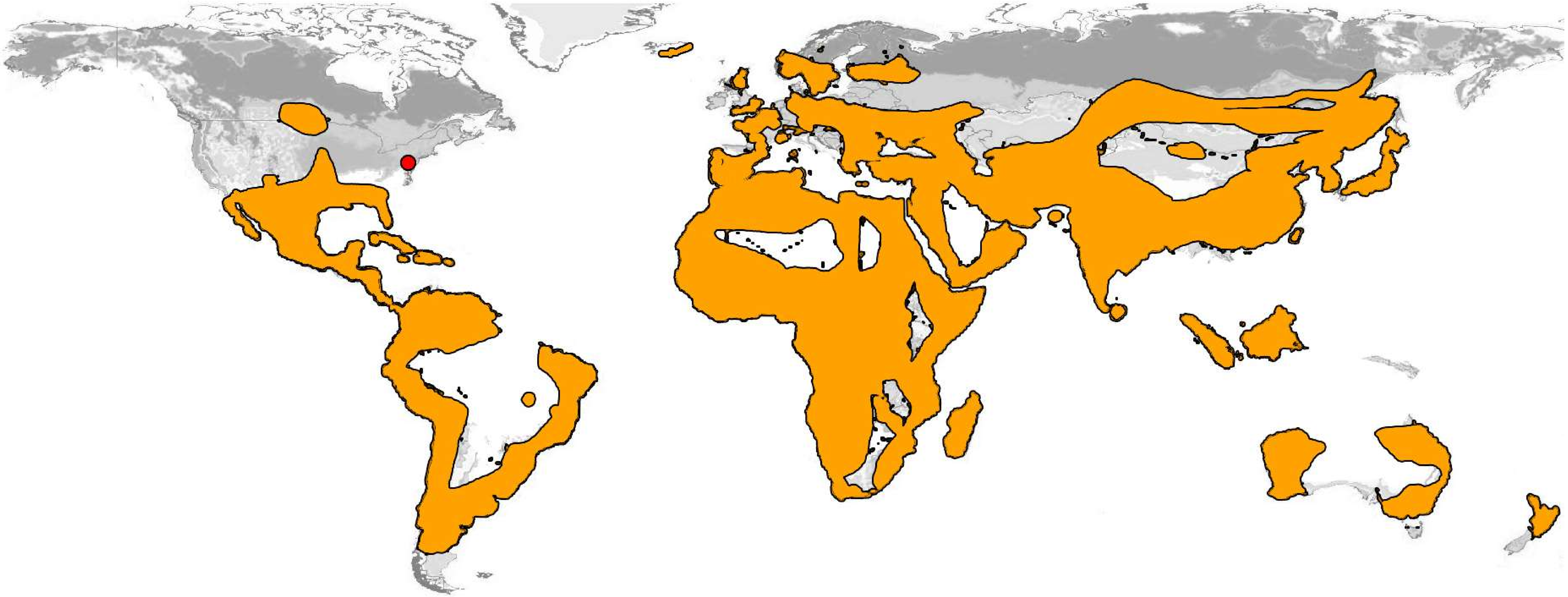
RAMMED EARTH:
Synergy of Natural Material in Artificial Earthscapes

The thesis explores the use of soil, a traditional and sustainable building material, situated in the landscape of an abandoned surface quarry mine, defined as drosscape by Lars Lerup and Alan Berger. In taking advantage of this new artificial landscape as a material for new production, the site develops into a vocational learning center and temporary housing, which serve to spread awareness of Rammed Earth construction as a refined, modern alternative to contemporary materials, that has matured beyond its origins as primitive mud huts set in warm, dry climates. The main facility provides a testing ground for application and research of Rammed Earth construction, expanded upon by a continual construction of various housing units throughout the lifespan of the project, utilized as a practical learning experience for the trainees.

This thesis project proposes to use an open pit mine's own materials to inhabit it with new structures, transforming the ground into a space that brings awareness of the artificial construction from natural materials. The abandoned open-pit mine therefore provides both an opportunity and a critique, as suggested by Solà-Morales, to present a solution to the contextual destructive practices.



Material - Rammed Earth



SITE GLOBAL

A Vocational Rammed Earth center could only function in an environment that can benefit from and has potential for a Rammed Earth growth. Therefore it was crucial to identify a region with little historical or cultural tradition for Rammed Earth, while still climatically and geologically viable for the technique,

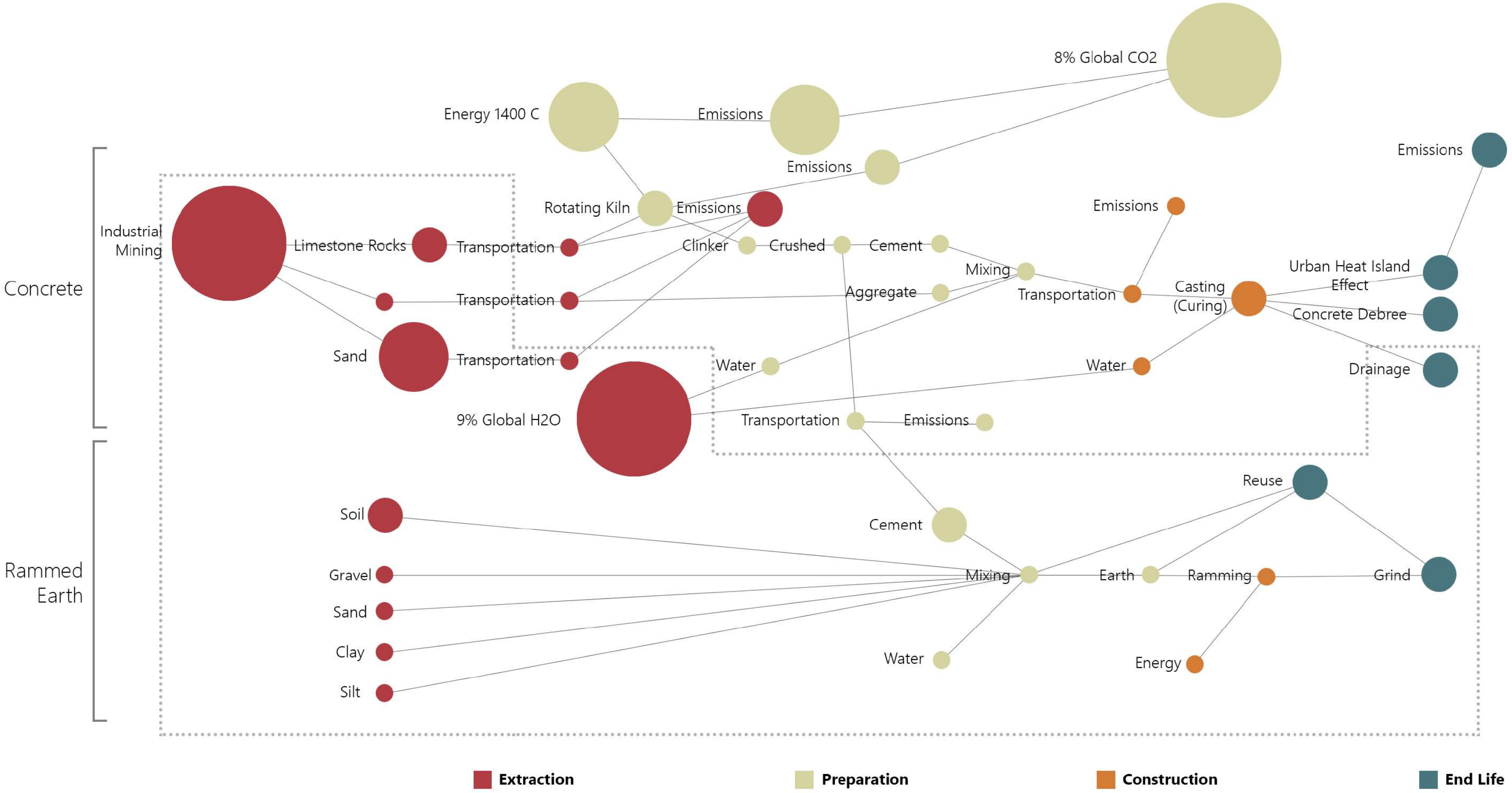
United States, especially the North, have been historically one of the last areas in the world to be introduced to Rammed Earth, and unlike South and middle America which adopted the technique from the Spanish settlers centuries ago, most of United States never moved beyond limited experimental projects. (Augarde)

The Northeast Megalopolis, stretching from Washington, over Philadelphian and New York to Boston represents the largest urban area on the continent. As the cities along the coast grow they require extraction of materials from the landscape a few kilometers further inland, resulting in a series of open pit-mines that continually penetrate the Earth in a North-South line parallel to the cities. With the growing urbanization of the American landscape it was inevitable the sprawl encountered the deformed drosscape that fuelled for its growth.

The project quarry is situated among an intersection of several highways, driving distance to each of the regional major cities. as with rising urbanization rises the diversity of population and therefore size of the target audience, maximizing the number of people the project can hope to educate. In fact for this reason the surrounding King of Prussia town is already the location of the largest shopping mall in North America, but while the mall is visited by millions of people, the quarry, which shares the same urban connection conditions, remains disconnected from the urban fabric and not utilized.

Reclassification from merely another post-industrial area in need of reuse into an area with exactly the right conditions and urban context makes the site desirable for the project, as the program wasn't conceived as a solution to the site, rather the site was chosen for the purposes of the program. The site allows the project to not merely answer the question of "how" but also the question of "why". A Rammed Earth vocational center and criticism of contemporary industry practices could each individually be accomplished at a different locale, but only here can the bisociation of the two topics occur.

Comparison



DRIVING FACTOR

It is this need for better standards and more construction experience in the face of the gradual rise of the Rammed Earth industry that warrants the creation of a vocational center that would allow experimentation and learning with the method. This ties into the reasons for the latest of Rammed Earth revivals, that has been going since 1970s.

Historically, this time around the movement differs from previous eras by its focus on Rammed Earth as a sustainable and landscape preserving material, rather than a method of cheap construction for the lower masses. Rammed Earth often works in tandem with other materials, however its defining monolithic characteristic positions it as a natural alternative to concrete. (Augarde, Carpenter)

Compared to it, Rammed Earth soil is gathered on site, cutting out need for transportation and destructive industrial mining practices. It does not contain the highs level of emissions associated with the production of cement, even in the case of CSRE, since it uses far less than concrete, And it also uses a significantly lesser amount of water.

More importantly, at the end of a life of a building, Rammed Earth can be grinded back into a fine aggregate and reused in a construction of a new building, Where concrete is rarely recycled and if so can only be reused as aggregate.

Nonetheless both materials share several commonalities like the need for formwork and the ability to be pre-manufactured, their thermal mass, or lack of need for finishes. Realistically Rammed Earth is unlikely to ever reach the compressive and tensile strength of reinforced concrete, and therefore unlikely to replace concrete in highrise and high-performance structures. However, as proved throughout its history, Rammed Earth can support buildings of at least six stories high, potentially more with modern approaches. This makes the technique suitable for use in the current trend of horizontal urbanization, where the majority of buildings that grow the seize of cities and suburbs are of low-rise and mid-rise character.

SOILS CONDITIONS

Soil is of course the main component of a Rammed Earth wall. In general, it is assumed the intention is to use local soil, as that is one of the drawing aspects of Rammed Earth construction. The soil is extracted from just below the layer of topsoil humus on the surface, this is because the amount of organic substances in the earth should not exceed 1%. Ideally the soil will contain a distribution of various particulate sizes, with the increasingly smaller grains filling the voids between the larger ones.

