Cloud Camp: *Refuge Above Paradise*

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A thesis
submitted in partial fulfillment of the
requirements for the degree of

Master of Architecture

University of Washington
2013

Peter Cohan, Chair
David Miller

Program Authorized to Offer Degree:
Architecture

University of Washington

Abstract

Cloud Camp: *Refuge Above Paradise*

Victor Alexander Velarde

Chair of the Supervisory Committee:
Associate Professor, Peter Cohan
Department of Architecture

Due to the heavy use during peak climbing months and extreme climatic conditions of Camp Muir's Historic District this thesis proposal seeks to rejuvenate, re-design and provide an innovative and appropriate pre-fabricated deployable architecture of self-sufficiency, while taking into consideration high season volumes, climatic responsibilities, accommodation of new program elements, and protecting natural resources. Through user assessment, historical, environmental and climatic research, precedent site visits; pre-fabrication techniques and self-sufficiency in energy, water and waste, the design tests current methods of deployable architecture in extreme alpine conditions, building technology, materiality, rapid assembly strategies, as well as social connectivity among mountaineers on this pristine landscape.

Mt. Rainier, Washington, USA

CLOUD CAMP: *REFUGE ABOVE PARADISE*

46° 51' 10.39" N, 121° 45' 37.34" W

Image 1.

Acknowledgments

First and foremost I would like to thank my mother for all of her love and constant support throughout my academic career, I would not be here with out you. To my family for pushing me to always seek for the best.

I would like to thank my committee, Peter Cohan and David Miller for their constant support and guidance throughout the development of my thesis. To all my professors at the University of Washington, College of Built Environments, Department of Architecture, who have opened a new learning path in my career. To my friends and colleagues at the University of Washington, College of Built Environments, Department of Architecture, for making the learning process more enjoyable and whom I have learned from by constantly engaging in discussions and generating a healthy competitive learning environment.

To my great friend and climbing partner, Justin for sharing excitement, knowledge and inspiration throughout our lowest and highest adventures.

To Marilyn for staying by my side throughout my studies, and always believing in me.

Thank you all.

Image 1.
Storm on Ascent to Camp Muir

Contents

Image 2.

An increasing popularity in mountaineering on Mount Rainier, specifically Camp Muir, has prompted calls for the construction of a new high-elevation shelter for climbing parties. Its remote location, extreme environmental conditions, and historical backdrop provide the opportunity for exploring new constructional techniques that are situated somewhere between vernacular and innovative building strategies.

Image 2.
Climbers Ascending to Camp Muir From Paradise.

Mt. Rainier National Park


Image 3

Mount Rainier National Park

Elevation: 14,411 ft (4,392 m)
Prominence: 13,211 ft (4,027 m)
Ranked 21st
Range: Cascade Range
Coordinates: 46°51′10″N 121°45′37″W
First ascent: 1870 by Hazard Stevens and P. B. Van Trump

Of all the fire mountains which, like beacons, once blazed along the Pacific Coast, Mount Rainier is the noblest.[1]

- John Muir

Mount Rainier was first known by the Native Americans as Talol, or Tacoma, from the Lushootseed word [təqʷúʔbəʔ] ("mother of waters") spoken by the Puyallup. Another interpretation is that "Tacoma", effectively means "larger than Koma (Kulshan)", a name for Mount Baker.

At the time of European contact, the river valleys and other areas near the mountain were inhabited by many Pacific Northwest tribes who hunted and gathered in its forests and mountain meadows. These included the Nisqually, Cowlitz, Yakama, Puyallup, and Muckleshoot peoples.

Captain George Vancouver reached Puget Sound in early May 1792 and became the first European to see the mountain. He named it in honor of his friend, Rear Admiral Peter Rainier. In 1833, Dr. William Fraser Tolmie explored the area looking for medicinal plants. Hazard Stevens and P. B. Van Trump received a hero's welcome in the streets of Olympia after their successful summit climb in 1870. John Muir climbed Mount Rainier in 1888, and although he enjoyed the view, he conceded that it was best appreciated from below. Muir was one of many who advocated protecting the mountain. In 1893, the area was set aside as part of the Pacific Forest Reserve in order to protect its physical and economic resources: timber and watersheds.

Citing the need to also protect scenery and provide for public enjoyment, railroads and local businesses urged the creation of a national park in hopes of increased tourism. On March 2, 1899, President William McKinley established Mount Rainier National Park as America's fifth national park. Congress dedicated the new park "for the benefit and enjoyment of the people" and "... for the preservation from injury or spoliation of all timber, mineral deposits, natural curiosities, or wonders within said park, and their retention in their natural condition."[2]

Mount Rainier ranks among the great mountains of the world. With a summit elevation of 14,411 feet above sea level, it is the largest in a chain of volcanoes that extends through the Pacific Coast states from Mount Shasta in California to Mount Baker in Washington. Most of these volcanoes rise several thousand feet above the other summits of the Cascade Range and are visible for a hundred miles or more, appearing ethereal at this distance like islands in the sky. Mount Rainier's significance relates in part to its premier place in this impressive range of Pacific Rim volcanoes. As viewed from Seattle or Tacoma through the intervening haze, the mountain's glistening, white dome appears to rise directly from a low, forested tableland.

Viewed at closer range, Mount Rainier reveals its distinctive form: massive, rugged, and asymmetrical. Successive eruptions of lava, ash, and cinders, and the probable movement of the volcano's main vent during the period of Mount Rainier's growth, produced a broad, irregular cone with inter-bedded layers of black andesite and lighter-shaded ash. The cone was further modified by the cutting action of streams in the soft ash, and later by the erosive force of huge glaciers which formed during the Pleistocene Epoch. Today a number of resistant dikes of lava radiate out from the mountain core, including the massive buttress on the southeast flank known as Gibraltar Rock and the 11,117-foot spire on the east known as Little Tahoma. Together with the mountain's broken summit, these features account for Mount Rainier's varied appearance.

Mount Rainier's twenty-five separate, named glaciers comprise the largest single-peak glacier system in the United States outside of Alaska. The largest of these glaciers descend into forested lowlands near the foot of the mountain. Measurements of the movement of the Nisqually Glacier date from 1857 and become detailed after the turn of the century, constituting the longest such record in the Western Hemisphere. The glaciers are another outstanding feature of Mount Rainier National Park and have long attracted both scientific and scenic interest.

Mount Rainier National Park is renowned for its sub-alpine meadows or "mountain parks" (see Image 3). Often graced by mountain lakes and profusions of wildflowers, these mountain parks are the most visited and photographed areas of the park. Encircling the mountain between approximately 5,000 and 7,000 feet elevation, the mountain parks are practically unique to Mount Rainier, without parallel in the Cascades or on the other volcanoes which occur at latitudes to the north and south. Early scientists attributed this feature, and Mount Rainier's great diversity of flora in general, to the mountain's tremendous range of elevations and the influence of its bulk and height on local climate. In the classic phrase coined by campaigners for the national park in the 1890s, Mount Rainier was "an arctic island in a temperate zone."[3] Since then biologists have identified much more intricate variations in the flora than the vertical zones that were once used to describe the mountain's varied plant life. The flora of Mount Rainier is influenced by differences of elevation, contrasting climates from one side of the mountain to another, variety of soil types, and disturbances from fire, flood, and other phenomena.

Mount Rainier is managed and protected by the National Park Service. The 235,625 acres of Mount Rainier National Park provide recreational opportunities for the million - plus people of the neighboring Puget Sound metropolitan area and for visitors from around the world.[4]

Image 3 & 4.
View of Mr. Rainier from
Paradise Meadows. Mt.
Rainier National Park Map

