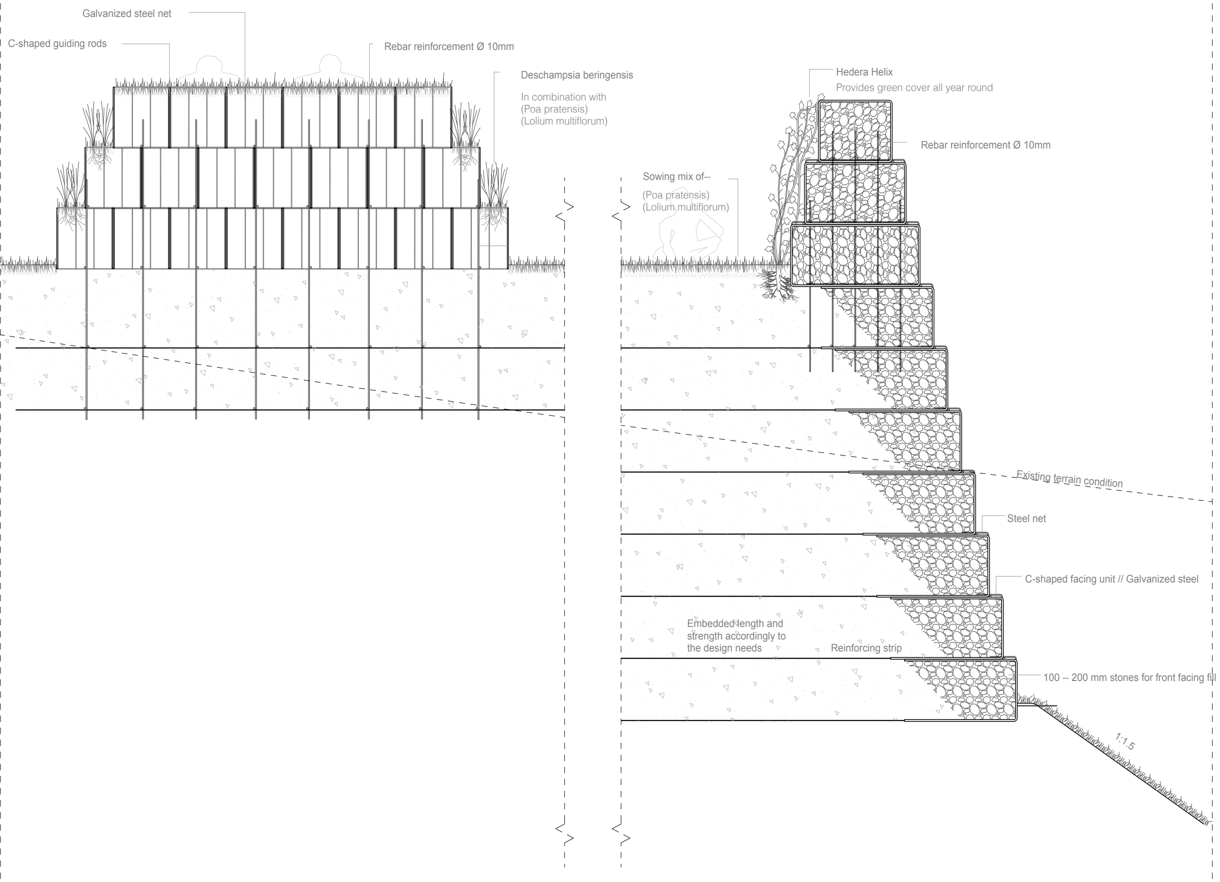
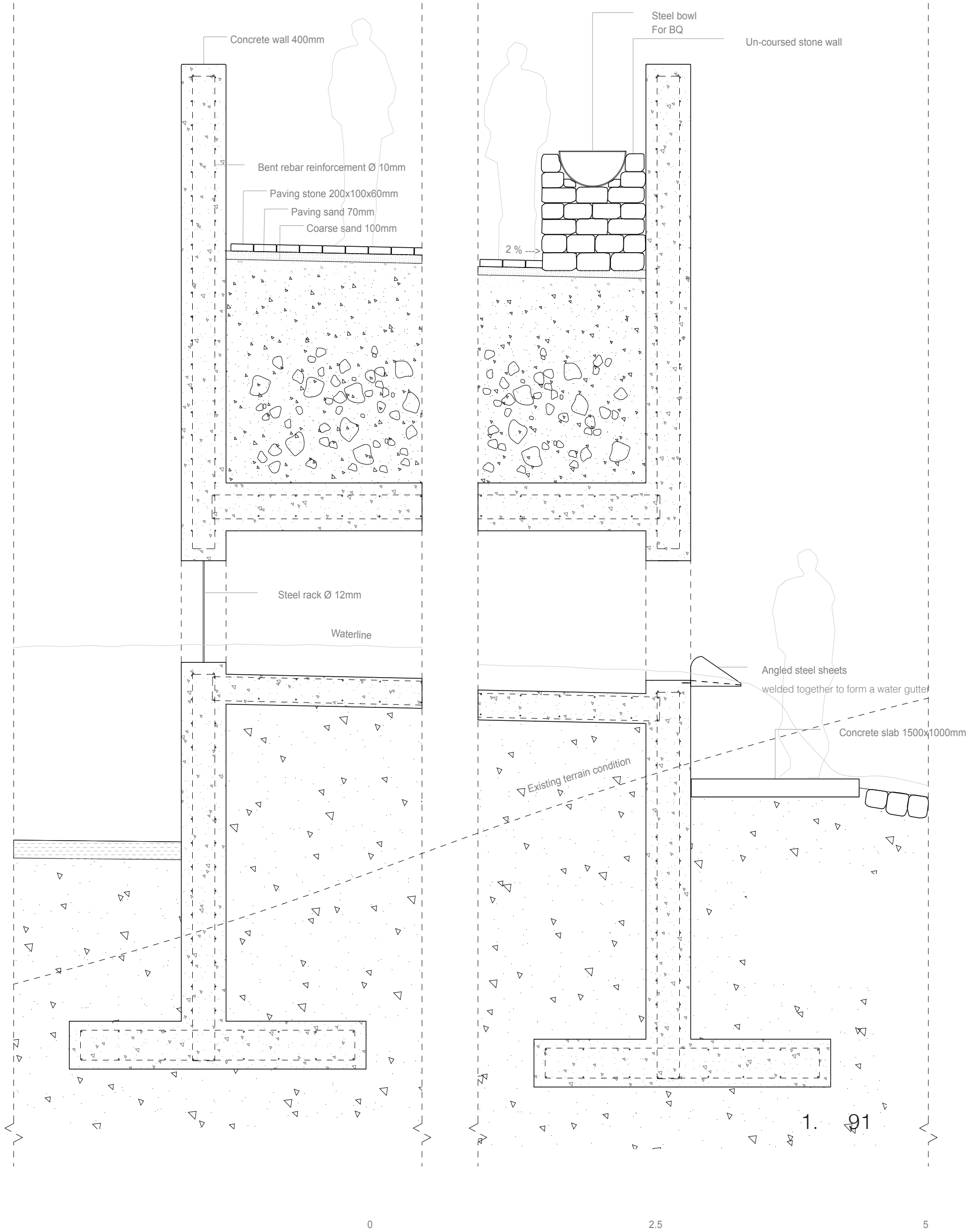
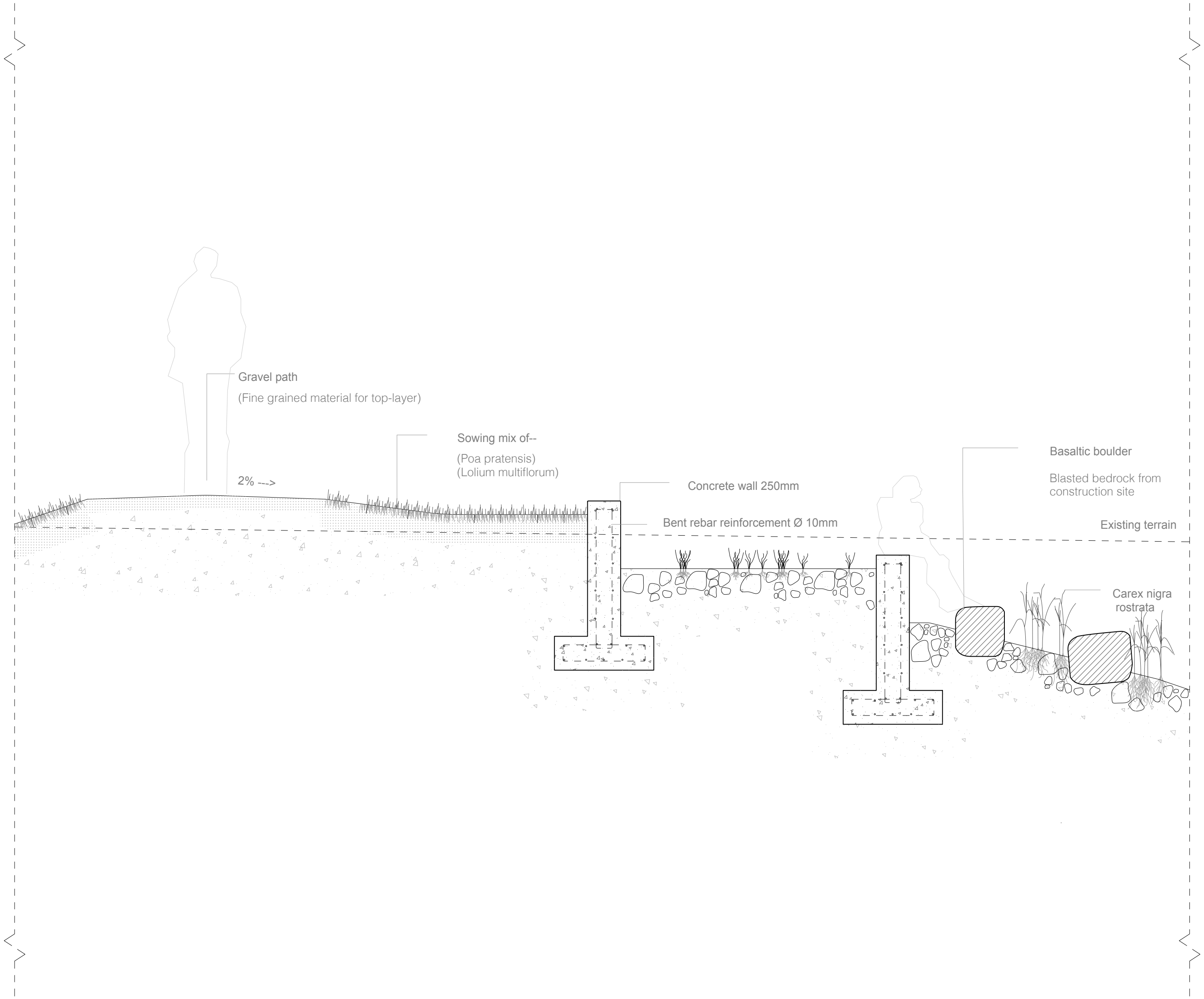