On average the best composition for Rammed Earth is 30% clay and 70% sand. The sand present in the earth should preferably be coarse and crushed, not round, eroded river sand. If the content of sand in the soil is inadequate it can be supplemented with off-site sand or gravel.

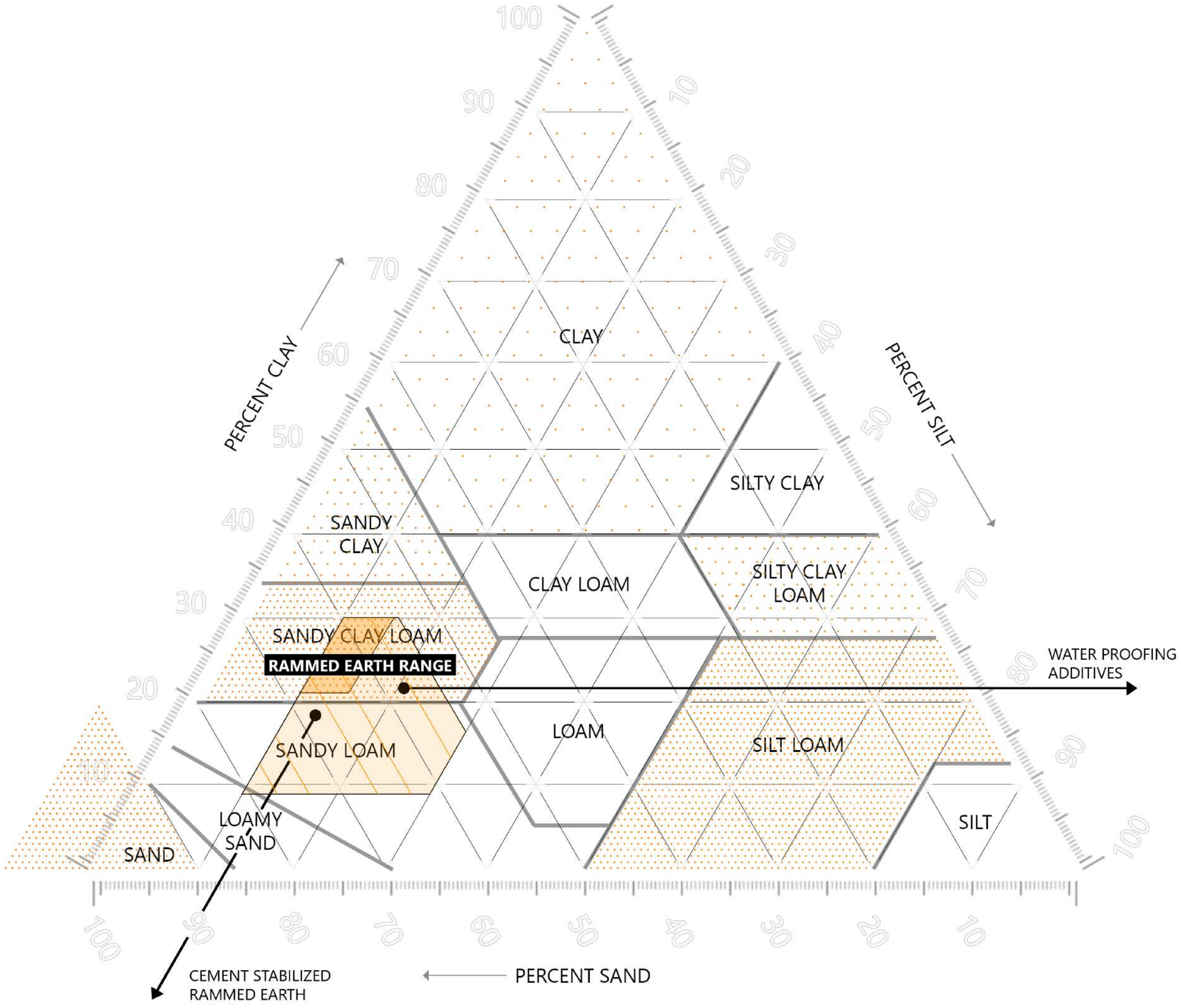
RESPONSE TO MODERN PARAMETERS

Although the industrial revolution and the 20th century was the main driving force behind the near-disappearance of Rammed Earth, some of the technologies developed during it can be used today to bring Rammed Earth up to modern code standards and to allow its use in historically less-than-ideal regions.

The most basic supplementation, if the soils mixture doesn't contain enough clay, is the addition of cement as a stabilizer to reduce the required content from 30% to as low as 8%. Cement Stabilized Rammed Earth (CSRE) also has increased durability, and by adding the appropriate aggregate together with Portland cement Rammed Earth can be made workable even with undesirable soil particle size distribution. To further increase strength reinforcements of steel or bamboo are now utilized in a manner similar to cast concrete.

Historically Rammed earth was used prevailingly, although not exclusively, in warmer climates. And while the finished material has a great thermal mass capacity it has low thermal resistance. To meet the contemporary codes in cold climates a layer of rigid insulation is now being added between two encompassing Rammed Earth walls, creating an assembly that contains both cheap thermal mass, traditionally not cost effective when it came to concrete, and good thermal resistance properties, which classic Rammed Earth walls struggles with. (Wong & Cook)

In an extremely wet climate with high erosion, a waterproofing hydrophobic agent may be added on top of cement, which completely seals every left over microscopic gaps. Additionally it prevents the salts in water from staining the wall.



Soil Characteristics

Earthscape - Abandoned Quarry


el. 29m
long -75.331007
N
Valley Forge Development Area 5.85km
King of Prussia Mall 5.09km
US-422
US-202
Mc Coy Quarry
New York 131.73km
I-476
I-276
Washington 197.23km
Levittown 43.15km
lat 40.096007
Philadelphia 21.36km
I-476
I-76

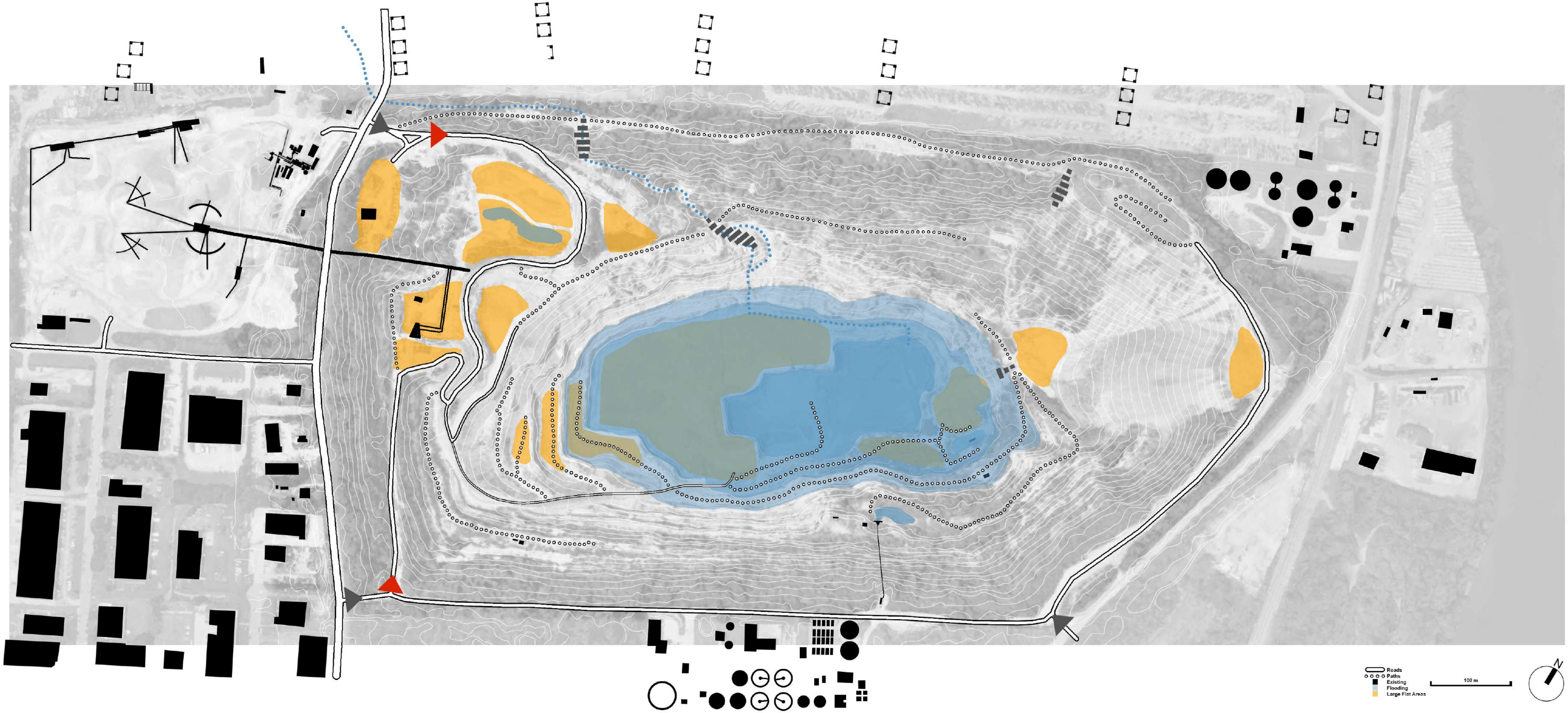
Region

SITE LOCAL

The McCoy quarry is situated in an industrial area, surrounded with material and manufacturing facilities and a commercial neighbourhood to the West. As the mining ceases and the surrounding facilities are abandoned this strip of post-industrial landscape, stretching form the river will be even more of a partition of unused land in between the city centre to the north and residential areas to the south.