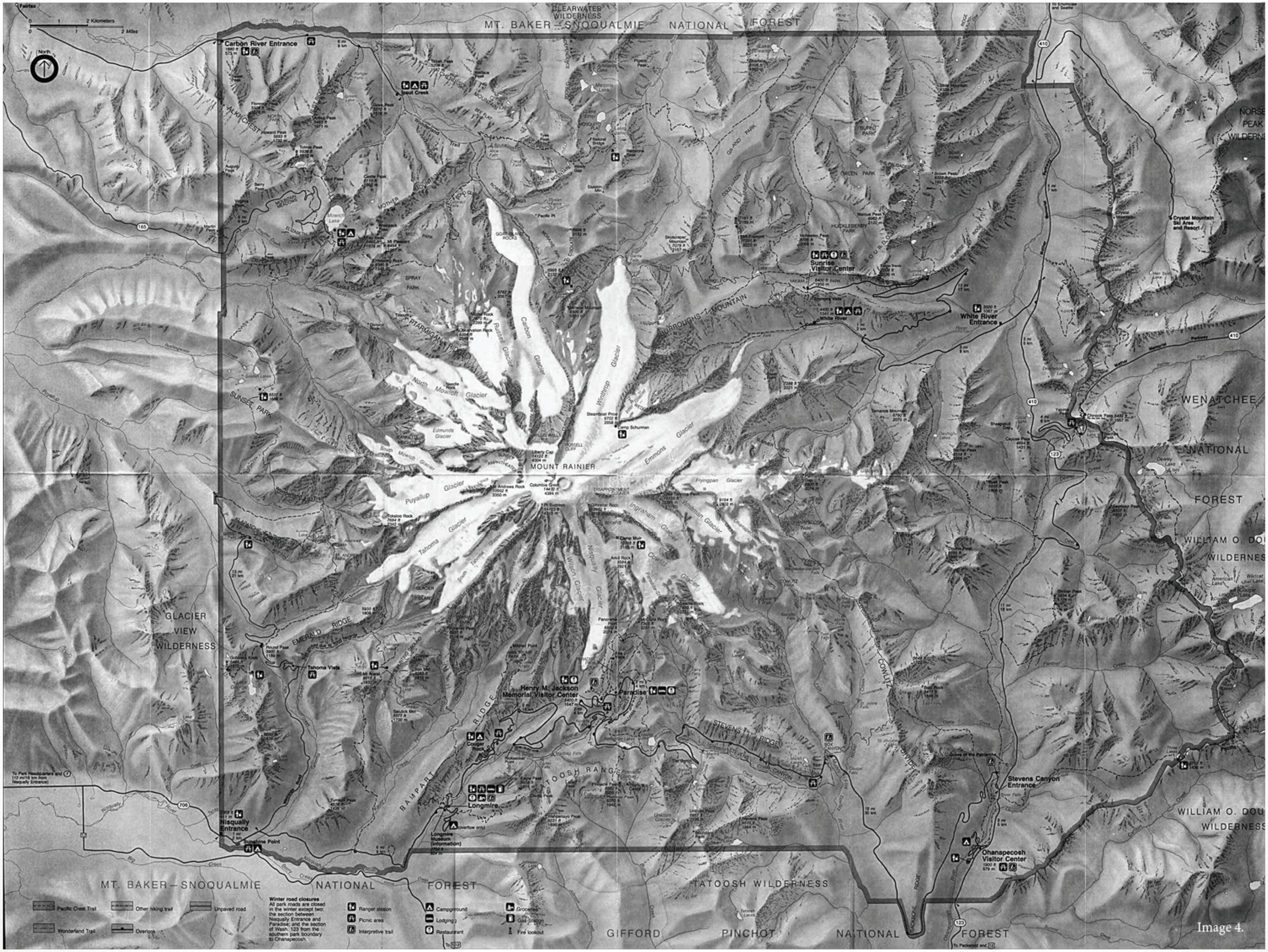

MT. BAKER – SNOQUALMIE NATIONAL FOREST
CLEARWATER WILDERNESS
Carbon River Entrance
Ipsut Creek
Mowich Lake
SPRAY PARK
SUNSET PARK
Carbon Glacier
Russell Glacier
North Mowich Glacier
Edmunds Glacier
South Mowich Glacier
Puyallup Glacier
Tahoma Glacier
Winthrop Glacier
Emmons Glacier
Fryingpan Glacier
Ingraham Glacier
Cowlitz Glacier
Nisqually Glacier
Wilson Glacier
Steamboat Prow
Camp Schurman
Liberty Cap
MOUNT RAINIER
Columbia Crest
Camp Muir
Sunrise Visitor Center
White River
White River Entrance
BURROUGHS MOUNTAIN
Crystal Mountain Ski Area and Resort
NORSE PEAK WILDERNESS
WENATCHEE NATIONAL FOREST
WILLIAM O. DOUGLAS WILDERNESS
GLACIER VIEW WILDERNESS
EMERALD RIDGE
Tahoma Vista
Henry M. Jackson Memorial Visitor Center
Paradise
TATOOSH RANGE
RAMPART RIDGE
STEVENS RIDGE
Longmire
Nisqually Entrance
Sunshine Point
Stevens Canyon Entrance
Ohanapecosh Visitor Center
TATOOSH WILDERNESS
GIFFORD PINCHOT NATIONAL FOREST
410
123
706
165
Pacific Crest Trail
Wonderland Trail
Other hiking trail
Unpaved road
Winter road closures
Ranger station
Picnic area
Interpretive trail
Campground
Lodging
Restaurant
Groceries
Fire lookout

Image 4.

Site

Image 5.

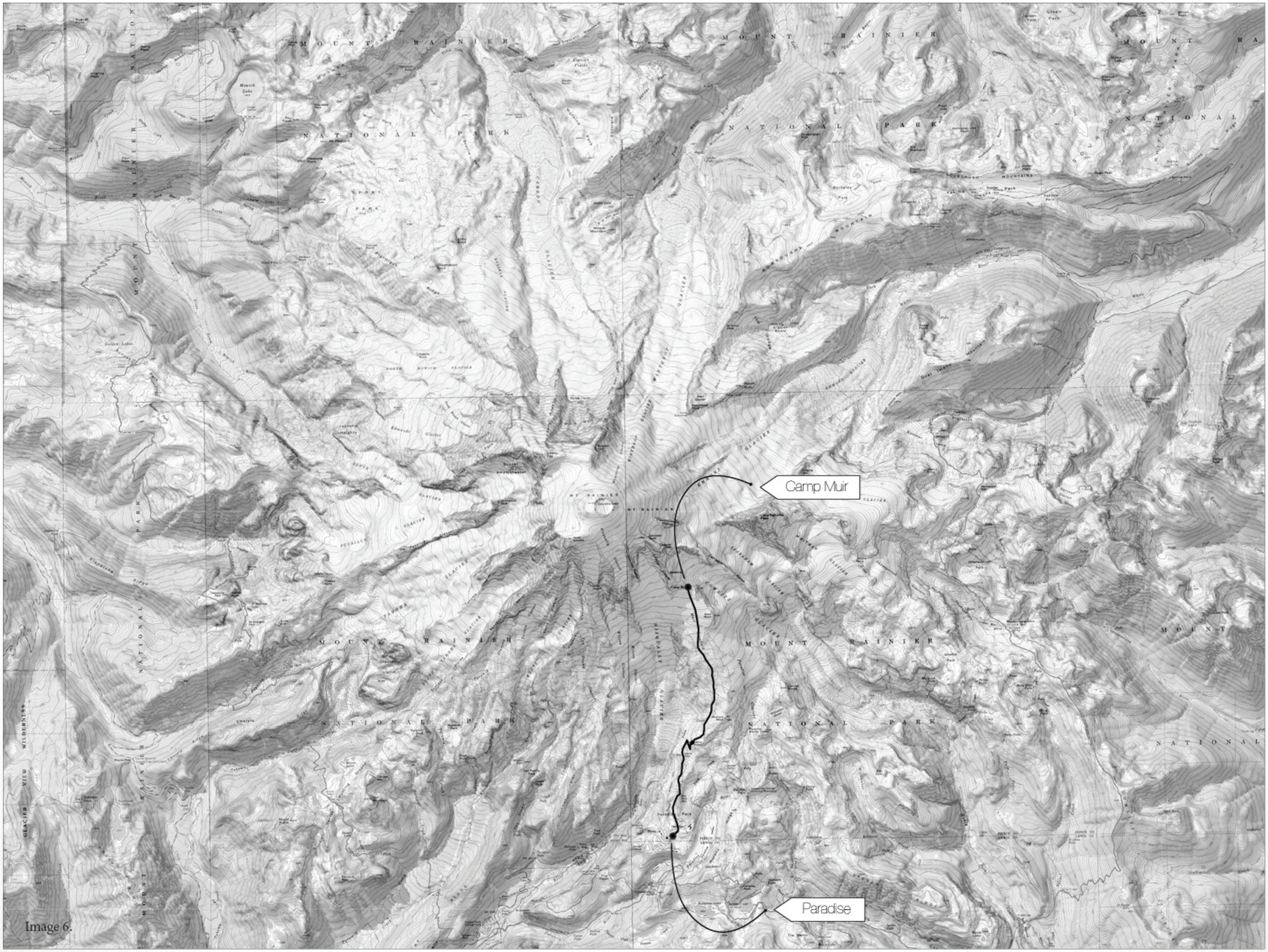


Image 6.

Site

Mt. Rainier's prominence in the landscape has been a symbol and beacon for the city of Seattle, Washington. Located 54 miles southwest of the city, Mt. Rainier's close proximity provides two environments a distinct relationship with one another (see Image 5). This distinction comes in the form of experiencing a multitude of scales, from the urban fabric and geological features, to the meticulous movements a climber relies on. Arriving at Camp Muir one has witnessed and experienced the richness these two environments have to offer.

Seven climbing routes are best accessed from Camp Muir and the upper Muir Snowfield. Camp Muir has Rainier's shortest high-camp approach, and the climb from Paradise to Muir is one of the most popular in the park. Most parties take 4 to 8 hours to climb the 4,500 feet of elevation gain to Muir.