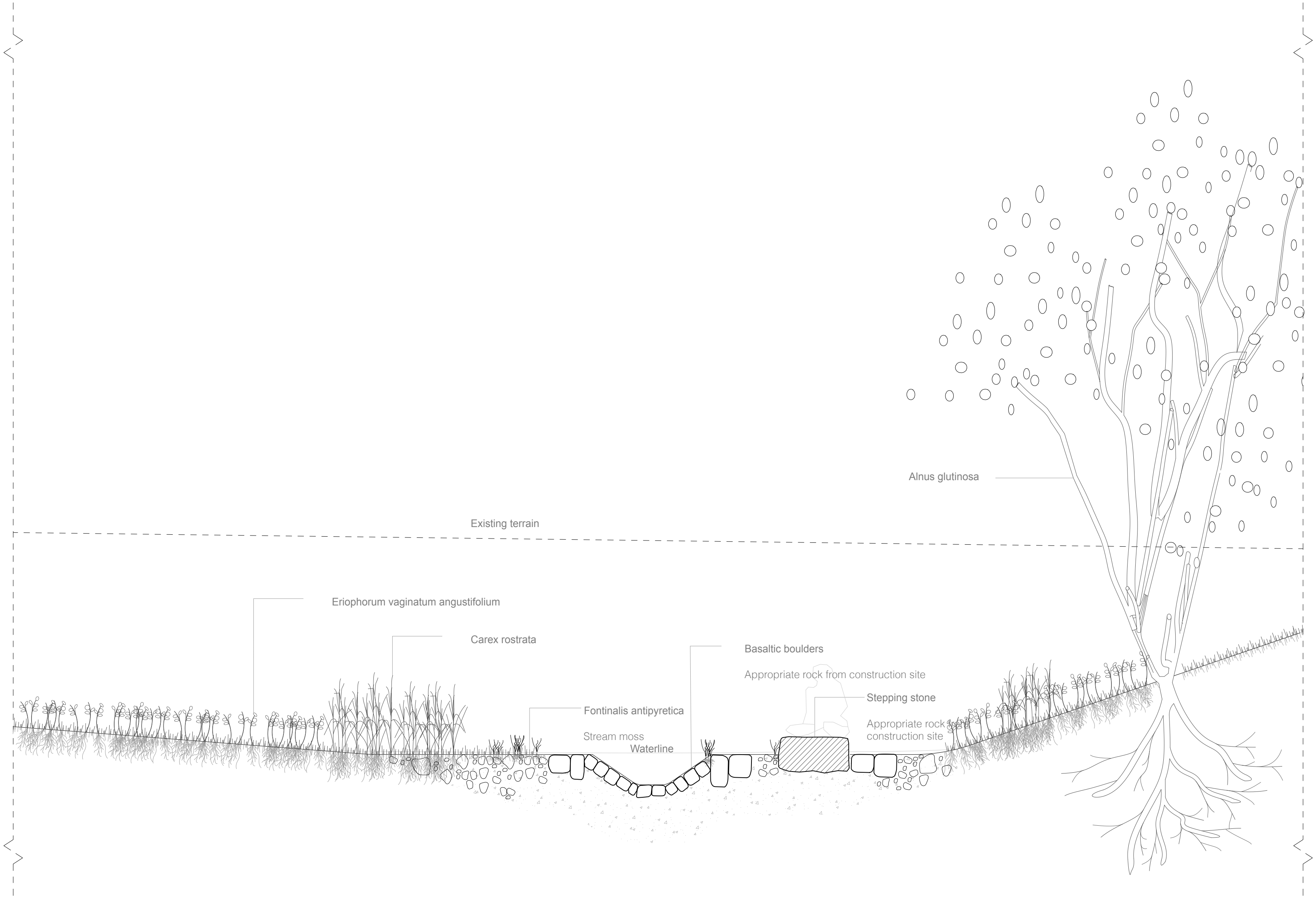
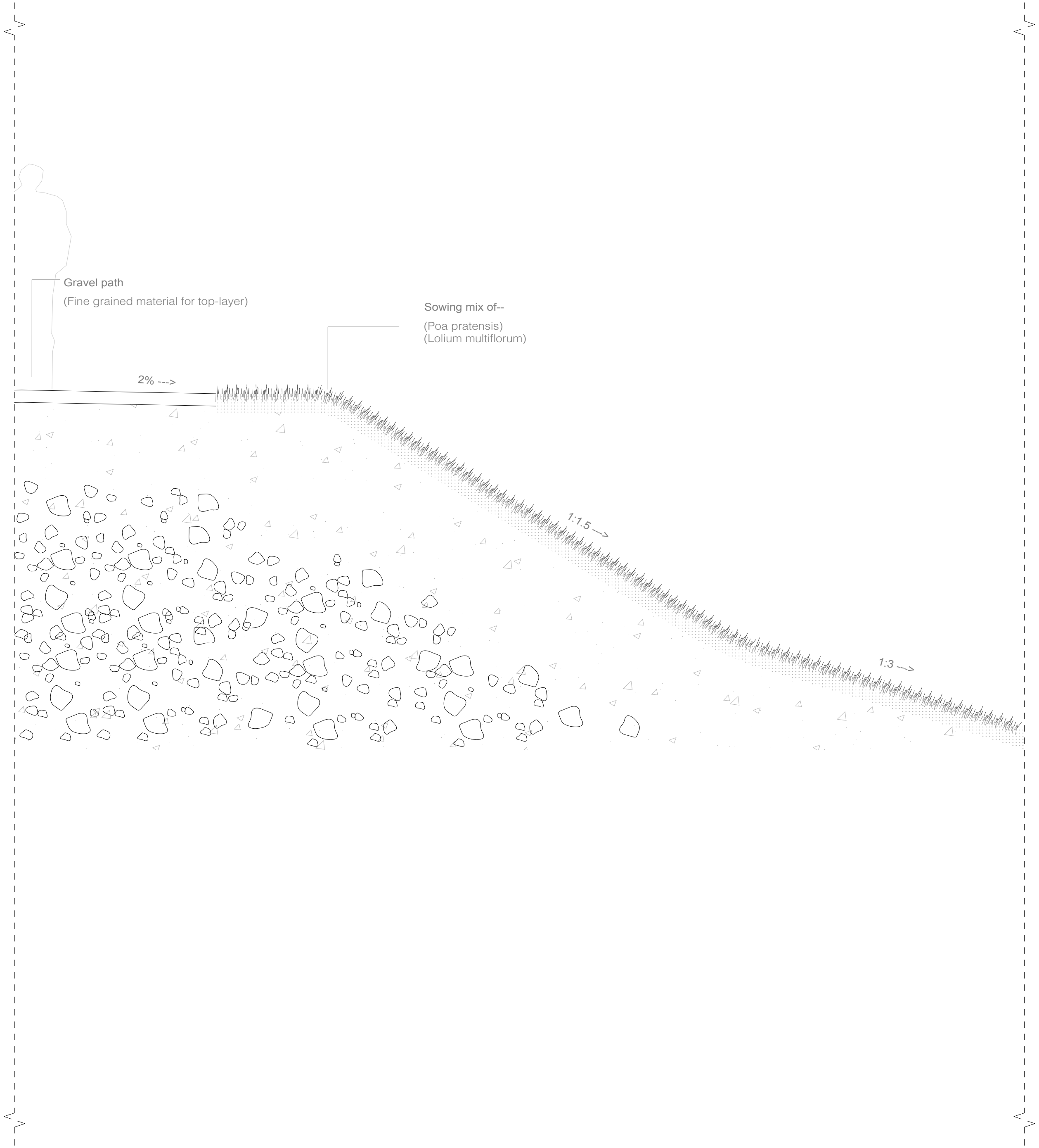
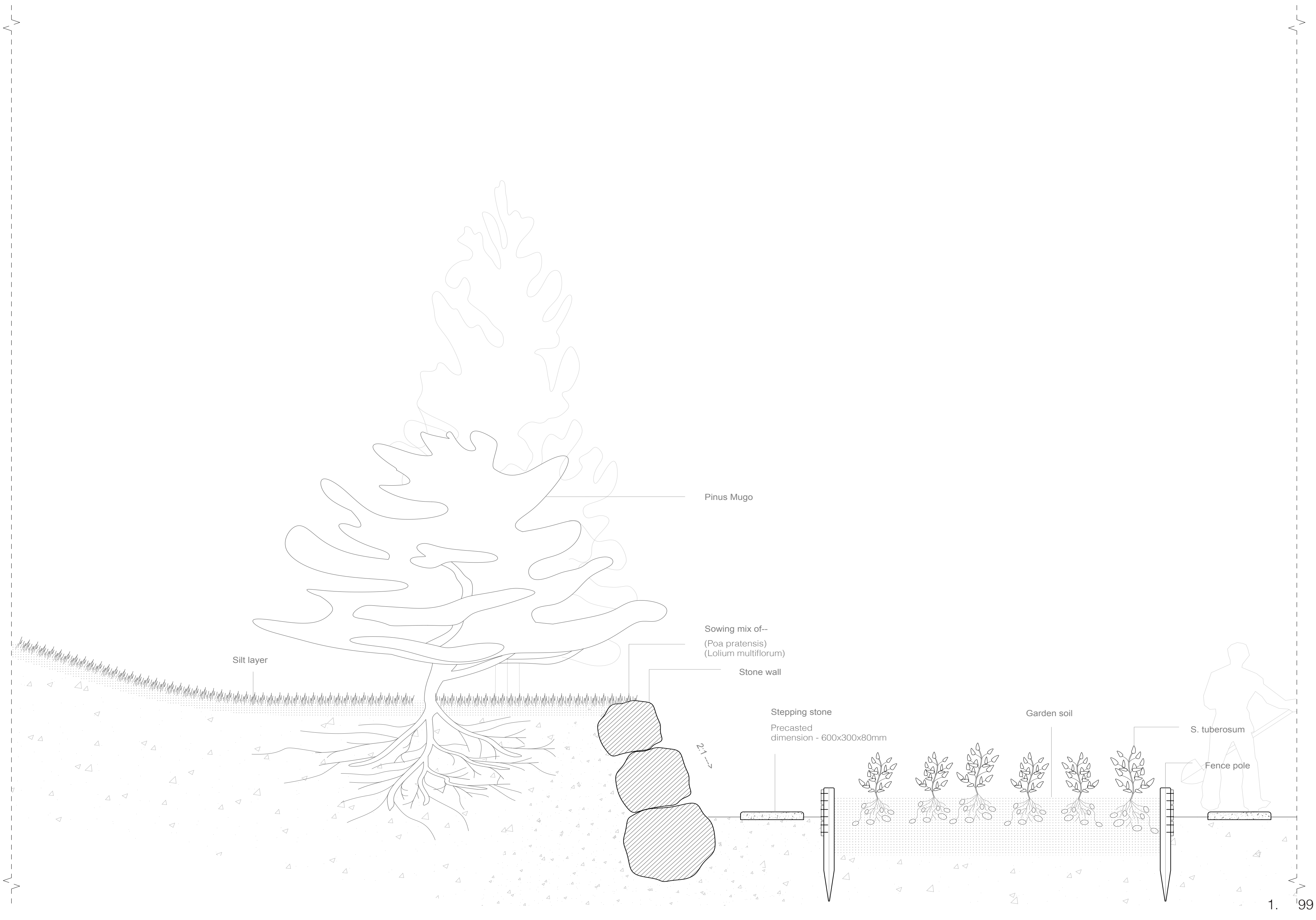