Besides being surrounded by highways to facilitate long-distance visitors, the two major communications between the North and South of the town pass around the site. However passing inhabitants are more oblivious to the quarry than might seem at first glance, as their awareness of it is visually blocked by earth mounds and dense vegetations around the quarry. Even though the quarry is geographically located in the mids of the city, it is functionally not a part of it, as Solà-Morales described, it is: "foreign to the urban system, mentally exterior in the physical interior of the city..." (Berger, p 35)

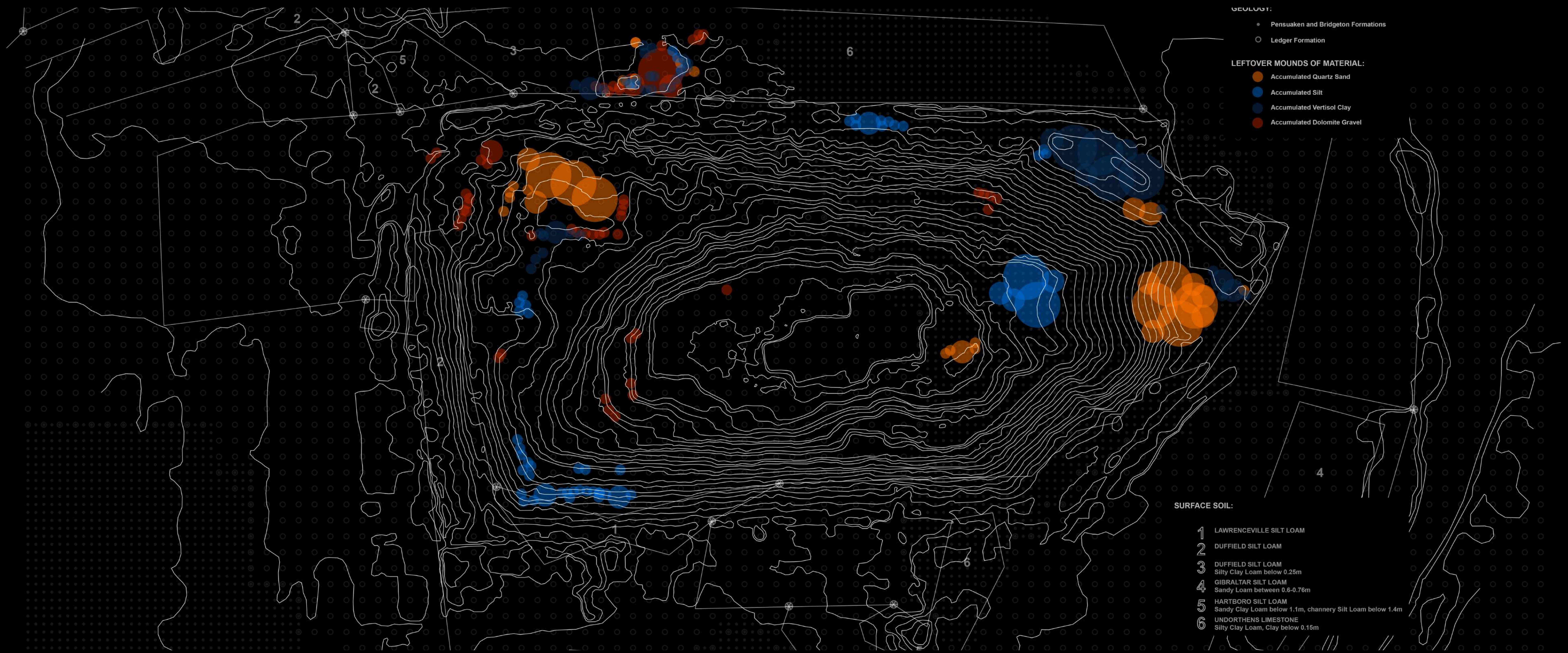
Location



SITE ISSUES

Access to the final structure will be problematic due to the sudden decrease in elevation relative to the surrounding landscape. Currently there are two left-over gravel paths that are sufficiently wide and safe to allow driving into the quarry by a car. There are number of secondary paths that would require significant repairs before they can be accessed. One issue will be the erosion of the quarry walls. From observation there are already a number of landslides in the section of the quarry that was discontinued earlier. Based on similar quarries in the area it can be expected the artificially hard edges will slowly erode and cover with greenery. Due to the disruption of soil by mining, several locations spread across the site accumulated mounds of various types of soil. This can be advantageous in some but will prove logistically problematic for the ones in harder to access locations.

Ammenities



SITE SOILS CONDITIONS

The surface mine produces mainly highway materials and cement, it being a crushed stone quarry. The surface soil was either removed from the site, moved to the edges or has slid back into the quarry, but it its natural form it was Silt Loam, which is comprised of 40% sand, 40% silt, and 20% clay. Silt Loam differs from Loam in that it contains more silt, which is a very fine river deposited sand.

Since the surface soil was disturbed and mixed with the layers bellow, the composition of the rock in the mine is also of importance. Most of the quarry carves into the Ledger Formation, which is mainly massive, pure and coarsely crystalline dolomite of white, light grey and locally mottled colors. The depth of the Ledger formation is approximatelly 600m deep, well below the deepest point of the quarry.

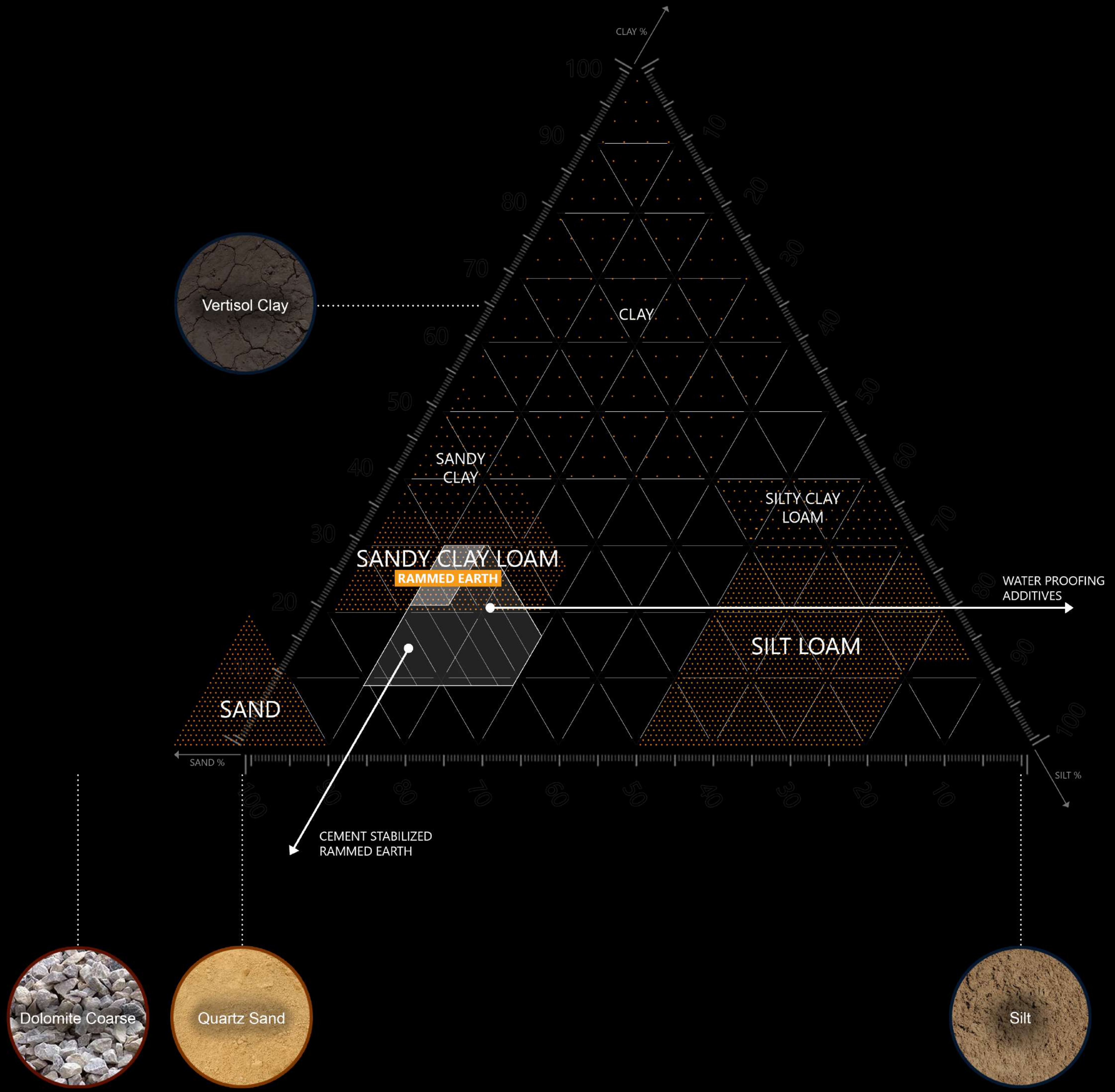
Eastern part of the quarry also cuts into an Undifferentiated Pensuaken and Bridgeton Formation. The Pensuaken formation comprises of cemented, extensively crossbedded, feldspathic quartz sand of yellow to dark-reddish-brown color and interbedded coarse gravel and boulders up to 1.5 meter in size. The thickness of the formation is at least 10 meters.

The Bridgeton Formation comprises of extensively crossbedded, clayey, feldspathic quartz sand and is stained reddish brown at its top, and reddened bellow. The sand itself is either yellow or white. The formation contains locally present beds of gravel and has a thickness of 10 meters.

Soil Extent

Soil Composition

The soil for Rammed Earth construction will be gathered from around the site. From observation we can infer that there are several locations with mounded, left over material around the site, containing Vertisol Clay, Quartz Sand and Silt. The composition of the final mixture will be subject to on-site testing and experimentation, but if the available mixture of Silt Loam proves to contain too much or too little of the fine silt particulates the composition can be altered by the addition of coarse sand, dolomite gravel or silt to complement the mixture. If the Silt Loam soil proves to contain insufficient amount of clay, then the available Vertisol Clay reserves or out-of-site cement will be added to supplement the binding availability of the mixture. And in case the profile of the sand comprising the silt containts far too many round grains then quartz sand from the lower geologic formations will be added.



SITE OPPORTUNITIES

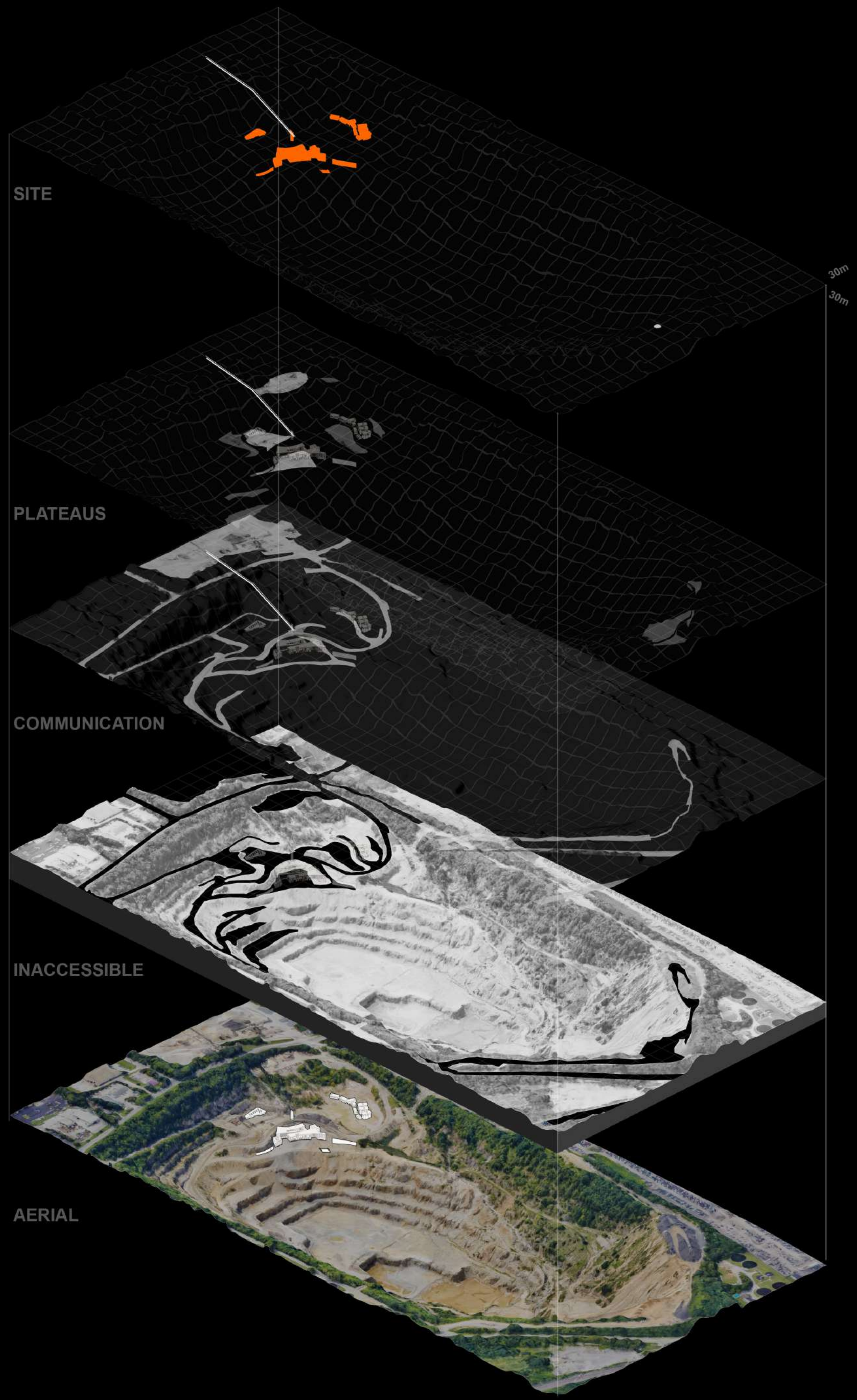
An alternative to car access to the site would be a pedestrian one. The site contains a conveyor belt with an attached staircase, that leads from near the location of the project, into a short tunnel and across the street to an area that could be utilized as parking.