Getting to Camp Muir: This first leg, either for climbers who are summiting or day users hiking up to Muir, is one that provides familiarity and clarity of the mountain. The journey to Camp Muir begins from Paradise, located at 5,420 feet at the foot of the mountain. Taking the Skyline Trail 1.5 miles to Panorama Point at 6,900 feet and continuing along the broad ridge above Panorama Point, staying west of McClure Rock at 7,385 feet to Muir Snowfield. Once on Muir Snowfield, ascend north-northwest to Camp Muir at 10,080 feet (see Image 6.). Along the way, climbers get dramatic views of Mount Adams, Mount St. Helens, Mount Hood, and sometimes even Mount Jefferson in central Oregon. [5]

Situated on a narrow east-west ridge or "cleaver" at 3,073 m. (10,080 ft.) Camp Muir, originally known as Cloud Camp, is a high-altitude refuge for climbers on Mount Rainier National Park in Washington State.[6] It is the primary base camp for west-side ascents to the summit of Mount Rainier. It also serves as a destination for many day-users that climb up the trails from Paradise area (see Figure 2). Camp Muir has a ranger hut, guide / cook shack, client hut, outhouses, a public shelter, and tent camping areas near the shelter. The shelter building can accommodate thirty climbers overnight.

The Camp Muir site measures roughly 360 feet long from east to west and varies in width from sixty to ninety feet, although the narrowest part of the ridge is about fifteen feet wide. The site, like the surrounding topography, varies greatly. Bounded on the north and south sides by the Cowlitz Glacier and the Muir Snowfield, respectively, the ridge is particularly susceptible to erosion through glacier scour, intense winds, freeze / thaw cycles, and human impacts (see Figure 1). The poor quality of rock found on the site consists of loose talus, pumice and miscellaneous rock that have been deposited along some of the steeper slopes. These unstable surficial deposits are generally unconsolidated with open voids caused by freeze-thaw and mass wasting activity, and are estimated to be about fifteen to twenty feet in thickness. The loose, unstable rock on this site has contributed to the loss of the ridge through erosion and use over the past thirty-plus years (see Image 7 -10).[6]

Image 5 & 6.
Mt. Rainier From Seattle.
Route From Paradise to
Camp Muir.

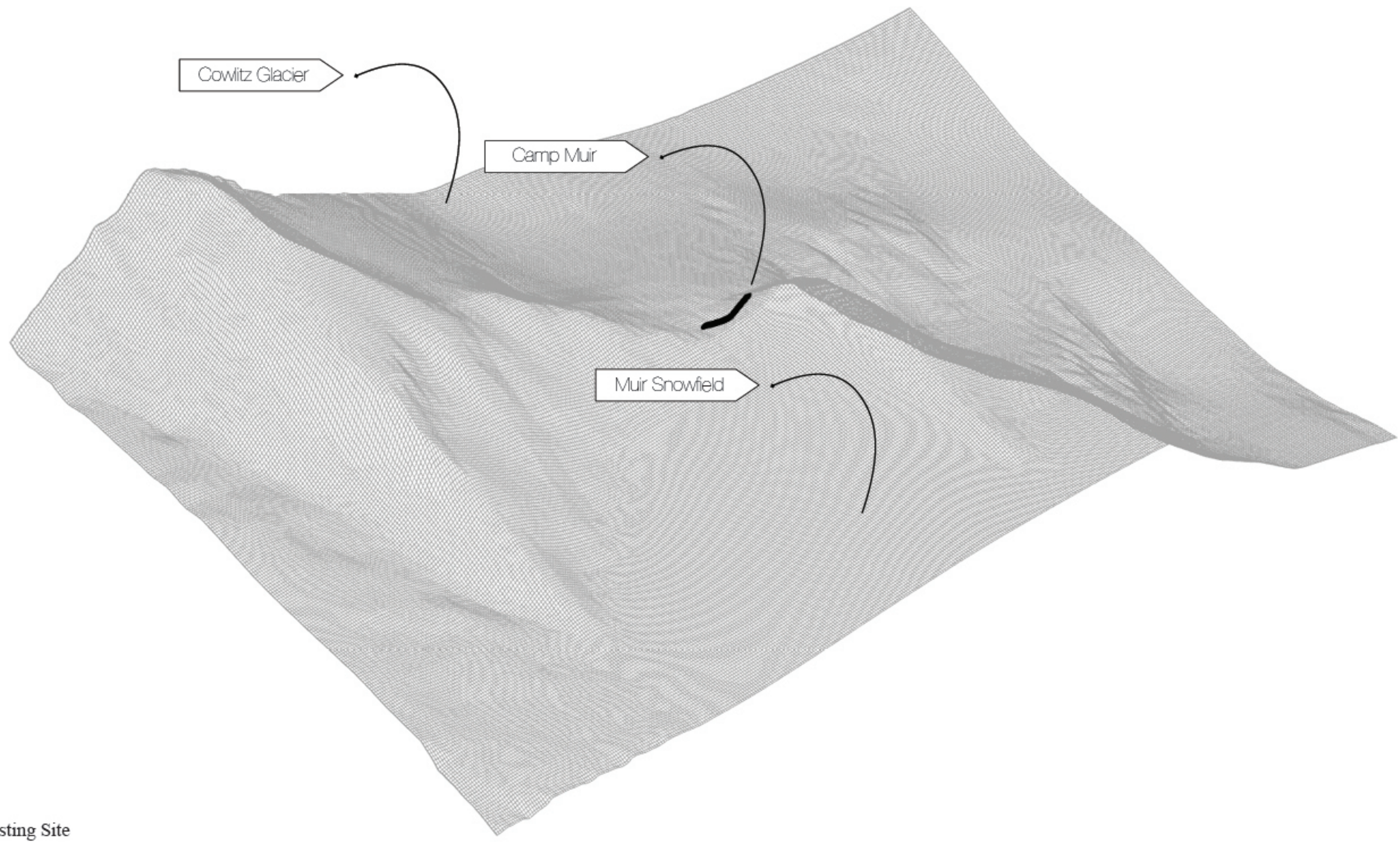


Fig. 1.
Camp Muir, Existing Site Context.

Image 7, 8, & 9.
North View of Camp Muir, South View from Camp Muir, View from Muir Peak.


Image 7.


Image 8.


Image 9.

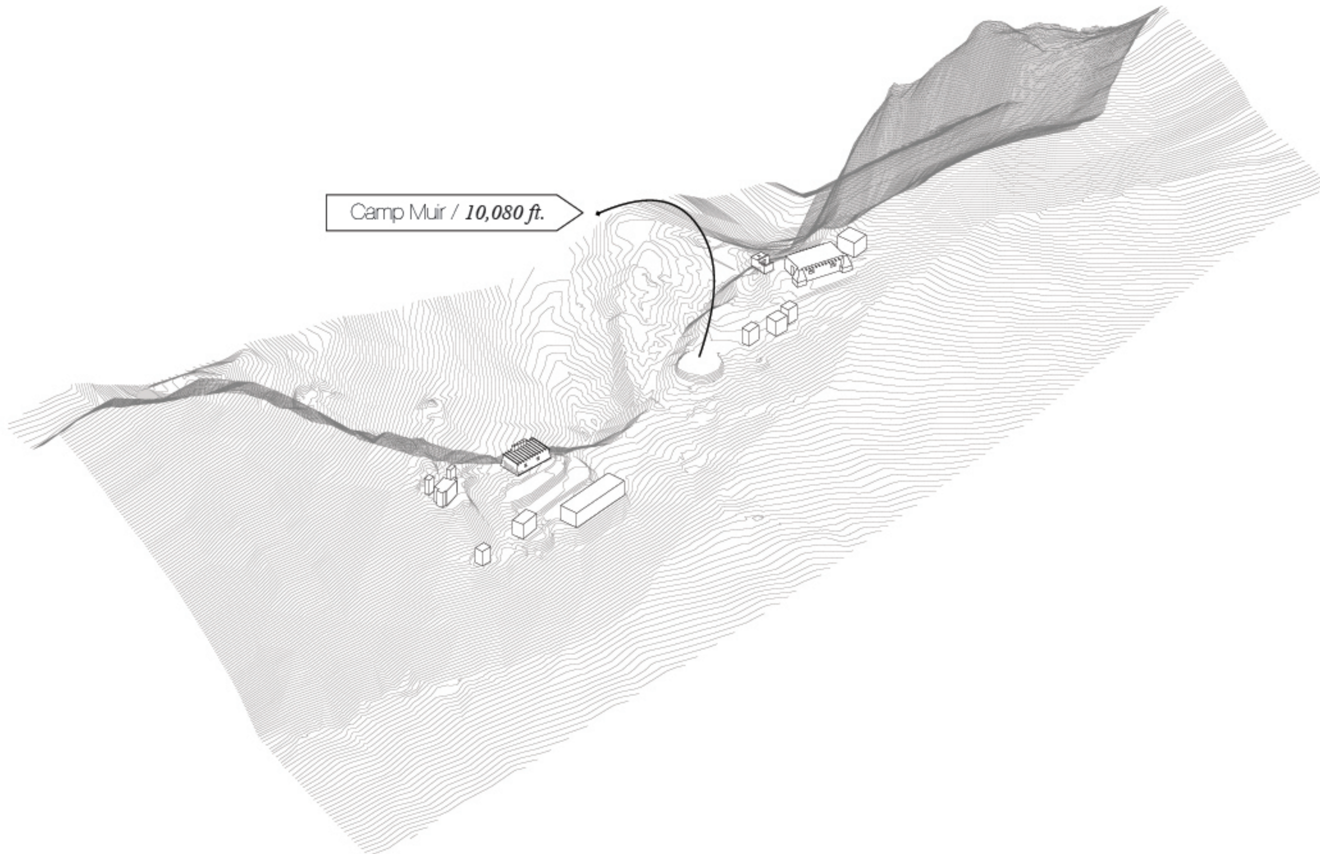


Fig. 2.
Camp Muir, Existing Site.