Galvanized steel net
C-shaped guiding rods
Rebar reinforcement Ø 10mm
Deschampsia beringensis
In combination with
(Poa pratensis)
(Lolium multiflorum)
Hedera Helix
Provides green cover all year round
Rebar reinforcement Ø 10mm
Sowing mix of--
(Poa pratensis)
(Lolium multiflorum)
Existing terrain condition
Steel net
C-shaped facing unit // Galvanized steel
Embedded length and strength accordingly to the design needs
Reinforcing strip
100 -- 200 mm stones for front facing fill
1:1.5


Concrete wall 400mm
Bent rebar reinforcement Ø 10mm
Paving stone 200x100x60mm
Paving sand 70mm
Coarse sand 100mm
Steel rack Ø 12mm
Waterline
Steel bowl
For BQ
Un-coursed stone wall
2 %
Angled steel sheets
welded together to form a water gutter
Concrete slab 1500x1000mm
Existing terrain condition
1. 91
0
2.5
5

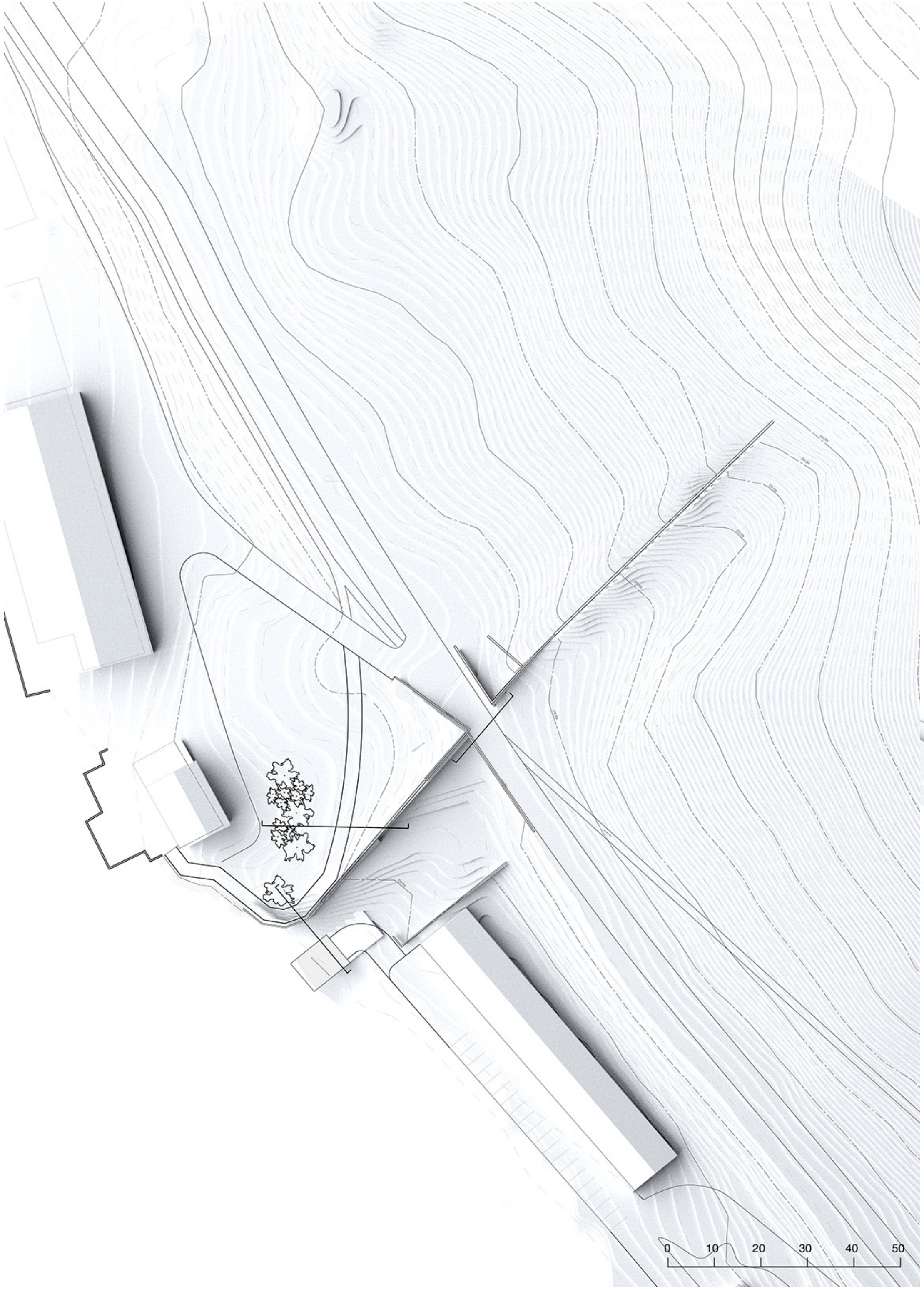

Gravel path
(Fine grained material for top-layer)
2% --->
Sowing mix of--
(Poa pratensis)
(Lolium multiflorum)
Concrete wall 250mm
Bent rebar reinforcement Ø 10mm
Basaltic boulder
Blasted bedrock from construction site
Existing terrain
Carex nigra rostrata


Alnus glutinosa
Existing terrain
Eriophorum vaginatum angustifolium
Carex rostrata
Basaltic boulders
Appropriate rock from construction site
Stepping stone
Fontinalis antipyretica
Appropriate rock from construction site
Stream moss
Waterline


Gravel path
(Fine grained material for top-layer)
Sowing mix of--
(Poa pratensis)
(Lolium multiflorum)
2% --->
1:1.5 --->
1:3 --->


Pinus Mugo
Sowing mix of--
(Poa pratensis)
(Lolium multiflorum)
Silt layer
Stone wall
2:1 --->
Stepping stone
Precasted
dimension - 600x300x80mm
Garden soil
S. tuberosum
Fence pole