The quarry offers scenic views and several mineral locations that would be explored by visitors. The quarry already contains paths that are no longer safe for cars but can now serve as pedestrian trails. The trails could double as a way to mitigate erosion

The terraced character of the quarry walls is a condition not found in nature, they impose a horizontal order into the quarry. They also offer leveled space that can be utilized without the need for landscaping.

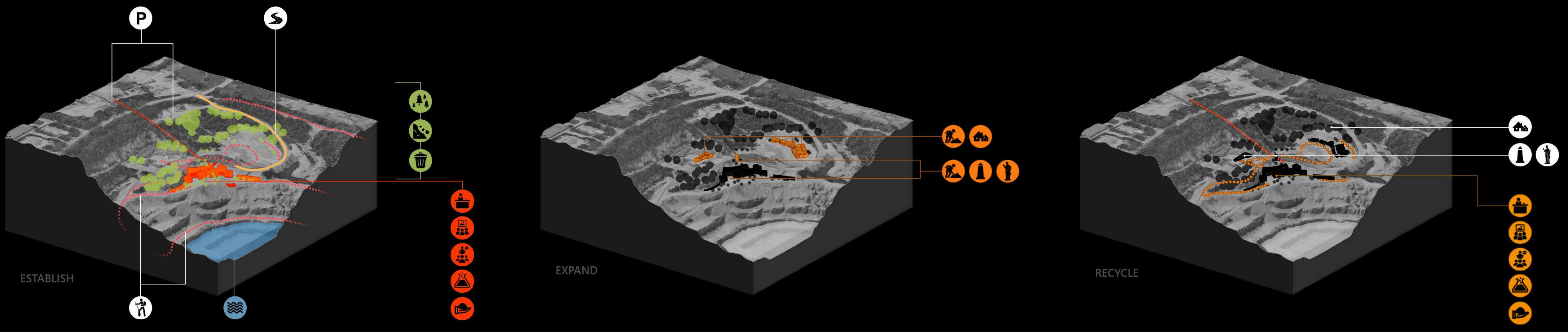
The bottom of the quarry will accumulate rain and ground water after artificial drainage stopped. This will lead to creation of a quarry lake, a body of water unsuited for swimming, but offering a scenic view and other posibilities.

Site Section



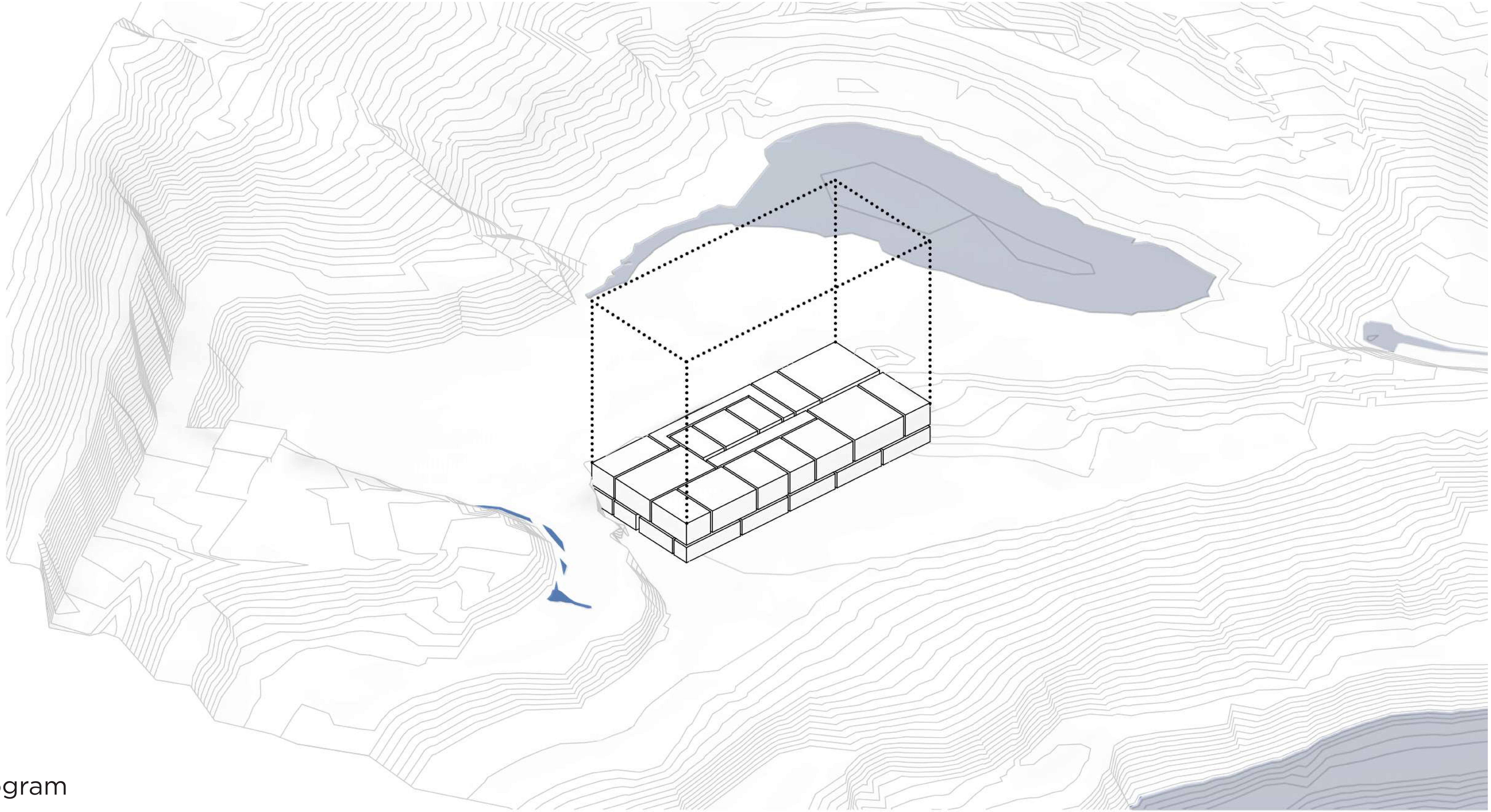
Site

Program

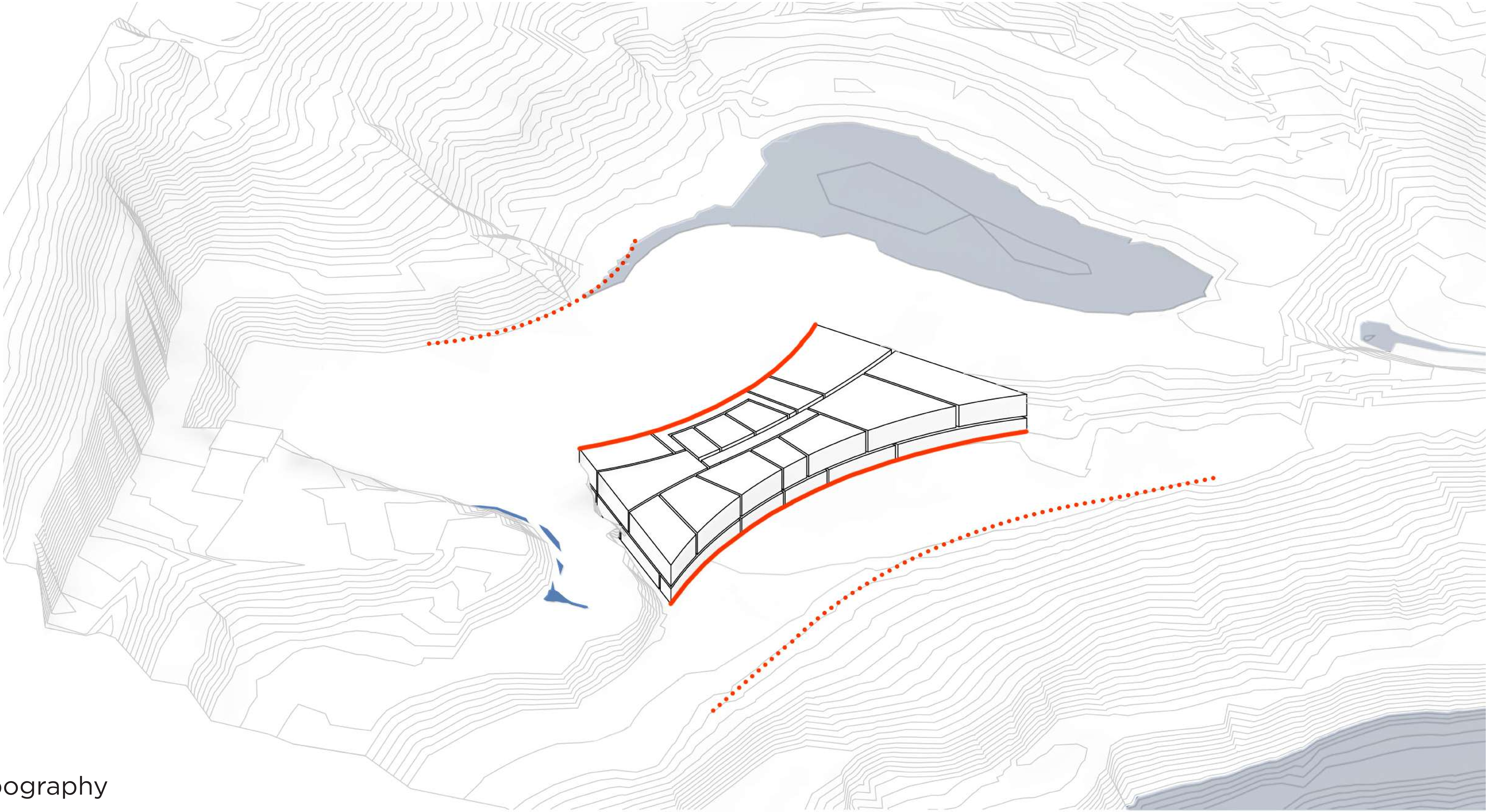


The project life-cycle includes three phases: establishment, expansion, and recycle. First, Establishment phase sees the cleanup of the site together with terra-forming and the construction of the main vocational pavilion building. There need to be basic safety features installed, communications solidified, and measures to prevent dangerous erosion installed before the area can be opened to the public. Expansion phase then takes place over several years, consisting of teaching the Rammed Earth construction to trainees as a learn-by-practise exercise, throughout which the amount and variety of Earth structures on the site expands. As new structures are added the capacity of the center grows, allowing more trainees to both learn and lodge on site. Lastly, after the soil reserves run out and the usable safe space in the quarry if filled, the Recycle phase no longer allows the addition of new structures. Rather a dedicated outdoor center area sees soil recycled for each new class to construct smaller Rammed Earth elements and aid to the continuing research. The variety of finished Earth structures on site will become a textbook for Rammed Earth construction. Vocational Learning Center Indoor - Not a museum but at the same time a place to see the earth as a building material in practice. Vocational Learning Center Outdoor - An area, sheltered or not, with ready to use soils, aggregate, and tools to practically learn earth construction. Workshops – For more advanced visitors/the staff experimenting with different mixtures, testing physical properties, integrating additional natural and artificial materials. Studios – There is an art aspect to building with earth, since it is a craft there is an availability to imbued every new structure with unique carvings, shapes, sculptures, ect. There is a precedent for this in other stone quarries where sculptors work, in real time during the mining process, carving sculptures. Attendee Housing – To provide stay for overnight visitors and longer term – visitors, maybe affordable nearby housing for artists. If the project intends for people to drive over for hours from at least the NorthEast Megalopolis then they need a place to stay overnight. Also another way to show rammed earth in a small residential aspect. Maybe the students can be building these as a part of the learning process. Landscaping – Especially in the vicinity of the buildings. Most likely not the entire quarry, parts of it are inaccessible and it will overgrow with greenery by itself after some time. There is also the question if to bring in greenery and try to "hide" the ugliness of raw mined earth or if to keep it for as a foil to green areas.