Image 10.
View from Muir Peak.


Image 10.

History

Nearest city: Paradise, Washington
Coordinates: 46°50'8"N 121°43'53"W
Governing body: National Park Service
MPS: Mt. Rainier National Park MPS
NRHP Reference#: 91000176
Added to NRHP: March 13, 1991

Camp Muir, originally known as Cloud Camp, is located on a narrow east - west ridge, or "cleaver," at 10,080 feet on the Gibraltar route, long known as the most direct route to the summit of the great mountain. It was this route that John Muir (see Image 11.), the founder of the Sierra Club, followed in his 1888 climb to the summit with Seattle mountaineer Edward S. Ingraham. Ingraham later proposed changing the site's name to Camp Muir. Muir himself recommended the site because of the pumice deposits found there. He believed that the pumice deposits indicated that the site provided shelter from the high winds that battered the mountain's higher elevations. [This would prove to be an error, as it was later proven (in 1972) to be one of the primary causes of continued instability and deterioration of the site.]

Camp Muir site measures roughly 360 feet long from east to west and varies in width from sixty to ninety feet, although the narrowest part of the ridge is about fifteen fee wide. The site, like the surrounding topography, varies greatly. Bounded on the north and south sides by the Cowlitz Glacier and the Muir Snowfield, respectively, the ridge is particularly susceptible to erosion through glacier scour, intense winds, freeze / thaw cycles, and human impacts. The poor quality of rock found on the site consists of loose talus, pumice and miscellaneous rock that have been deposited along some of the steeper sloes. These unstable surficial deposits are generally unconsolidated with open voids cause by freeze - thaw and mass wasting activity, and are estimated to be about fifteen to twenty (15 to 20) feet in thickness. The loose, unstable rock on this site has contributed to the loss of the ridge through erosion and use over the past thirty - plus (30+) years. Below the loose rock deposits are competent bedrock materials inter-layered with various lava flows.

Climbing became increasingly popular in the years following Muir's successful summit attempt, and many other ascents to the summit were realized. As mountaineering on Mount Rainier grew in popularity, a climbing fatality in 1897 prompted call for the construction of a high - elevation shelter for climbing parties. A decade later the Army Corps of Engineers recommended the construction of a shelter at Camp Muir, funded in part by private donations. The Department of the Interior approved the shelter project in 1911, but plans for the construction did not

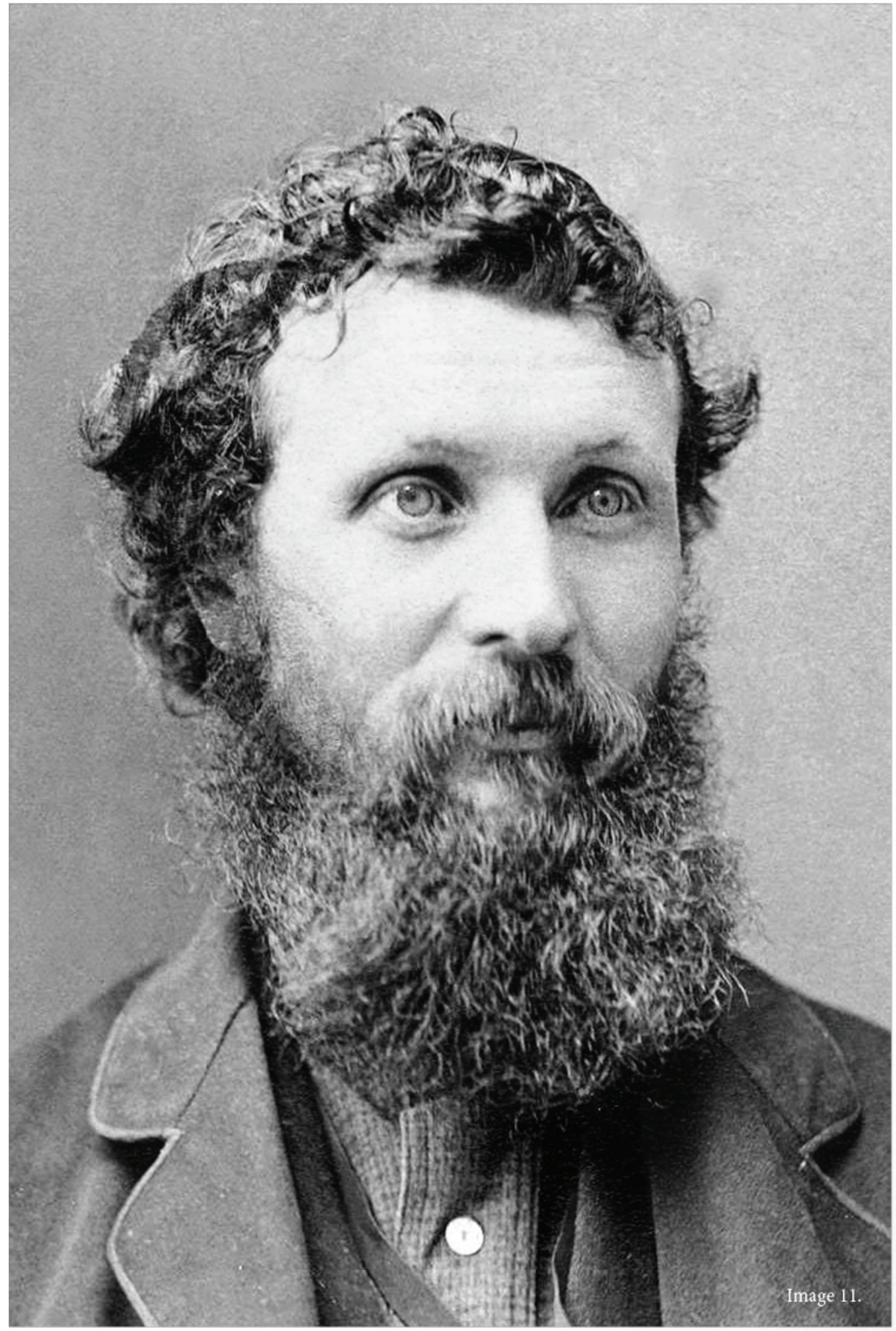


Image 11.

get underway until after John Muir's death in 1914.

The first structure, known as the Climbers' Shelter (but later known as the Guide Shelter), was completed in 1916 with plans from Carl F. Gould, a Seattle architect and member of the Mountaineers (see Image 12.). The structure blended in naturally, almost to the point of being camouflaged, with the surrounding ridge since it was made up of stone found on the ridge.

In 1921, the National Park Service built a second, larger structure at Camp Muir. It was about twice the size of the first shelter, and was similarly a stone masonry one - room structure. At the time of this construction, the original building was dedicated for mountaineering guides while this one served the public. Again, the structure blended in with the surrounding environment (see Image 13.).

These two shelters remained the only structures at Camp Muir for the next 15 years. Between 1935 and 1936, the Civilian Conservation Corps built two pit toilets at the site, which were constructed in methods similar to the climbing shelters. These toilets were the first sanitary facilities provided for climbers along the Gibraltar route. Only the Men's Comfort Station presently remains intact (see Image 14.), since the Women's Comfort Station was dismantled in 1973. Three mortared walls of the Women's remain on the northeast side of the Public Shelter, and are approximately three feet high.

Climbing on Mount Rainier increases gradually between 1950 and 1970, but after 1970 the popularity of climbing grew dramatically, and the vastly greater number of users put enormous pressure on the facilities available at Camp Muir. In order to accommodate increasing climber pressure, the Guide Shelter was repaired in 1966, and the Public Shelter was remodeled in 1968. These upgrades were a result of a series of existing condition surveys that were performed in the early and mid -1960's to respond to structural deterioration and increasing visitor use. The integrity of both the Guide and the Public Shelters declined as a result of surface erosion, glacial scouring, and human forces. In addition to the upgrade made, a pre-fabricated guided client shelter, the Gombu Shelter, was authorized to be built by the commercial guide service, Rainier Mountaineering Incorporated (RMI), in 1970.

The A - frame "Butler" Shelter was built in 1969. This shelter was constructed for NPS (National Park Service) mountaineering Rangers. At the time, the interior of the historic Guide Shelter was remodeled and converted for use as a kitchen and quarters for guide service staff.