1. 99


0
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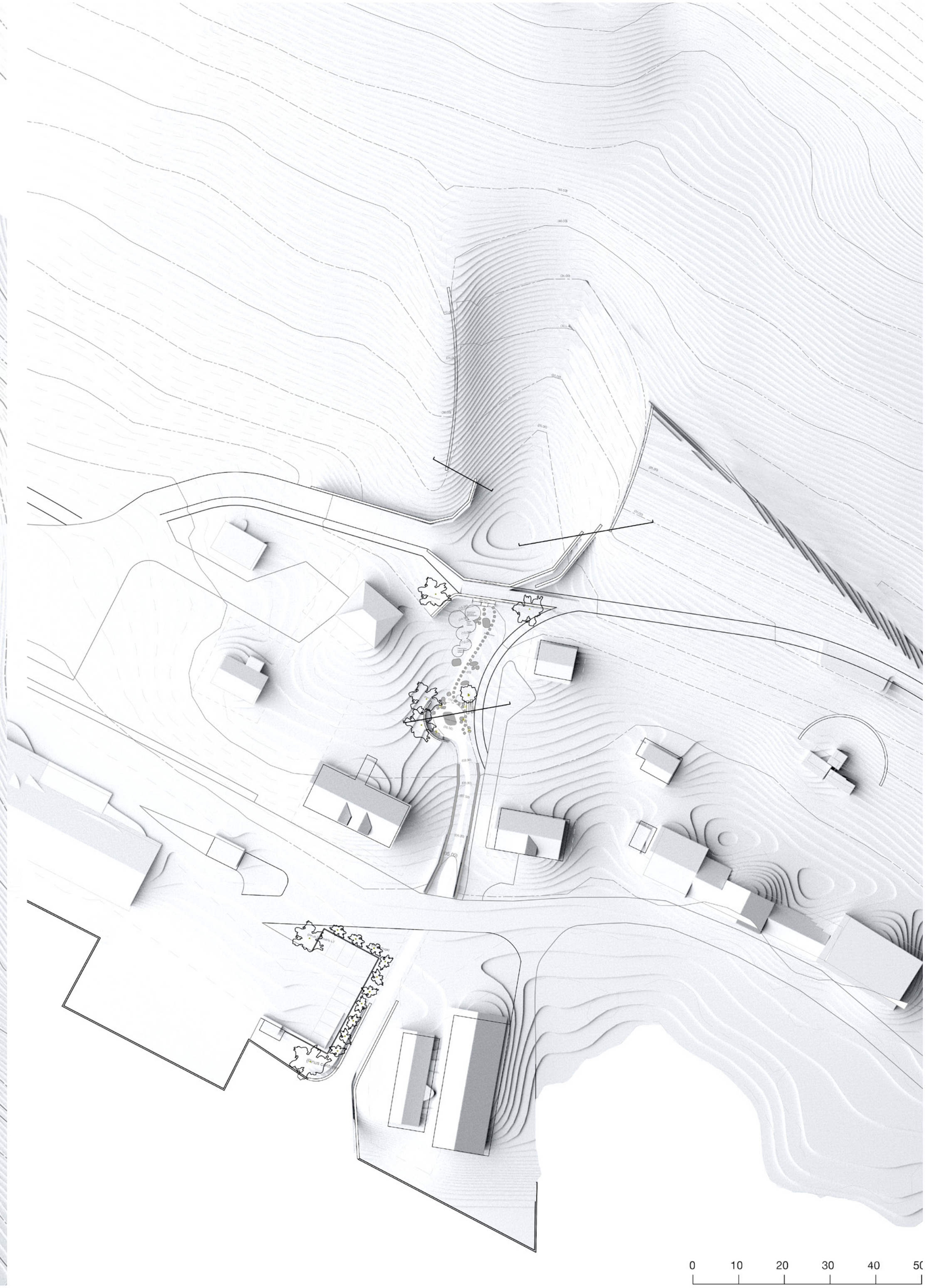
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