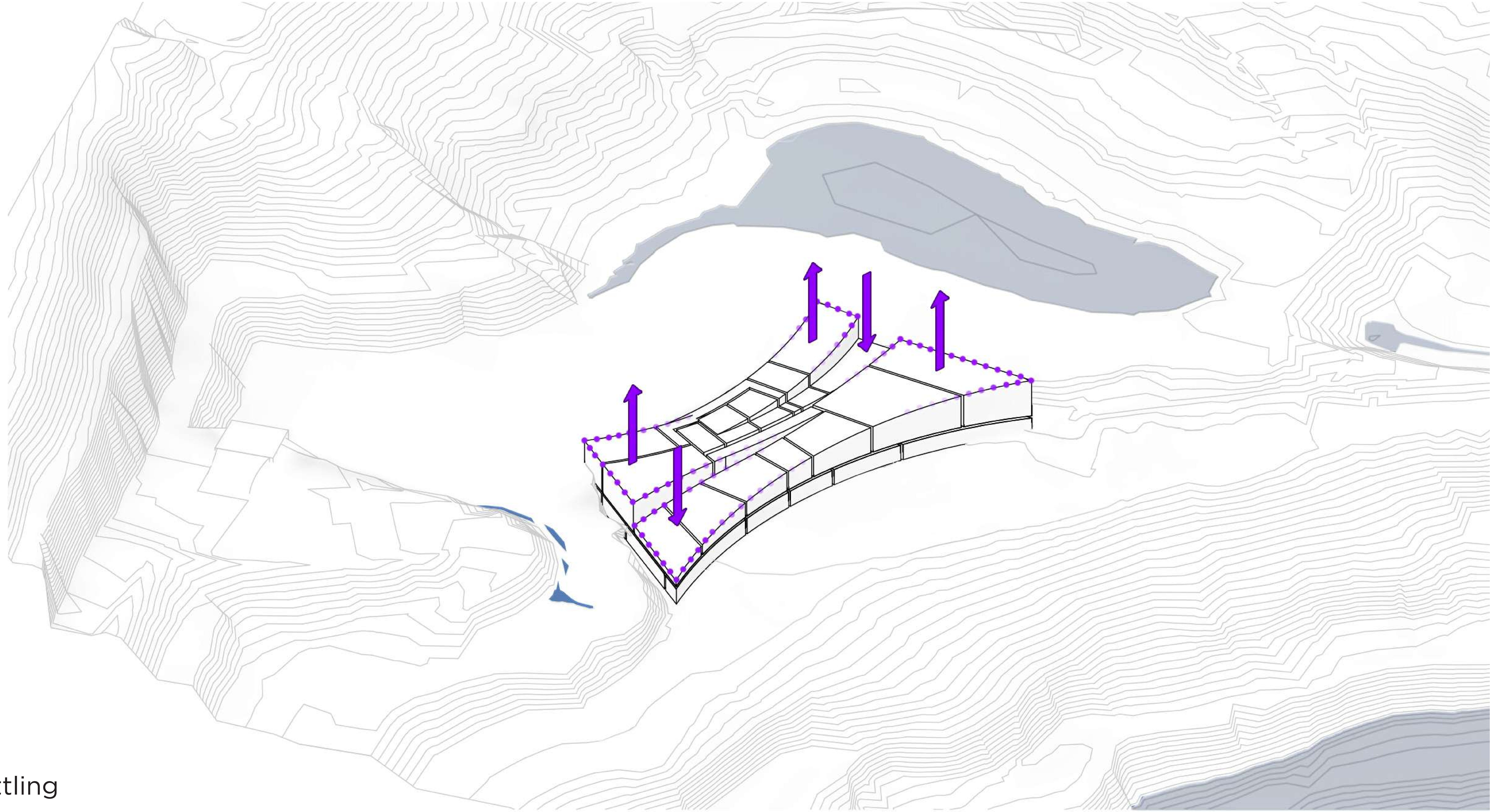
Programming



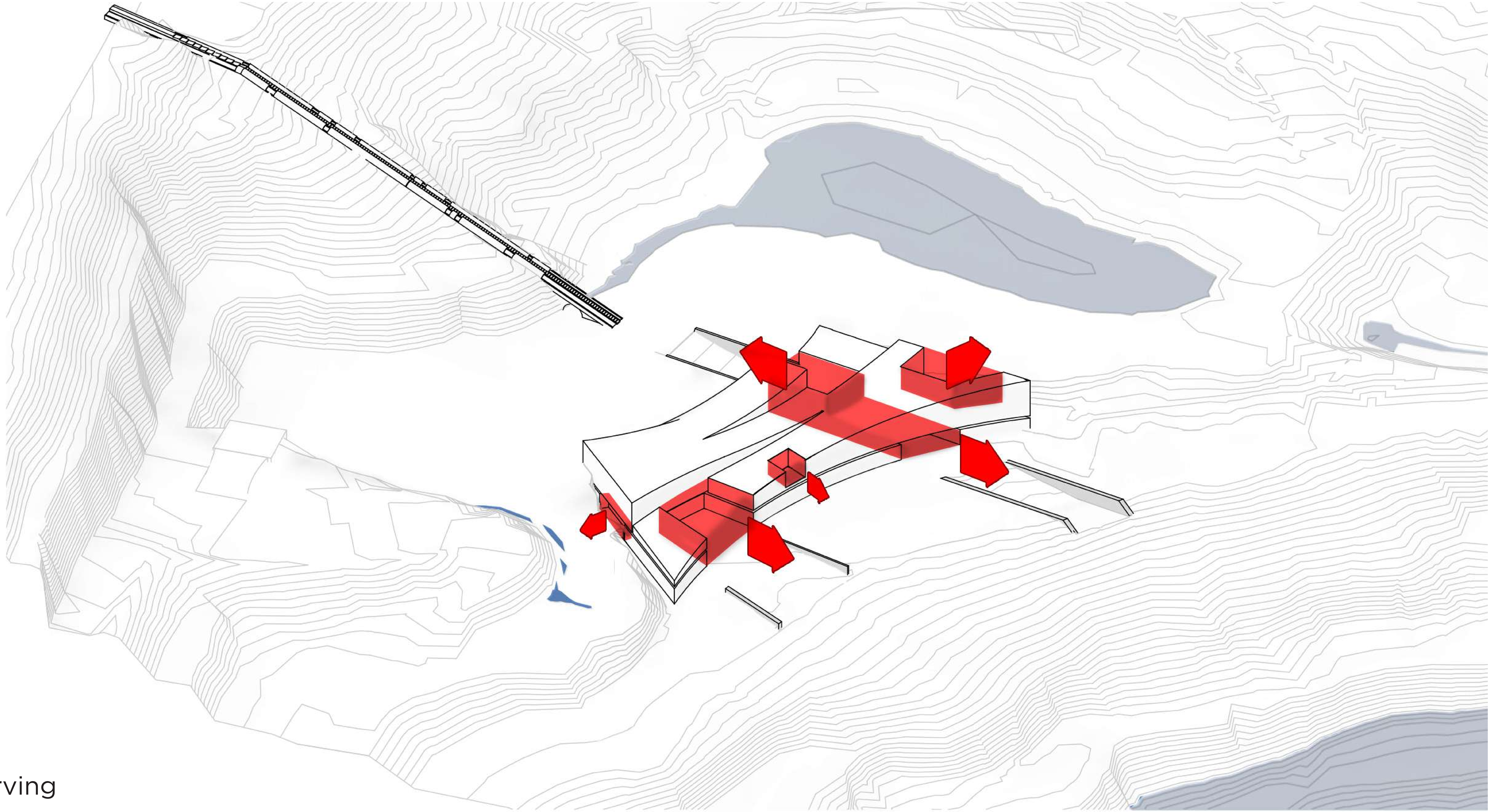
Program



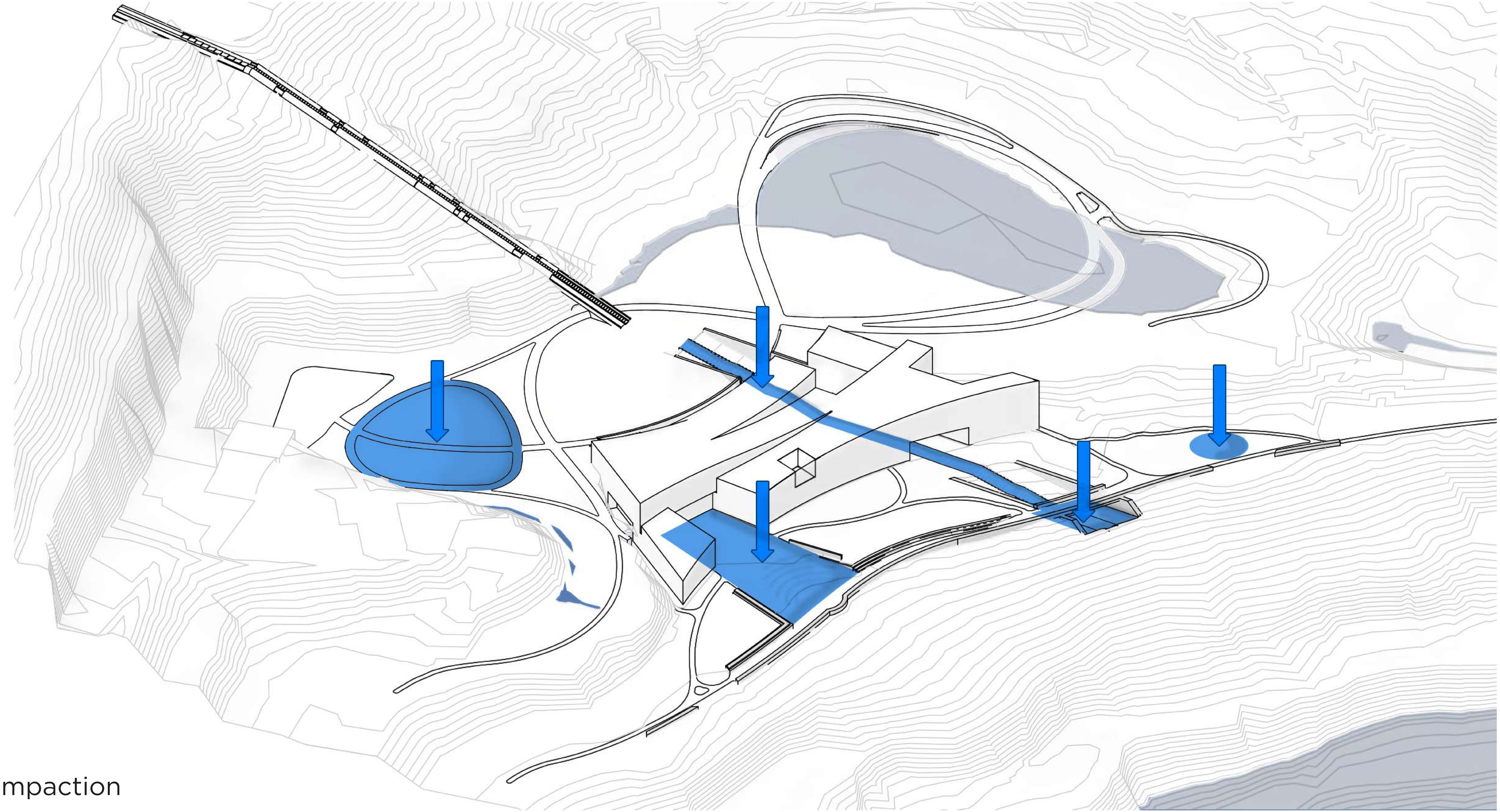
Topography



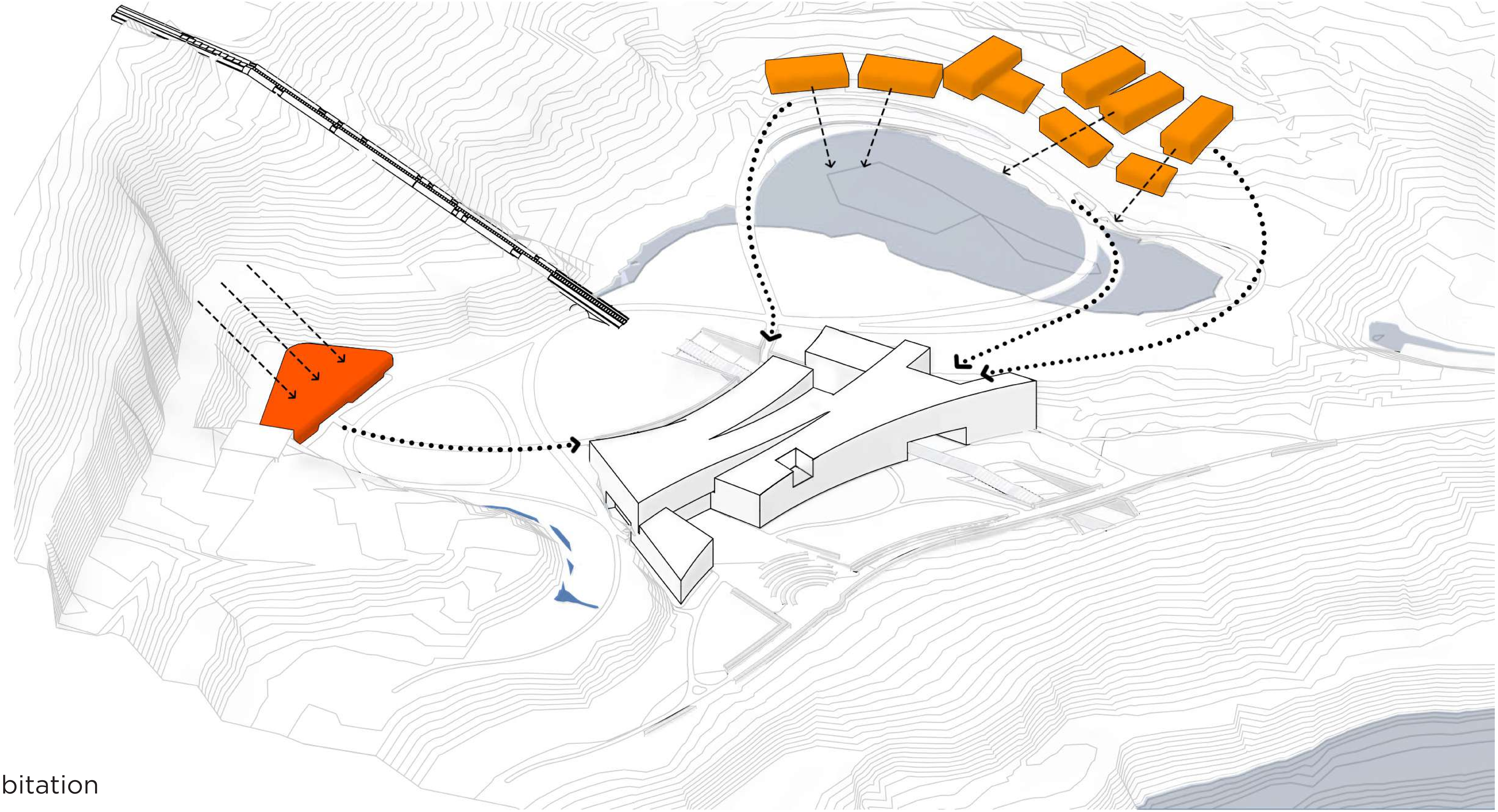
Settling



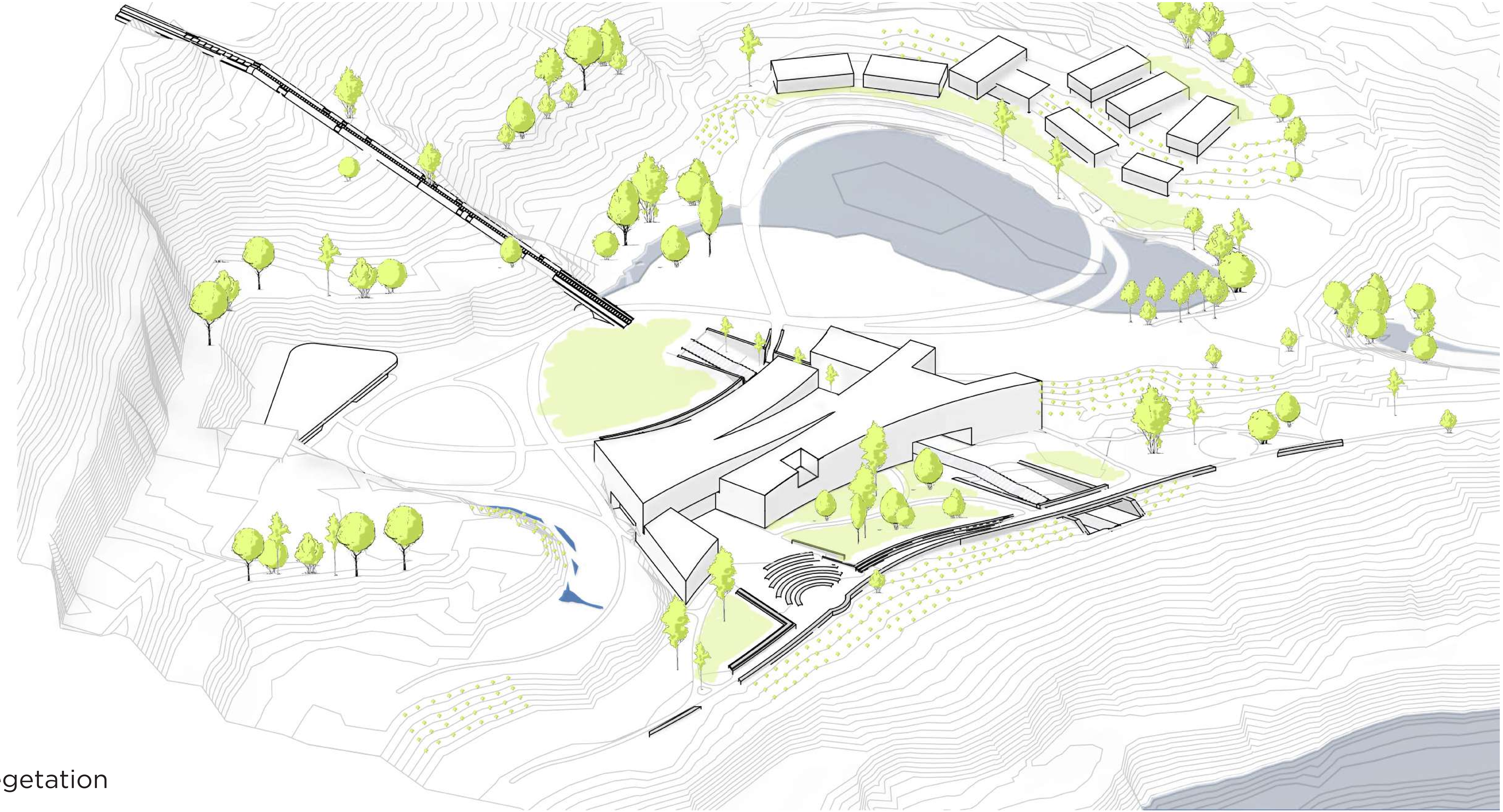
Carving



Compaction