The same year, the park replaced the CCC pit toilets with new fiberglass chemical toilets. Solid waste is removed from the site entirely, and liquid is dissipated, instead of merely dumping waste down the slope onto the Cowlitz Glacier as the old pit toilets were designed to do. Despite the new facilities, the original pit toilets were maintained, and in 1973 the men's pit toilet was converted for use as a storage shed. At the time, the women's facility was removed, along with the stone masonry wall that screened the entrances of both toilets.

Eventually, a heli - pad was constructed in 1984, to deal with the human waste removal, which had become the Park's biggest maintenance concern. (Camp Muir Rehabilitation Schematic Design Feasibility Report)

The larger "public" shelter hut was built in 1921 to plans supervised by Daniel Ray Hull of the National Park Service. The 12-foot (3.7 m) by 25-foot (7.6 m) single-story one-room shelter was initially constructed of dry-laid stone. It replaced a smaller shelter which was used as a shelter for climbing guides. A dedication plaque at the entrance to the large shelter plaque reads "Erected in memory of John Muir, 1921." The guide shelter was built in 1916 by a climbing organization, the Mountaineers. It was designed by Seattle architect Carl F. Gould, a member of the Mountaineers and was approved by Park Service director Stephen T. Mather. The single-story guide shelter measures about 10 feet (3.0 m) by 24 feet (7.3 m), and is the oldest stone structure in the park. Two stone pit toilets were built at Camp Muir in 1936 by the Civilian Conservation Corps, one of which survives and is used for storage.[7]

Camp Muir was placed on the National Register of Historic Places on March 13, 1991. It is part of the Mount Rainier National Historic Landmark District, which encompasses the entire park and which recognizes the park's inventory of Park Service-designed rustic architecture.

Presently, the high demands users play on Camp Muir is affecting the longevity of the site. Its close proximity to Paradise give Camp Muir a growing popularity put strain on its infrastructure and sensitive alpine environment. In 2012, 7,728 climbers were registered to summit Mt. Rainier through one of the Camp Muir's routes (see Figure 3.), this data makes it clear that user growth is increasing and new needs need to be met.

Image 11 & 12.
Portrait of a young John Muir. Historic Guide Shelter.

Image 12.

John Muir's 1888 summit climb through the ridge set forth the creation of a mountain camp.

Muir himself recommended the site because of the pumice deposits found there. He believed that the pumice deposits indicated that the site provided shelter from the high winds that battered the mountain's higher elevations. [This would prove to be an error, as it was later proven (in 1972) to be one of the primary causes of continued instability and deterioration of the site.]

• As climbing became increasingly popular in the years following Muir's successful summit attempt, and many other ascents to the summit were realized. As mountaineering on Mount Rainier grew in popularity, a climbing fatality in 1897 prompted calls for the construction of a high - elevation shelter for climbing parties.

• In 1916 the first structure, known as the Climbers' Shelter (but later known as the Guide Shelter), was completed.

• In 1921, the National Park Service built a second, larger structure at Camp Muir, known as the Public Shelter.

• Between 1935 and 1936, the Civilian Conservation Corps built two pit toilets at the site, which were constructed in methods similar to the climbing shelters.

• The A - frame "Butler" Shelter was built in 1969. This shelter was constructed for NPS (National Park Service) mountaineering Rangers.

• A heli - pad was constructed in 1984, to deal with the human waste removal, which had become the Park's biggest maintenance concern.

• Camp Muir was placed on the National Register of Historic Places in 1991. It is part of the Mount Rainier National Historic Landmark District, which encompasses the entire park and which recognizes the park's inventory of Park Service-designed rustic architecture.

Present - High numbers of climbers and day users put a strain on the facilities and natural environment of Camp Muir and its surrounding.

Image 13.
Historic Public Shelter.

Image 13.

Image 14.

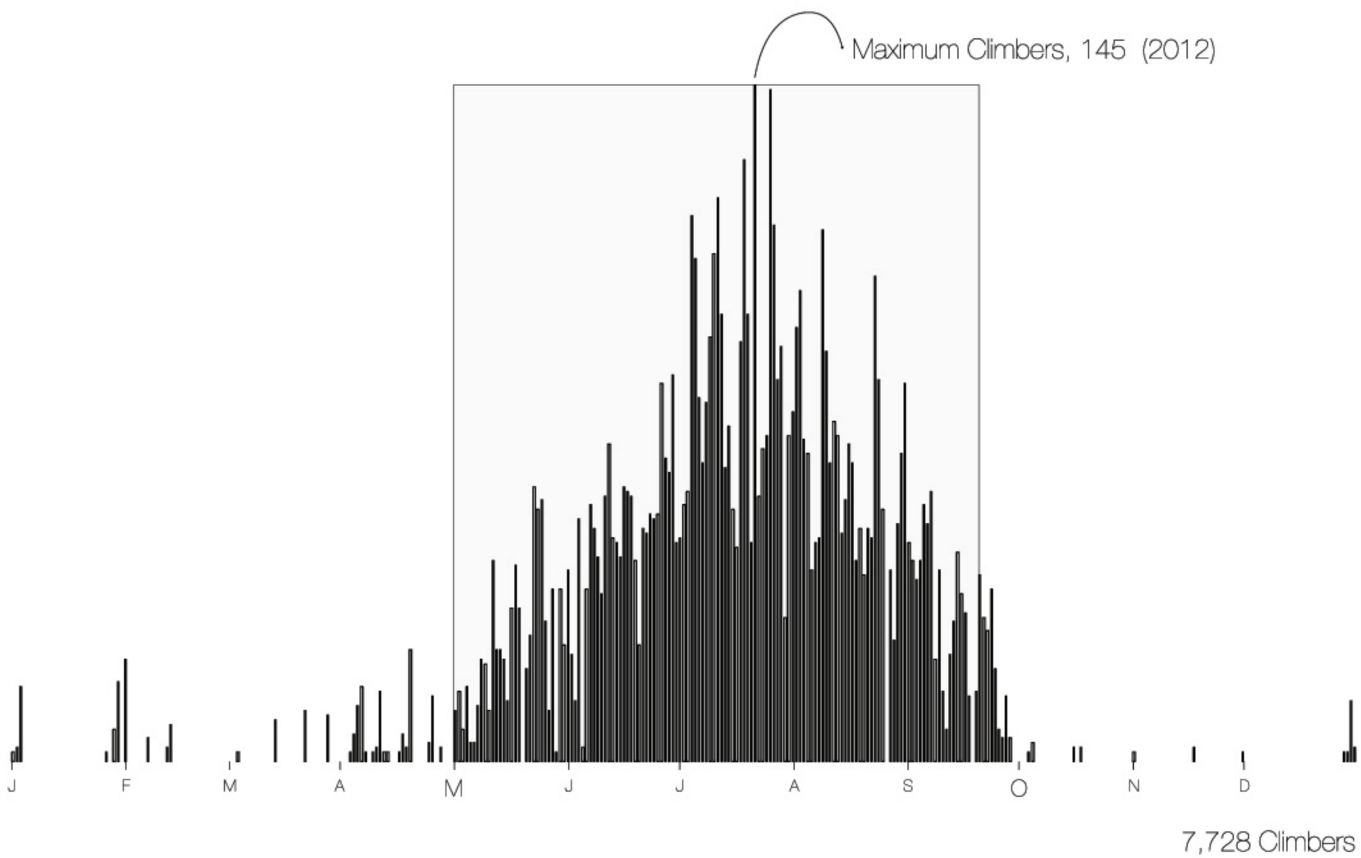


Fig. 3.
Number of Climbers via
Camp Muir (2012).

Image 14.
Historic Men's Comfort
Station.

Alpine Precedents

Building in nature, in the mountains, also known as living in the mountains is a great adventure and challenge.

"So this is were humans come in, with their requirements, restricted at first to the bare essentials, rational when it comes to form and materials, expressing their resistance to inhospitable conditions in rural artefact's..."[8]

The selection of precedents investigates modularity, typology, climatic approaches, self-sufficiency, spatiality, and ingenuity within an alpine environment. Though all three case studies approach building in the mountains or harsh environments through different aspects, either being time period, materiality, size, etc. they all provide guidance and inspiration in finding an appropriate solution in this thesis.

The Refuge Tonneau looks at compactness and mobility through early pre-frabrication techniques. The New Monte Rosa Hut in the Swiss Alps creates a high altitude net zero refuge using modern use of pre-frabrication techniques and computer simulation for a feed loop response, creating a building that responds to its climate and users. Ralph Erskines Study for an Arctic Town and Housing in Byker, Newcastle, England look at the landscape and form of the building to create a comfortable living environment dependent of climatic positioning. These examples present a variety of responses to harsh climates but they each maintain a very specific identity in the landscape.

The Refuge Tonneau (Le Refuge Tonneau)

Charlotte Perriand and Pierre Jeanneret
1938

When Charlotte Perriand and Pierre Jeanneret designed the Refuge Tonneau in 1938, it was considered to be a futuristic design, way ahead of its time although in later years, many of its features have been incorporated into mountain refuges. At the 2012 Salone del Mobile in Milan, the construction of the original 12 sided mountain hut became a tactile reality, thanks to Cassina (see Image 15.).