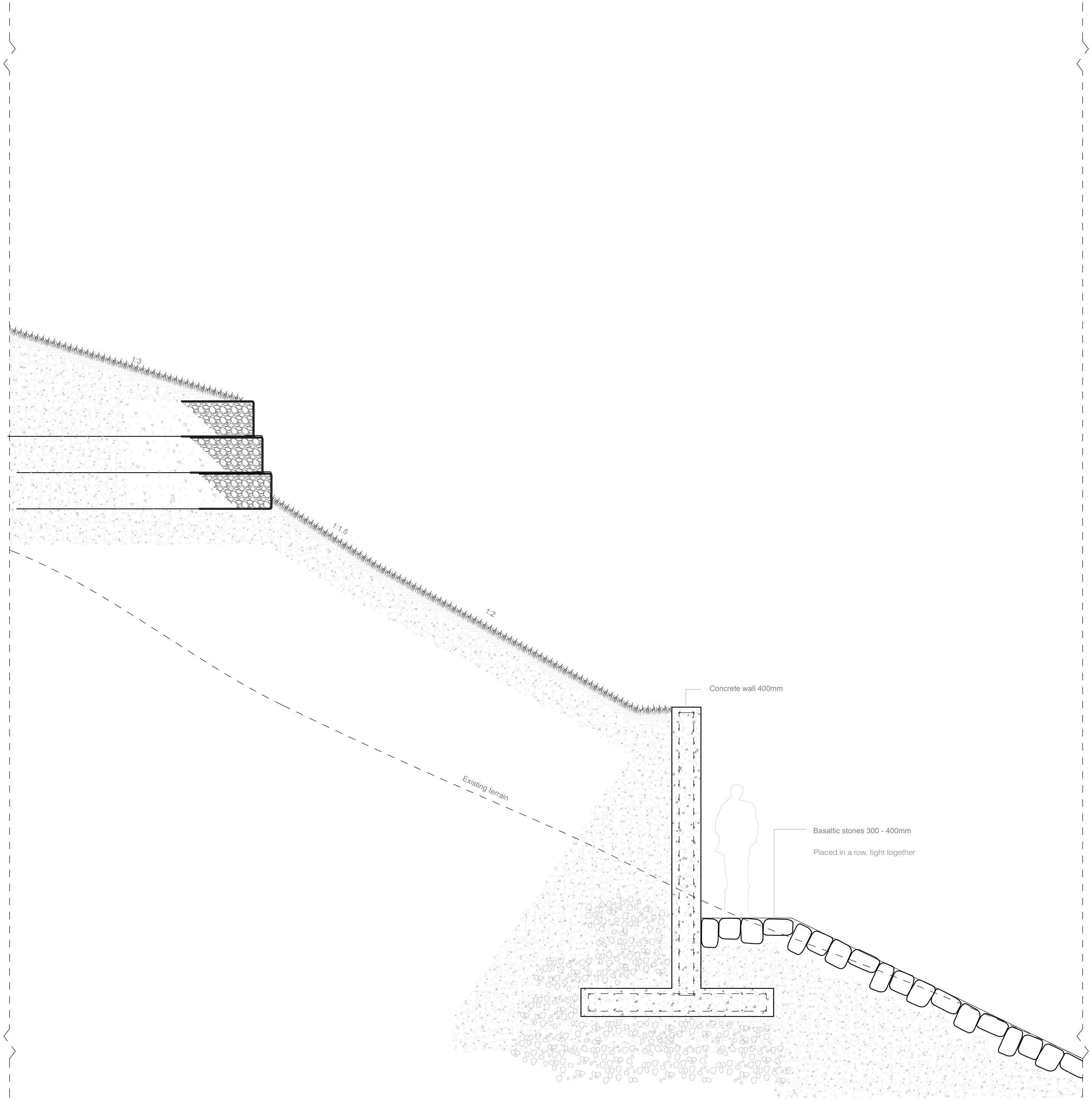
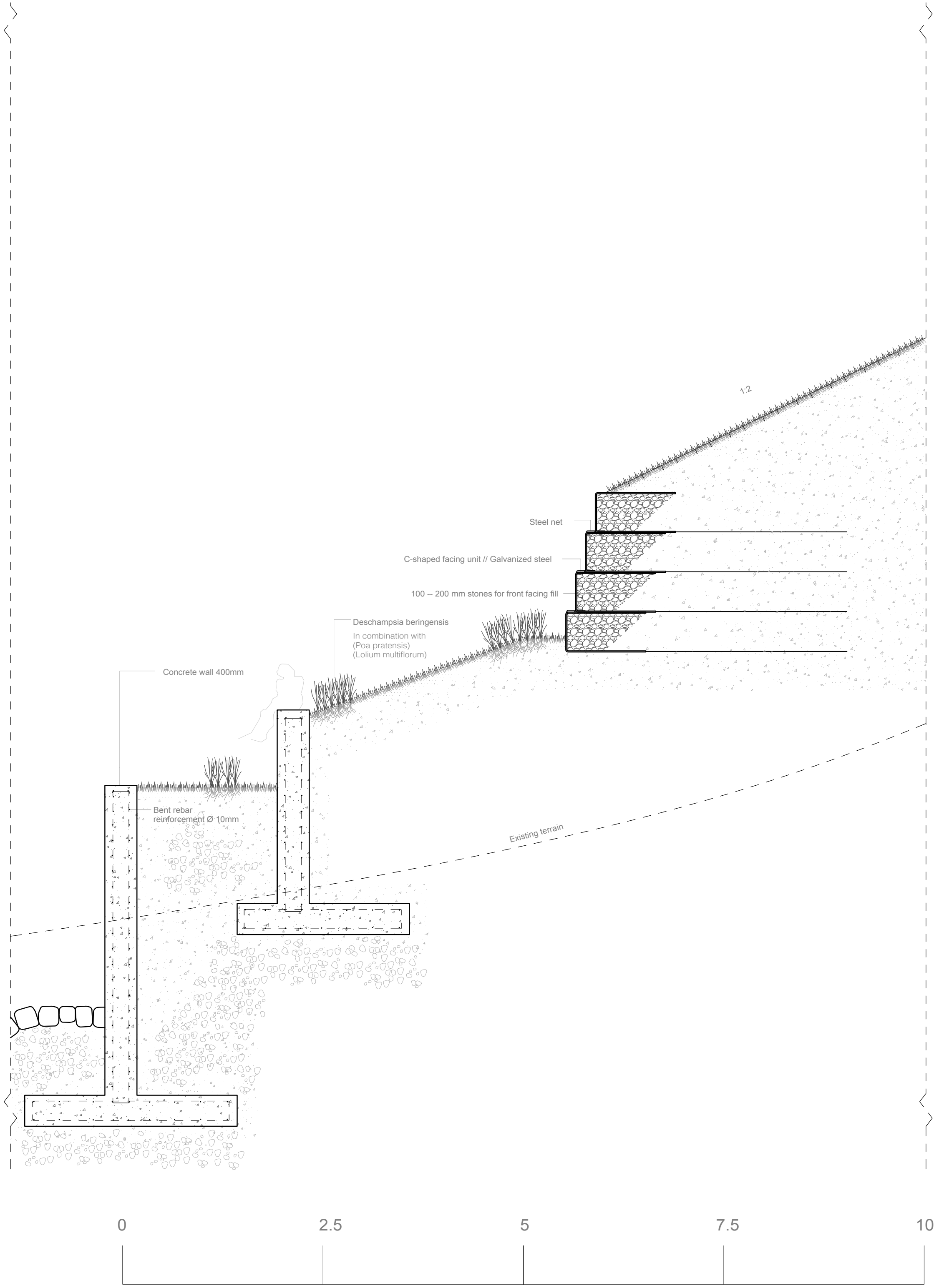
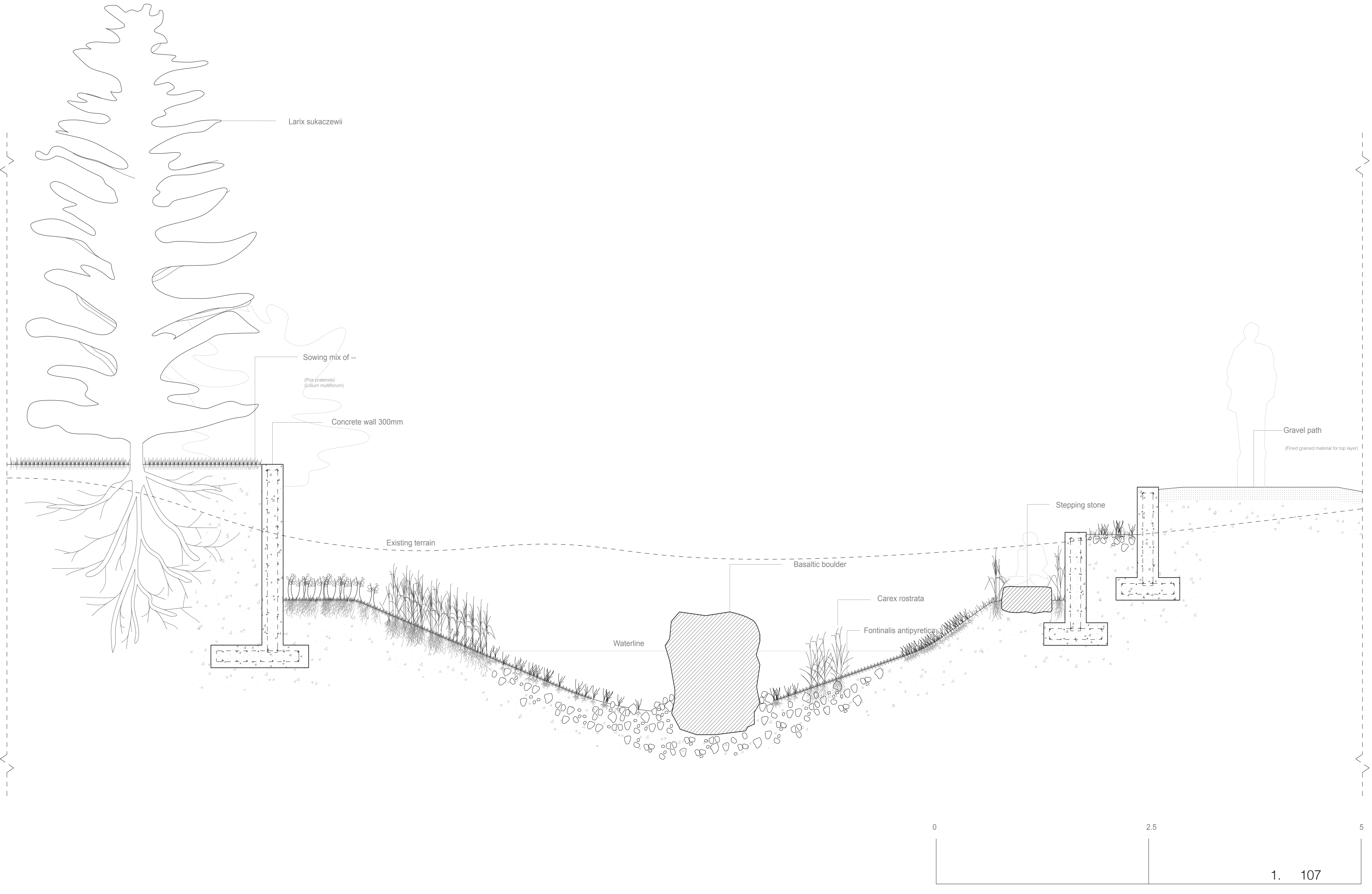