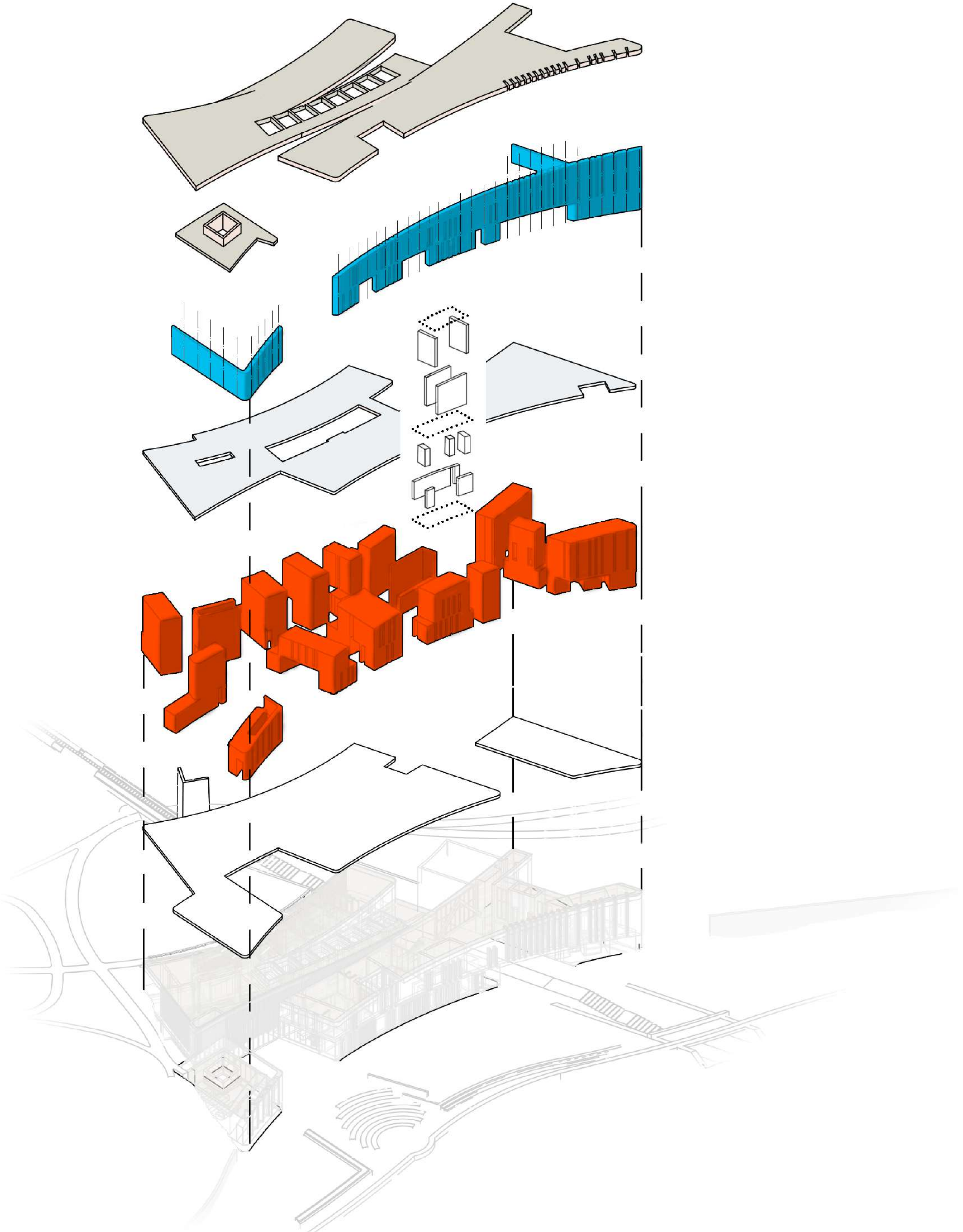


Habitation



Vegetation

Material



Reinforced Concrete Slab

Cement Reinforced Rammed Walls
with Waterproofing Additives

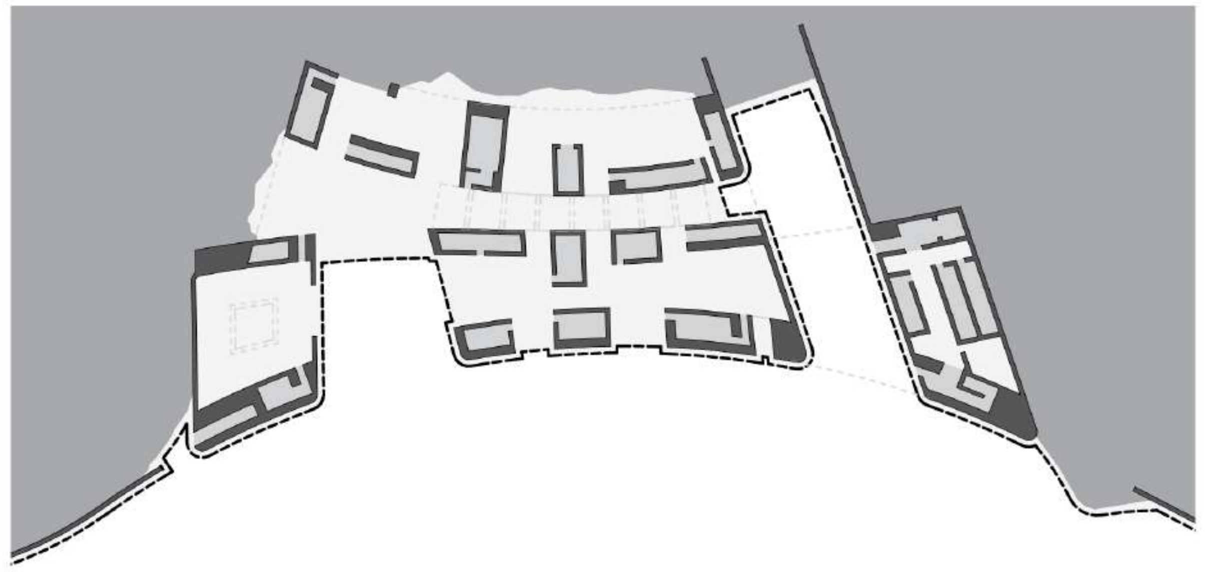
Rammed Floor on top of Wooden
Beams

CSRE Prefabricated Panels