All components were prefabricated and organized around a tubular steel frame Aluminum components were used for the many qualities possessed by this material: it is lightweight (can be transported easily) and robust (it can withstand difficult weather conditions). The construction was adaptable to different locations and could be mounted and assembled in just 4 days.[8]

The elegant two story aluminum structure stands on 12 poles and is barely 4 meters in height (see Image 16.). The pine wood lined interior sleeps 8 in two double beds on the first floor and two on the ground floor which double as seating or may be folded and restrained by means of leather straps, much the same as beds in a railway carriage (see Image 17.). A central heating pole ensures warmth is distributed throughout the hut, a wooden kitchen counter fitted with an aluminum sink for melting snow with space for a camping stove and supplies as well as space for skis and rucksacks are just a few of the incredibly efficient features contained within this tiny sanctuary (see Image 18.).

The inspiration of Perriand for the design came from a photograph of a children's fairground ride in Croatia. The 3D project came to fruition from the designer's extensive notes and sketches as well as close collaboration with her daughter, Pernette Perriand-Barsac.

Image 15, 16, 17 & 18.
The Refuge Tonneau.


Image 15.


Image 16.


Image 17.

Image 18.

New Monte Rosa Hut

ETH Zürich (Eidgenössische Technische Hochschule Zürich)
Monte Rosa, Switzerland
2009

The New Monte Rosa Hut is a exemplary example of self - sufficiency through pre-fabricated techniques in the realm of high altitude architecture and construction. Though the building offers a large array of luxury accommodations usually not seen in high altitude mountain huts, it still serves the primordial purpose of the high altitude mountain hut, refuge. Making this building of great interest and importance in researching mountain architecture.

This facility is 90 percent self-sufficient and offers hikers protection from the elements in a new-style alpine hut that rises dramatically out of the snow-covered terrain. At first glance, the Monte Rosa Hut looks like a large glacial formation rising out from the snowy peak (see Image 19.). In reality, however, it's a high-altitude mountain shelter that sets new milestones in sustainability and innovative design.

The Swiss Federal Institute of Technology (ETH Zürich) a top technology and science university teamed up Swiss firm Bearth & Deplazes Architekten, the legendary Swiss Alpine Club (SAC), and Vectorworks® software to design and build the "hut", which sits 9,459 feet high in the Swiss alpine sky near Zermatt. The facility houses a state-of-the-art research lab which measures the building's efficiency as a self-sufficient entity.

The asymmetrical angles of the five story hut minimize exposure to snow and wind and provide more room for guests. Studio Monte Rosa, a combined group of selected ETH students and Swiss architecture firm Bearth & Deplazes Architekten, designed a structure that would replace the original hut, which was in great need of repair. The new lodging serves two important purposes: to provide alpinists and hikers protection from the elements as well as a comfortable, clean space to eat, rest, and commune with fellow travelers; and to provide ETH Zürich with valuable research on effective sustainable practices (see Image 20.).

The facility can accommodate up to 120 guests. It contains a simple kitchen and dining area—both fashioned from spruce and fir, which were chosen for their sustainability quotients. A large common room provides a spot for socialization. The bedrooms feature trapezoidal mattresses in various sizes made to minimize wasted space by matching the shape of the human body (broader at the top and tapering for the legs) (see Figure 4.). During the specialty research phase, the ETH students used Vectorworks software to maximize the placement and number of beds within the given space. By simulating many different scenarios for the beds and other building elements, the design team optimized the hut's entire design—which saved a great amount of development time and significantly reduced building costs.

The end result: precisely-manufactured building elements and smooth collaboration with numerous other project teams. By using the digital chain to address complexities and efficiencies, they were able to reduce the number of building elements by 30 percent and the weight by 40 percent, and also adjust design elements throughout the process.[10]

Image 19.
New Monte Rosa Hut.

Image 19.

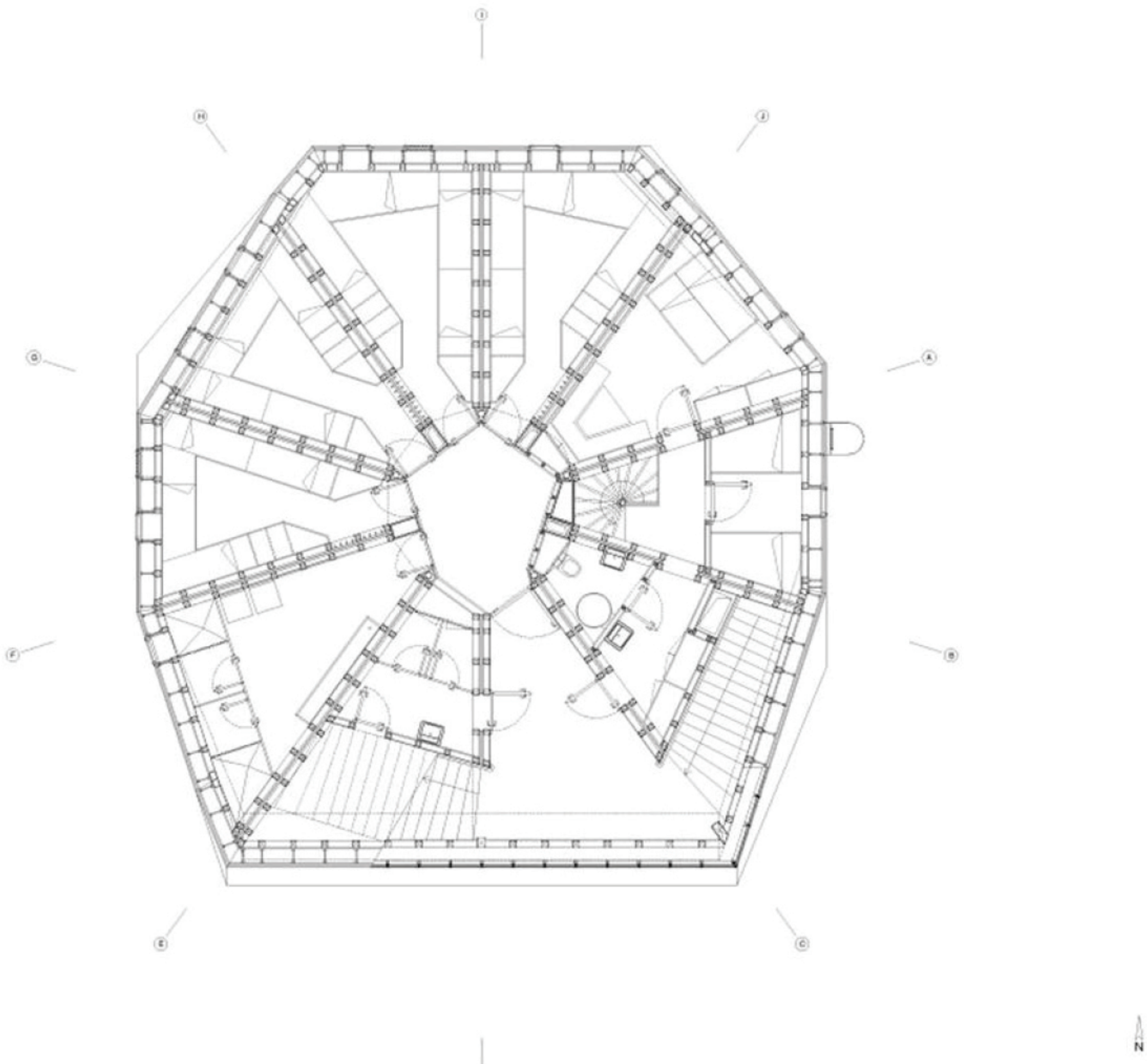


Fig. 4.
Room Plan

Image 20.
Pre-Frabricated Compact
Interior.


Image 20.

Study for an Arctic Town
Ralph Erskine
1958 - Unbuilt

Placed on a south facing slope, it is enclosed on east, west and north sides, like a medieval walled town but now keeping out invasion by Arctic winds and blizzards. Within the shelter of the enclosure, the sun trap, are dispersed the individual houses and small town facilities (see Image 21.). Later Erskine wrote that 'cities in the north ought, because of their isolation, to be made more attractive and pronounced than their counterparts in southern parts. They ought to be gathered in a cluster to create a human environment in the [Arctic] desert'.[11]

Erskine's notion on creating a more attractive and pronounced living environment is fundamental in building in the mountains. Such a harsh climate divides the social aspect of mountaineering from refuge, while providing areas of social gathering begin to allow a merger between refuge and the social attributes of mountaineering.

Furthermore, Erskine touches on a new building typology, the wall or bar scheme. This elongated building form embraces the site and creates a compactness, not as an interior element, but as an outdoor space or spaces. The interior spaces still act as individualized areas for its users, though these modules of individualized spaces together as a whole creating a protective enclosure from surrounding climatic factors.