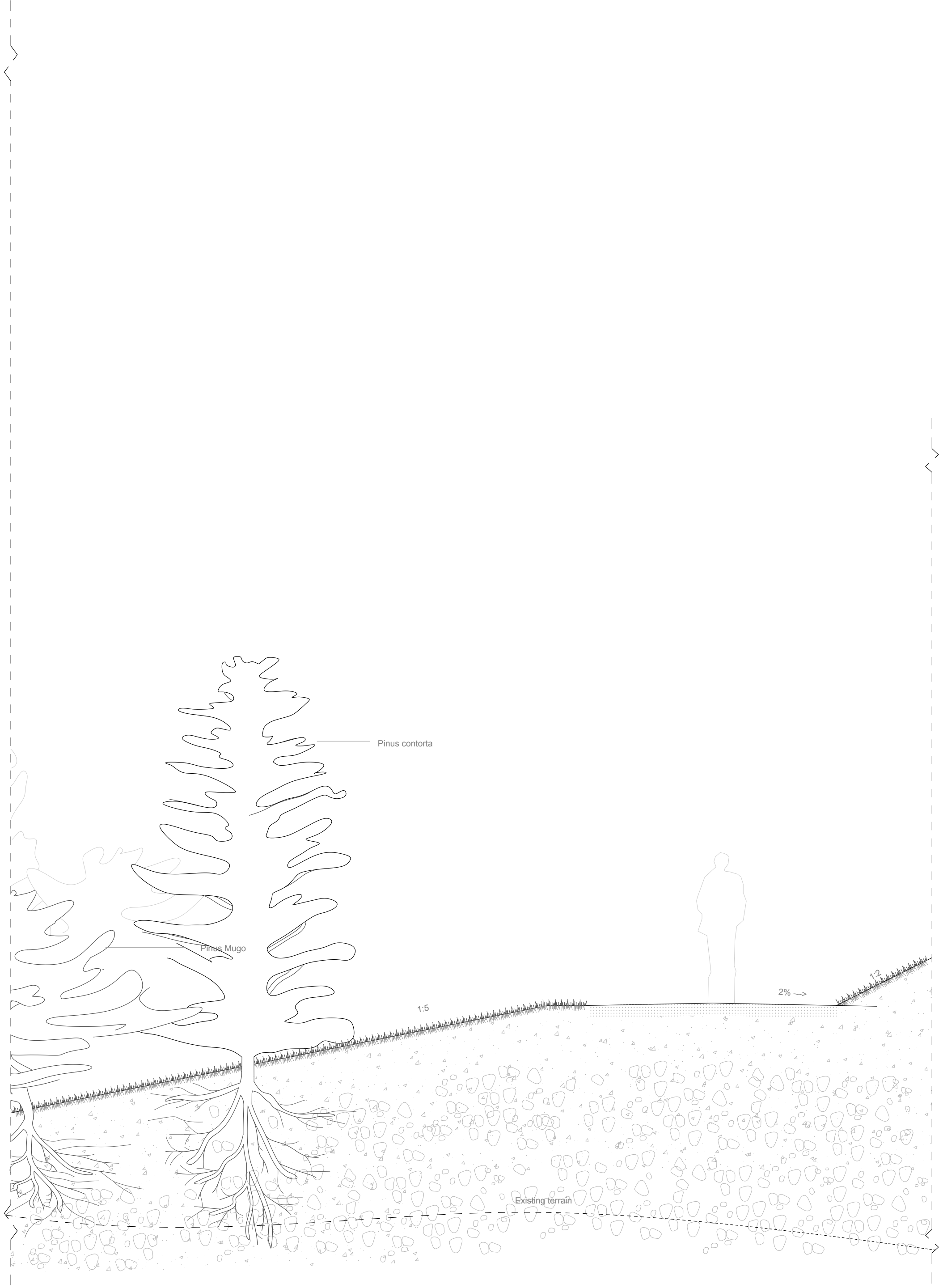
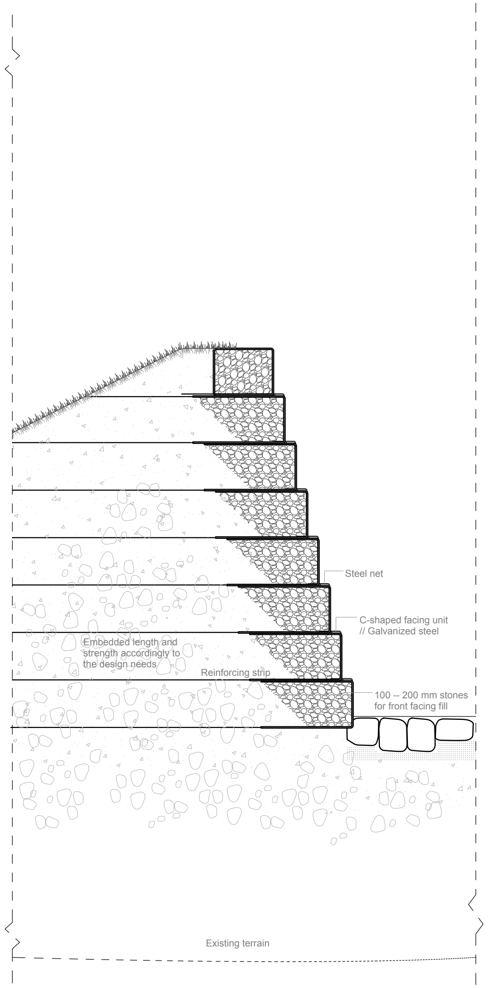
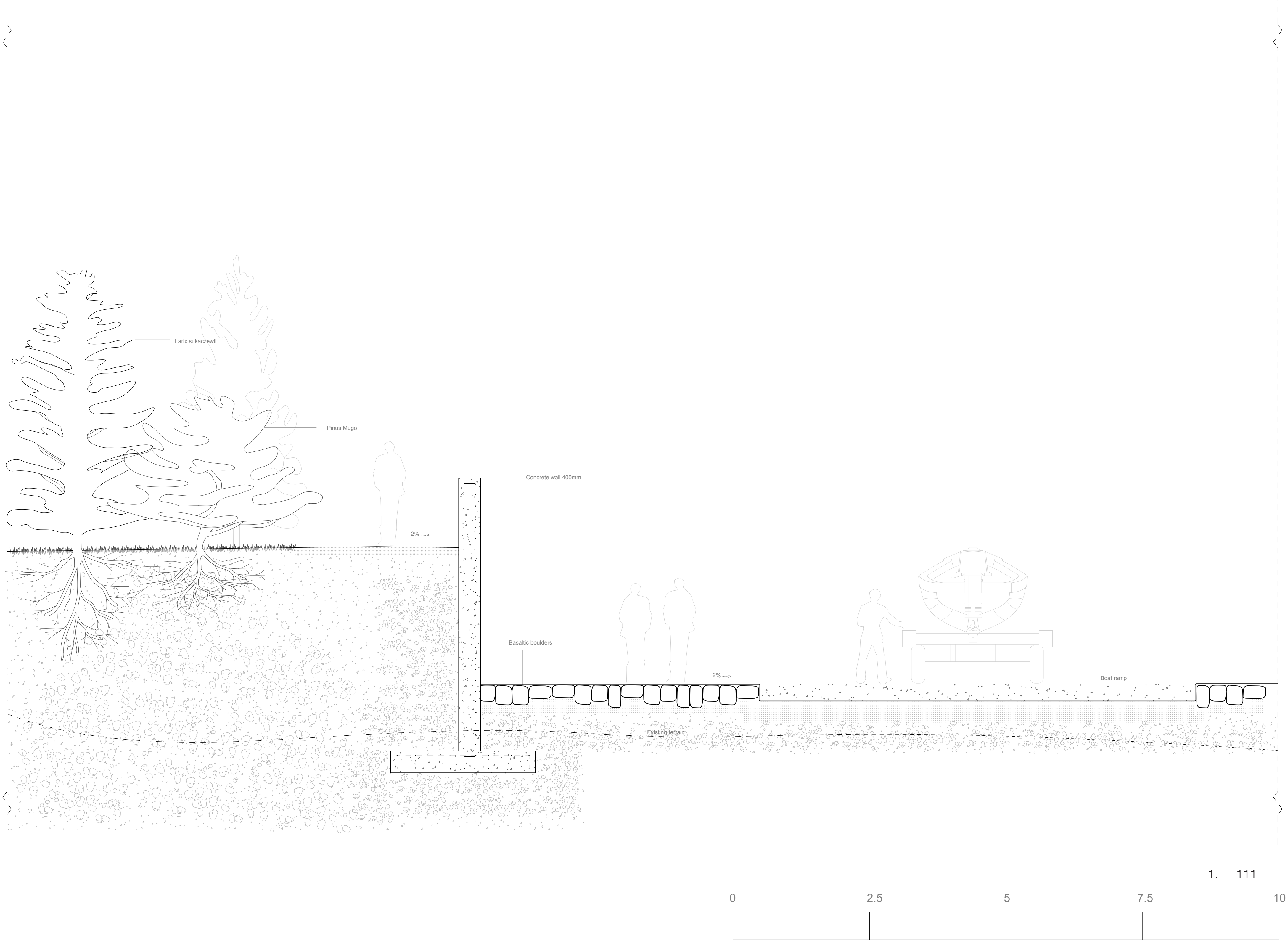