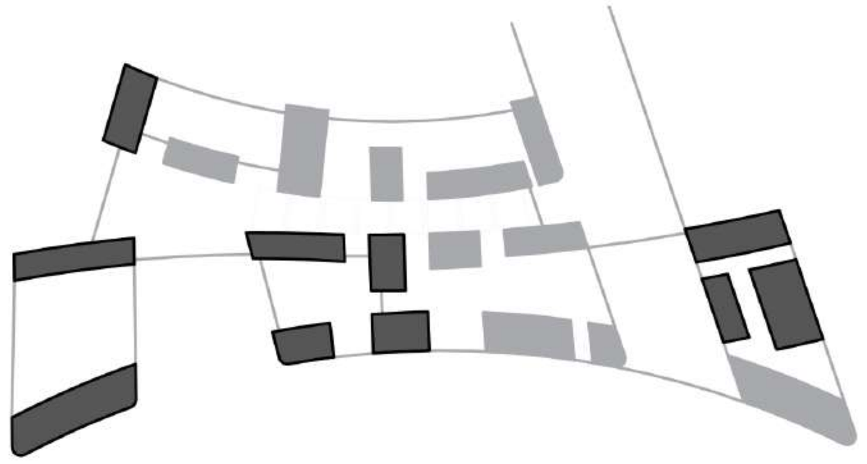
Concrete Foundation

Technique

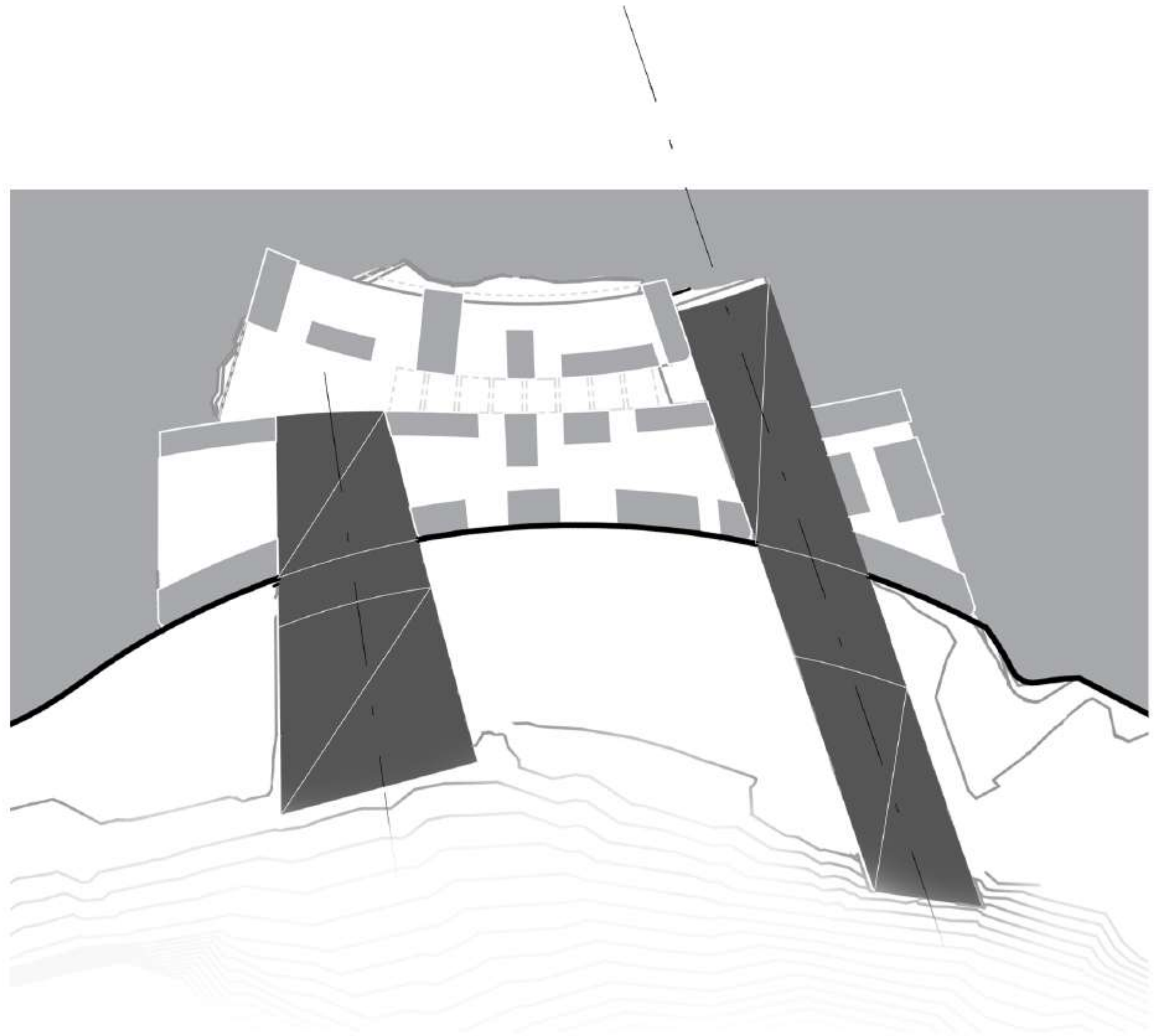
Site Plan



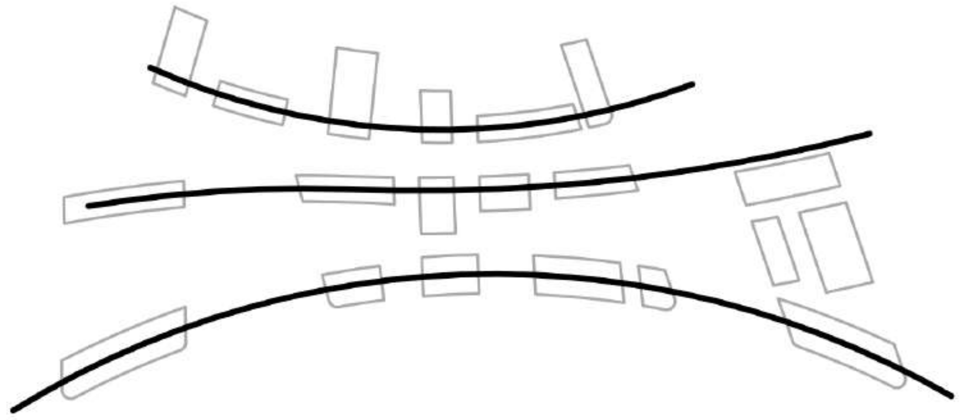
Structure | Enclosure



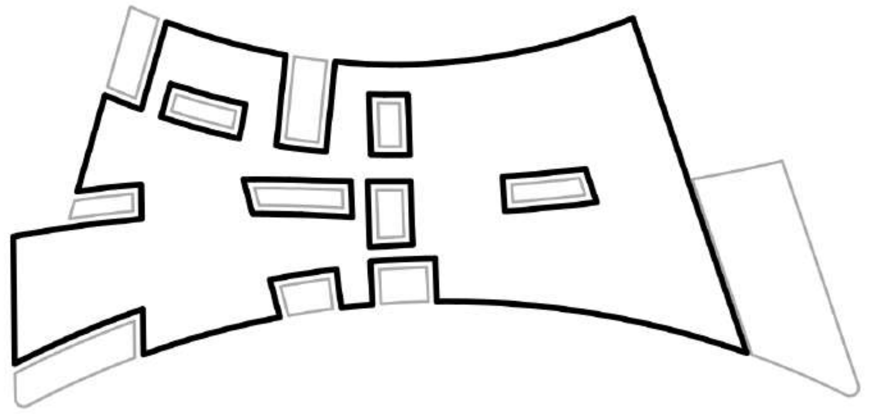
Public | Private



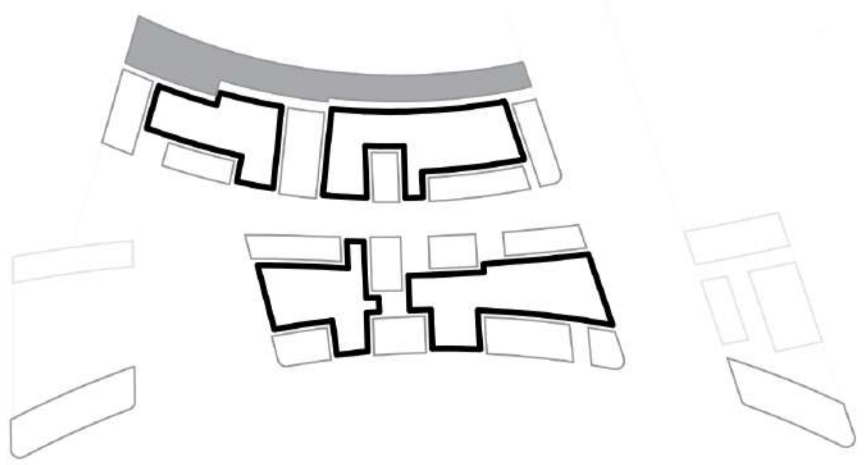