Housing at Byker
Ralph Erskine
Newcastle upon Tyne, England
1969 - 1981

First to be built was a pilot scheme of forty-six dwellings which was in the nature of a guinea pig to test reactions and participation possibilities (see Figure 5.). The wall building at Byker is the most astonishing part of the housing scheme. Its precursor in the Arctic studies was to keep out the Arctic winds and shelter the rest of the town in front of it, as well as giving a sense of enclosure and protection. At Byker the wall lies along the crest of the hill and shelters the south slope in front of it from the winds coming off the North Sea (see Image 22.). The completed scheme contains 2,317 dwellings of different sizes accommodating approximately 7,850 people.[12]

The Byker Housing scheme again follows the bar typology though in an urban setting. The issues here are similar to its predecessor, protection from surrounding elements, creating exterior social spaces, as well as capturing climatic conditions to its advantage.

Image 21.
Study for an Arctic Town
Sketch.

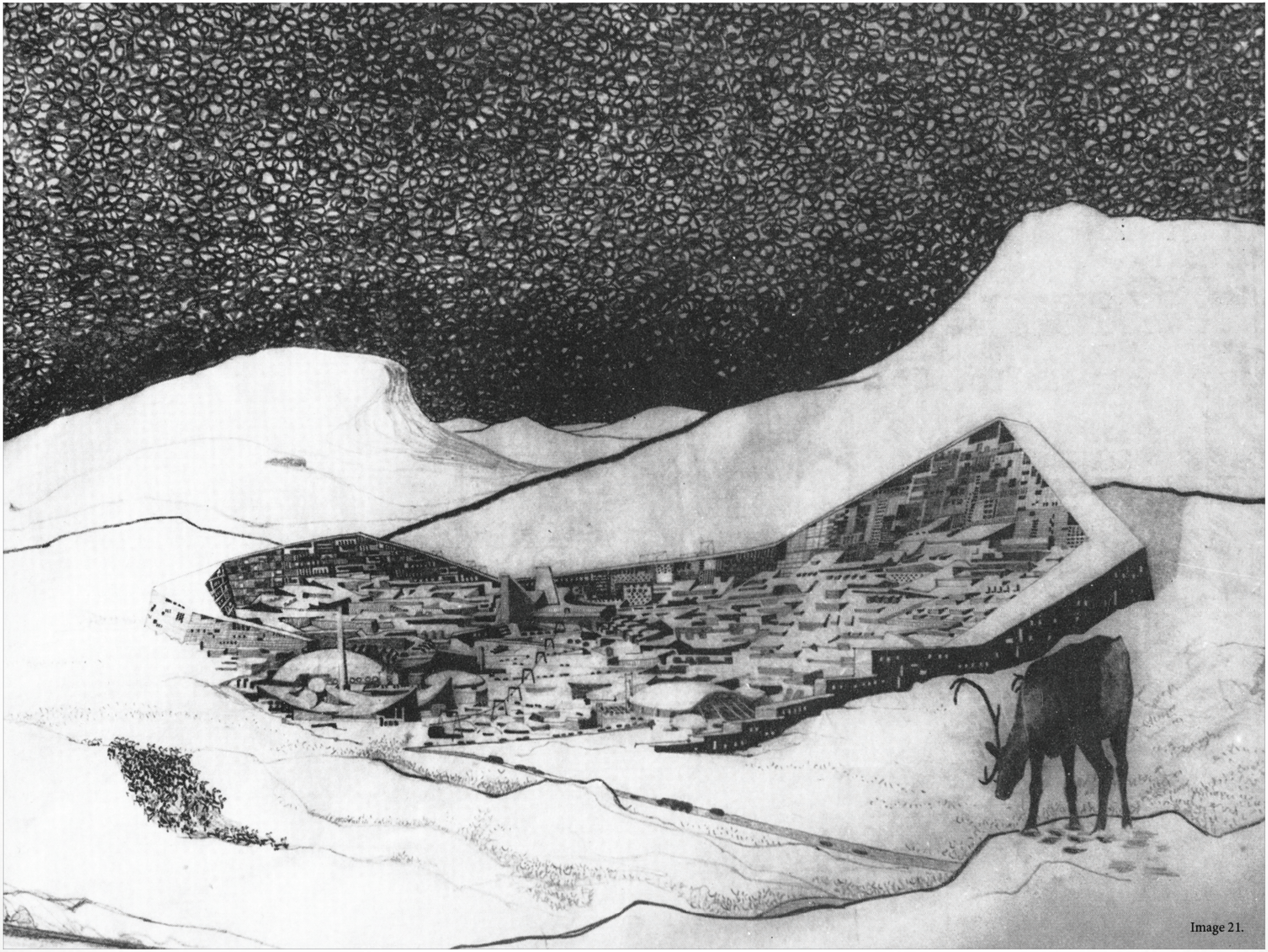


Image 21.

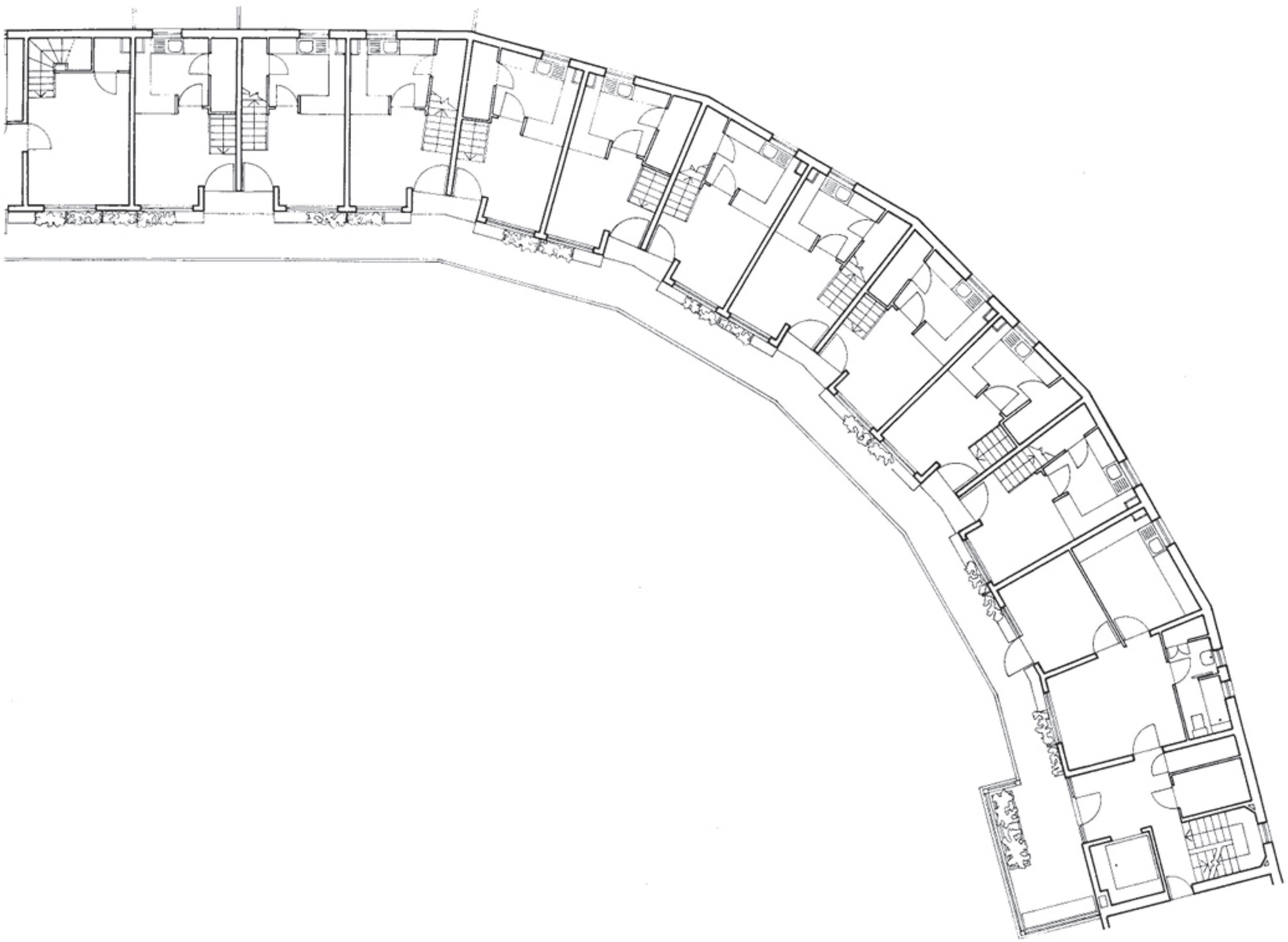


Fig. 5.
Partial plan of Byker Wall Housing, bend on south facade.

Image 22.
Byker Wall Housing in the landscape.