1:3
1:1.5
1:2
Concrete wall 400mm
Existing terrain
Basaltic stones 300 - 400mm
Placed in a row, tight together

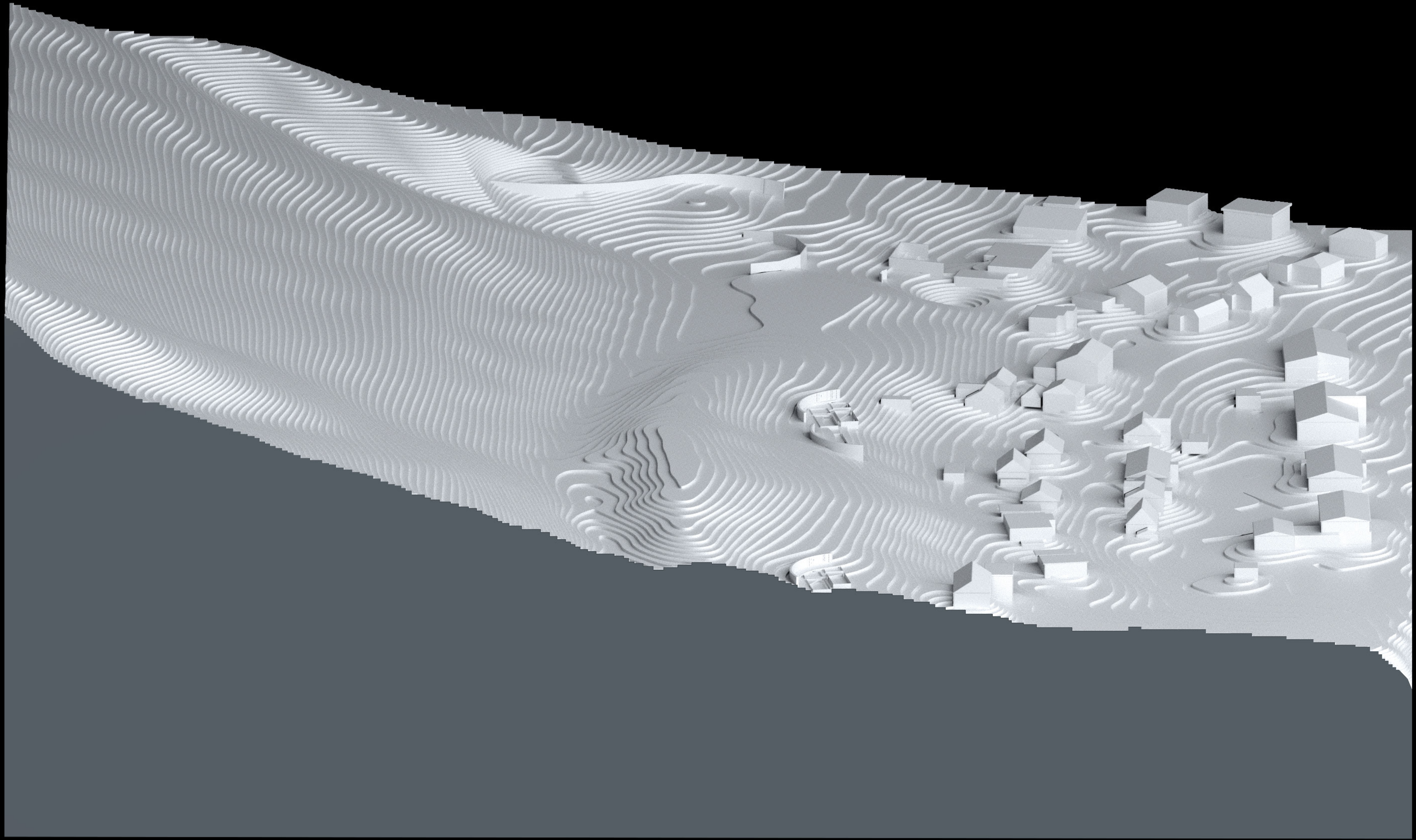

1:2
Steel net
C-shaped facing unit // Galvanized steel
100 -- 200 mm stones for front facing fill
Deschampsia beringensis
In combination with
(Poa pratensis)
(Lolium multiflorum)
Concrete wall 400mm
Bent rebar
reinforcement Ø 10mm
Existing terrain
0
2.5
5
7.5
10

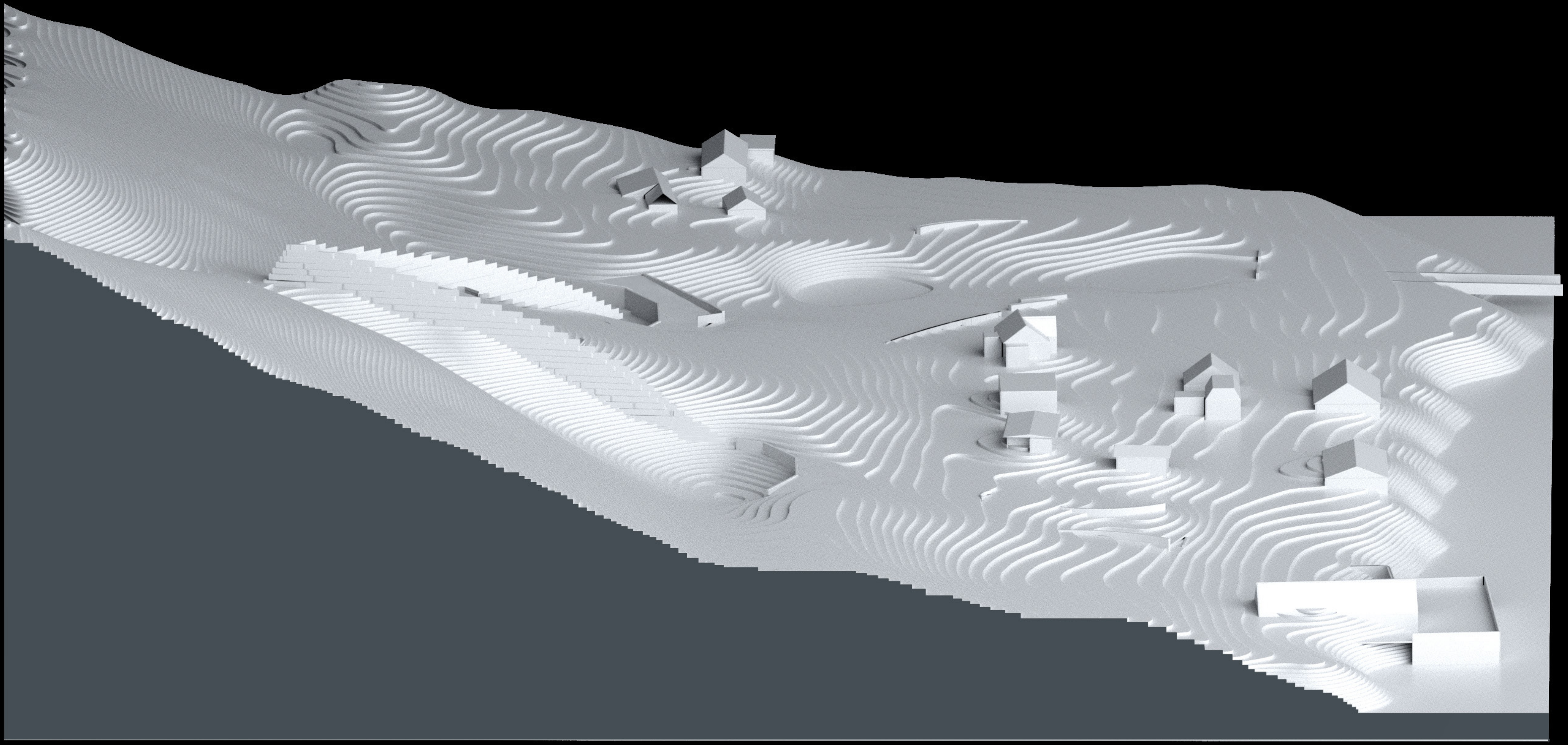

Larix sukaczewii
Sowing mix of --
(Poa pratensis)
(Lolium multiflorum)
Concrete wall 300mm
Gravel path
(Fined grained material for top layer)
Stepping stone
Existing terrain
Basaltic boulder
Carex rostrata
Fontinalis antipyretica
Waterline
0
2.5
5
1. 107