Plaza



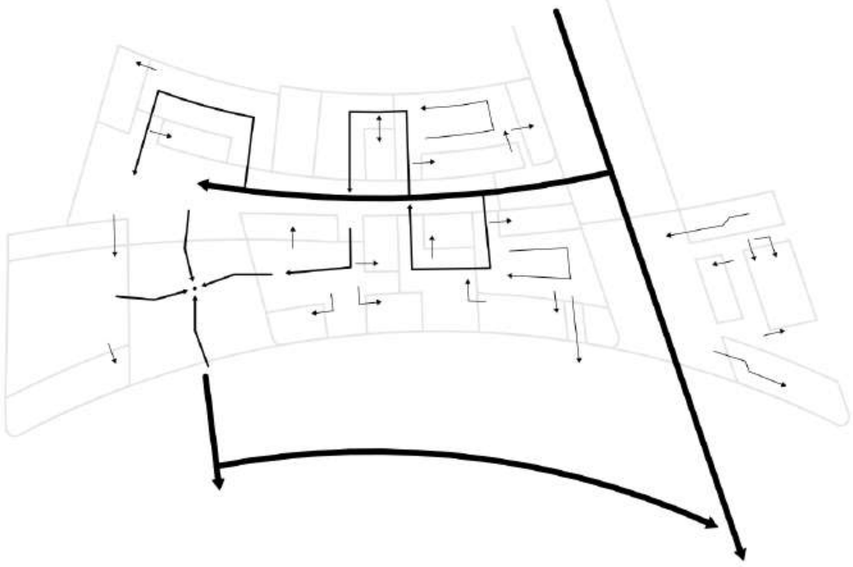
Whole



Served | Servant



Volume



Circulation

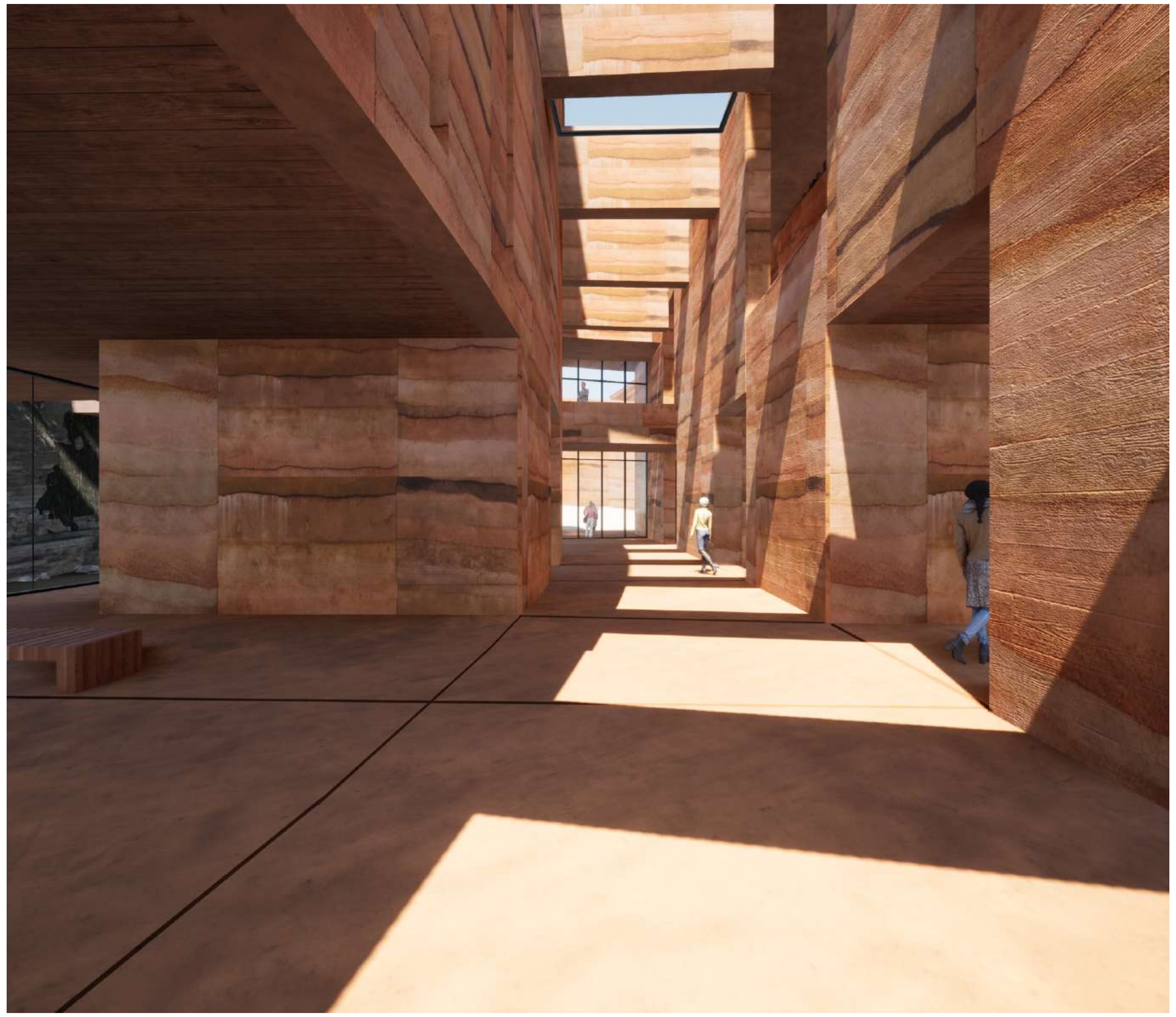
First Floor Plan

Second Floor Plan

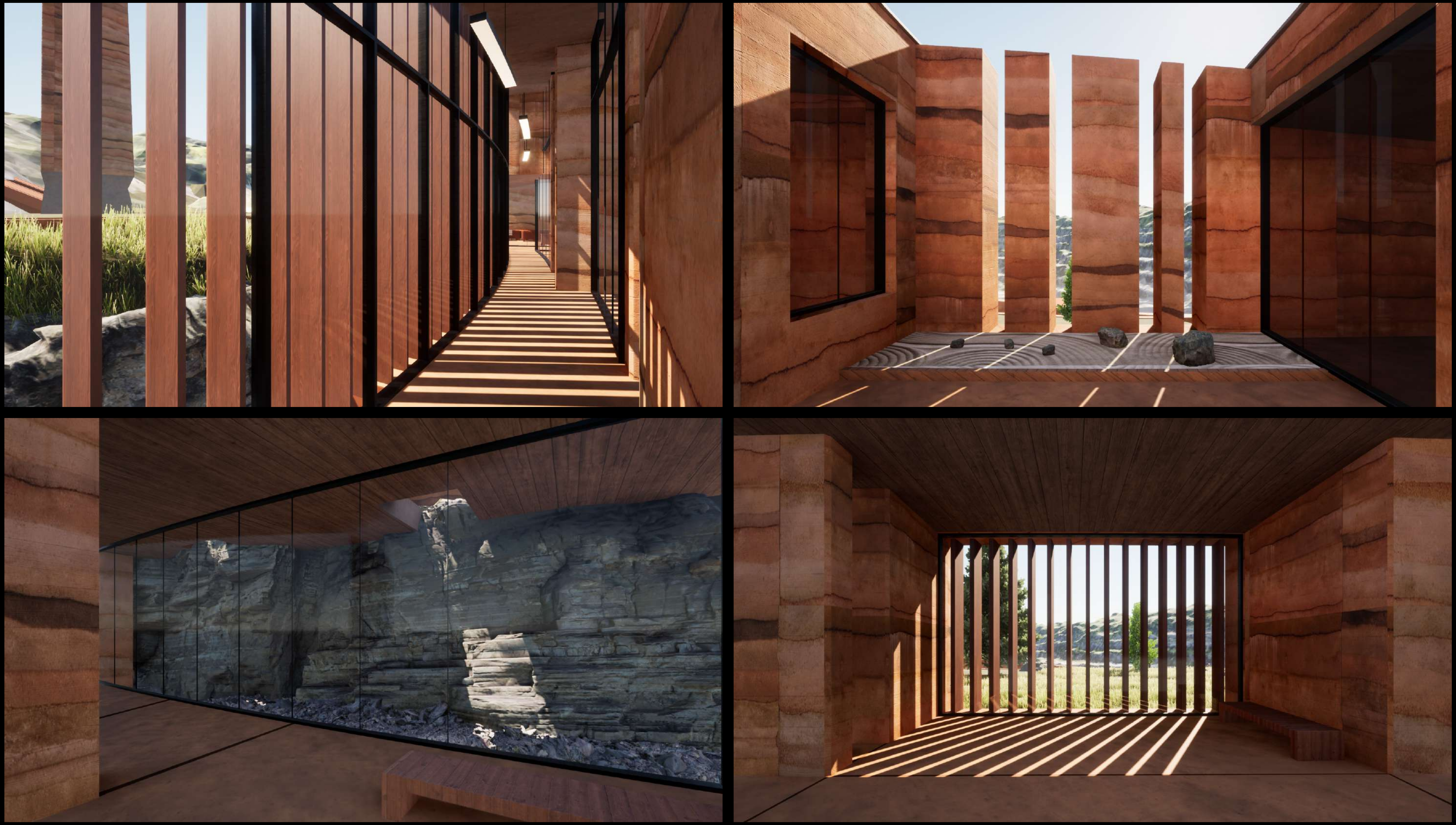
Section A

Section B

Elevation



Mass



Boundary

Space