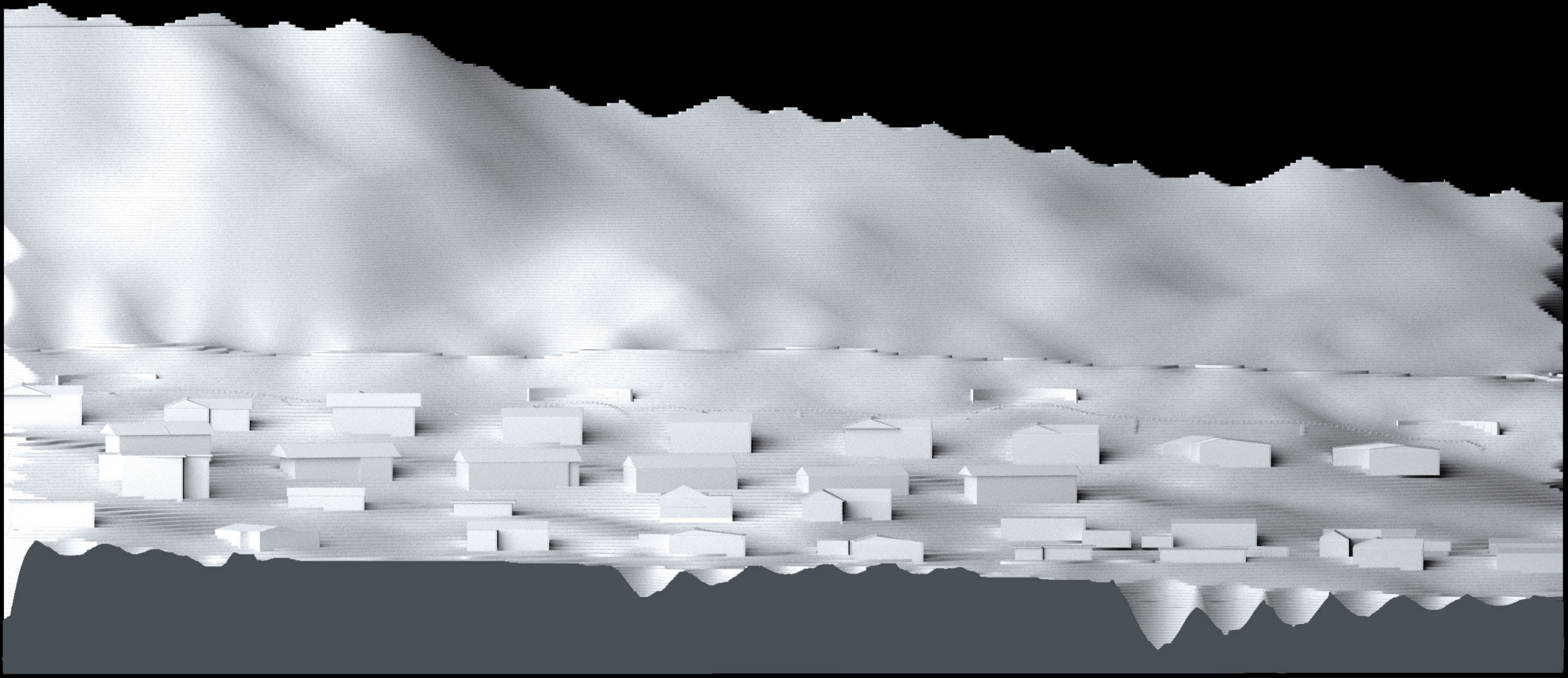

Pinus contorta
Pinus Mugo
1:5
2% --->
1:2
Existing terrain

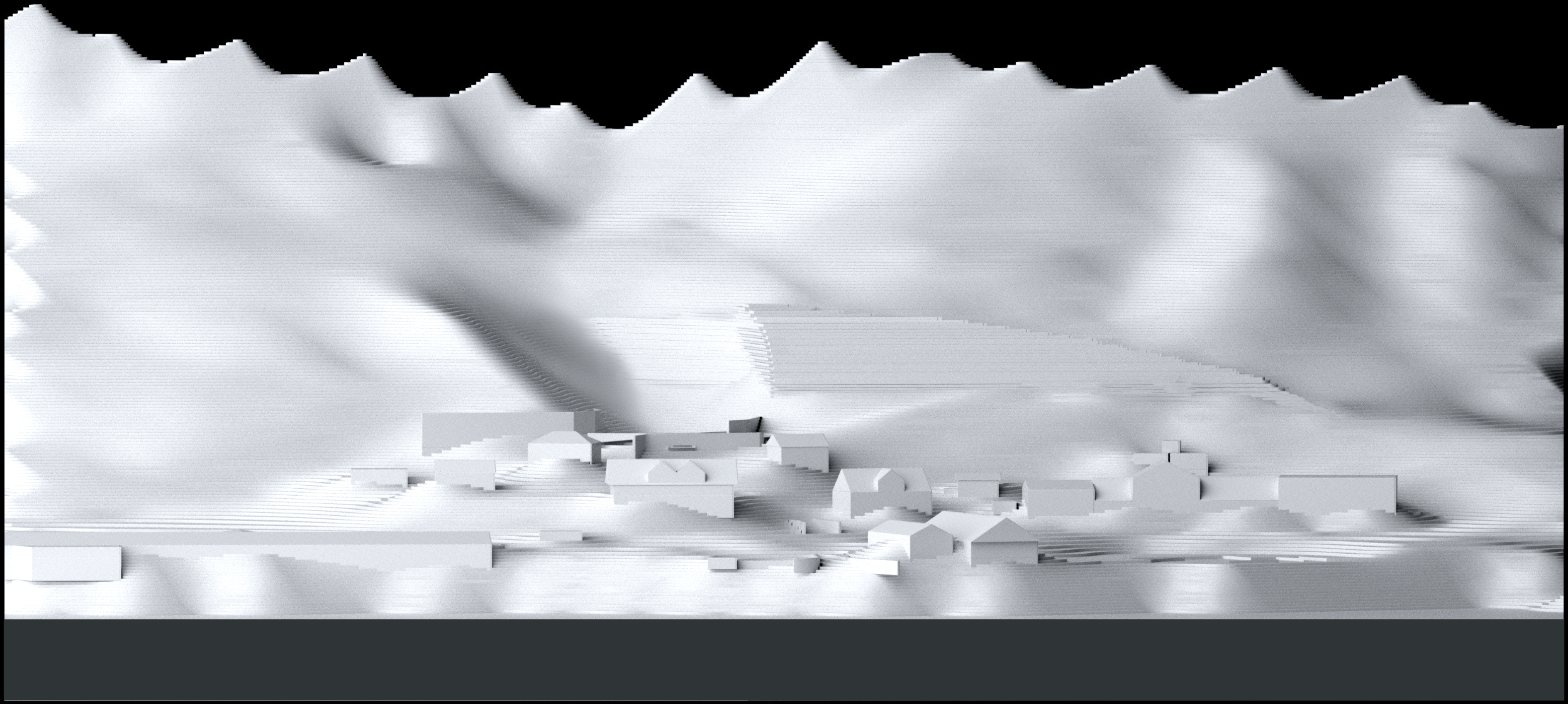

Steel net
C-shaped facing unit
// Galvanized steel
Embedded length and
strength accordingly to
the design needs
Reinforcing strip
100 -- 200 mm stones
for front facing fill
Existing terrain


Larix sukaczewii
Pinus Mugo
Concrete wall 400mm
2% --->
Basaltic boulders
2% --->
Boat ramp
Existing terrain
1.   111
0
2.5
5
7.5
10









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49(165), 191–200.

Heimild: Hættumatsnefnd Snæfellsbæjar. 2004. Mat á hættu vegna ofanflóða á Patreksfirði, Vesturbyggð. Greinargerð með hættumatskorti.

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Note
All drawing, if not indicated in the same page the opposite, are made by the author of the research work.