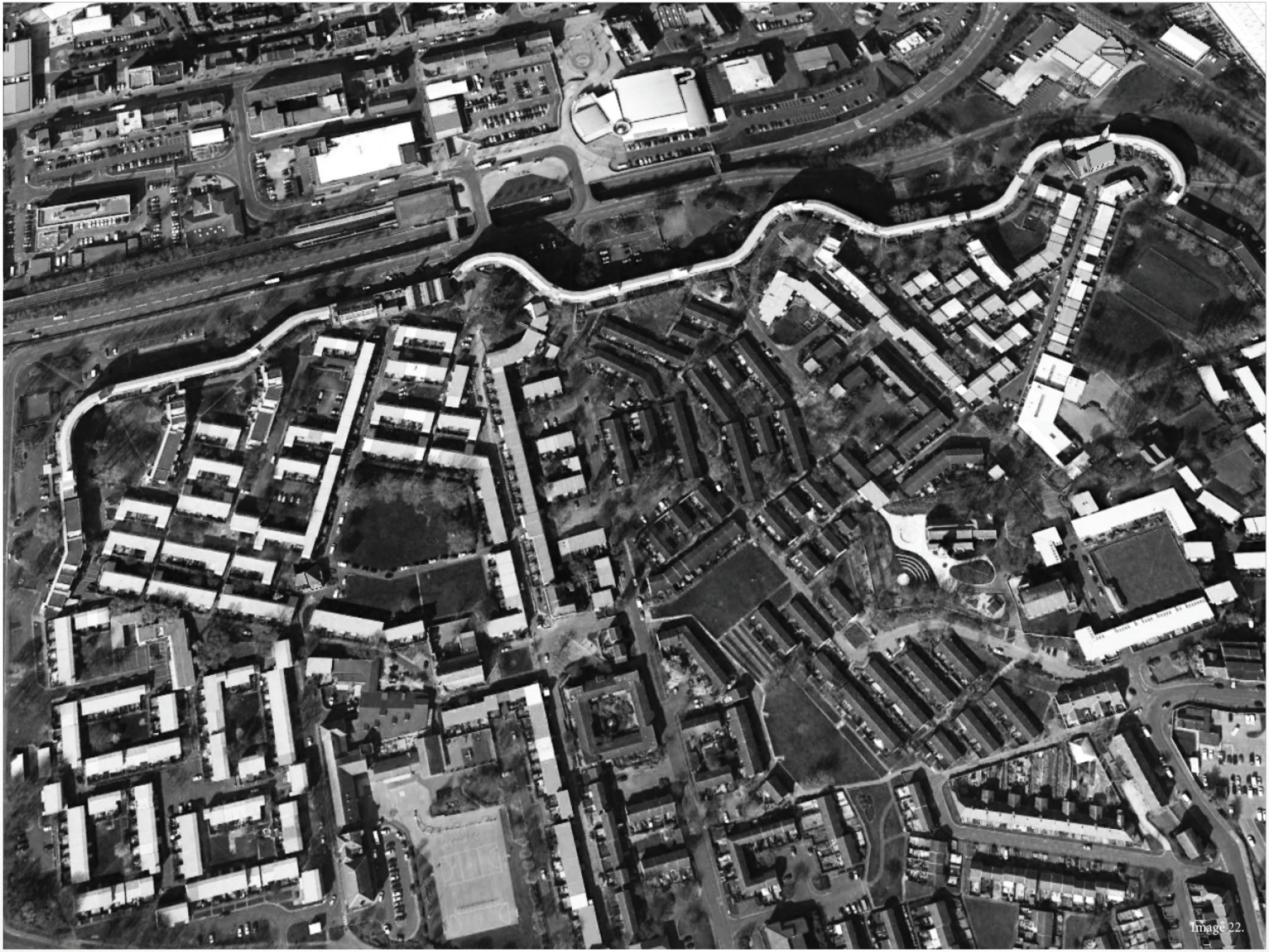


Image 22.

Weather

Image 23.

Weather

If I wished to see a mountain or other scenery under the most favorable auspices, I would go to see it in foul weather, so as to be there when it cleared up; we are then in the most suitable mood, and Nature is most fresh and inspiring. There is no serenity so fair as that which is just established in a tearful eye.

- Henry David Thoreau

The weather on Mount Rainier is as diverse and unforgiving as the terrain. Strong storms know no season; high winds, rain, snow, and subfreezing temperatures can occur any month of the year.

Mount Rainier generates its own weather. Because of local variations in wind flow, lifting air, sinking air, and Rainier's great height, amazing changes in weather are common from day to day, hour to hour, and elevation to elevation. Cool temperatures, lights winds, and foggy skies at Paradise may give way to clear skies only an hour's hike above on a typical summer day. Also, Rainier's weather can be extreme. When it's wet, it's damp and penetrating; when it's windy, it's cutting and fierce; and when it's cold, it's brutally frigid.

The weather on Mount Rainier can be dramatically different from what it is elsewhere in Washington. The mountain and its 12,000 feet of vertical relief directly influences what's happening on the peak. For example, moist air from the Pacific cools by approximately 3.5 degrees Fahrenheit (2 degrees Celsius) for every 1,000 feet (roughly 300 meters) that it rises. This cooling produces temperatures differences of 30 degrees Fahrenheit or more between Paradise at 5,240 feet and the summit at 14,410 feet.

Other local weather effects induced by the mountain include small - scale wind eddies and turbulent swirls formed as winds interact with ridges, ribs, valleys, gullies, and rock outcroppings. Also, solar heating and radiant cooling produce substantial daily cycles of rising and falling mountain winds. During the clear nights and early - morning hours of summer, heat loss off the snow, rock, and ice creates a river of cold, dense air that flows down the mountain. Conversely, solar radiation warms close air to the surface during the day, producing an up - mountain wind during the late - morning and afternoon hours.

Spring: April to early June

After months of harsh winter weather, storm cycles decrease their intensity as spring arrives. Storms are less frequent and less powerful in April and May. Breaks in the weather allow the sun to bring the year's first real warming to the mountain. During this transition in seasons, sudden and unexpected storms are still likely. April averages 10 inches of measurable precipitation and close to 70 inches of snowfall. Rain at Paradise means heavy snow on the mountain.

Summer: Late June to early September

Summer weather provides the most stable opportunities for recreation. Good conditions make Rainier a popular summer climb. Clear, warm weather is likely in late July, August, and early September. Even during the worst of years, Paradise has received only 6 inches of snowfall during August. Both July and September have recorded years of no measurable precipitation. A high - pressure ridge normally develops off Washington's coast during these months. It pushes storm energy to the north of splits and weakens its intensity while still offshore. It's not unusual for freezing levels to hover at 12,000 to 14,000 feet as precipitation dwindles significantly. June and early July are a bit more temperamental than late summer. Springlike storms that deposit significant snow are common. The effects of solar radiation are the greatest during the long days of June and early July, particularly on clean, bright, reflective snow. Such reflection makes cirques and bowls seem like ovens, even above 10,000 feet. Cold clear nights result in radiant cooling of the snow. As the snow refreezes after the day's heat, a substantial crust is formed.

Autumn: Mid - September to early November

During late September and October, the jet stream begins to dip southward into the Pacific Northwest. The increased onshore flow associated with decreasing heat from the sun allows storms to bring a surge of pre-winter conditions to the mountain. It's entirely possible to find a foot or two of snowfall at Paradise in September and October. But just as possible is the return of a summer like high pressure ridge, sometimes for a week or two; brilliant clear days and cold nights, a so - called Indian summer. With November and December approaching, the sun recedes lower on the horizon, producing a strong temperature contrast between the north and south poles. During this imbalance the onshore flow over the Pacific Northwest increases even more. Pacific - born storms now bring heavy rain, snow, ice, wind, and lowering freezing levels.

Winter: Late November to late March

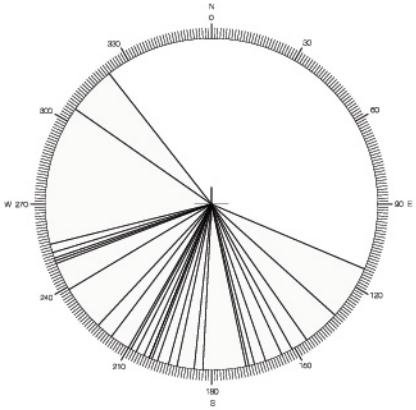
Winter on Mount Rainier generally means frequent clouds and heavy precipitation. Several major storms hit the mountain each winter. The storms produce heavy rain or substantial snowfall and high winds, particularly above the tree line. Storms can last for a week or more and may deposit 80 to 100 inches of snow and bring temperatures below zero degrees Fahrenheit and winds in excess of 100 miles per hour, creating hostile conditions. Due to Washington's temperate climate, it's not uncommon for the freezing level to rise above 9,000 feet in winter; inevitably the freezing level will lower back to between 2,000 to 5,000 feet. Some winters experience a break in the westerly flow of storms. This happens when a large upper ridge of cold air flows over the Pacific Northwest, resulting in several days to a week or more of clear weather, especially at higher elevations. During this time, northeast and northwest winds commonly buffet the mountain. As this high - pressure, cold - air ridge moves eastward over Washington, northerly winds yield to weak westerlies, increasing the high clouds in the sky and the freezing levels on the mountain. The pressure gradient becomes great between the east and west side of the state, causing heavy cold air to sink under the warmer air aloft. Strong temperature inversions are likely between 4,000 and 6,000 feet, trapping low - level moisture as a blanket of low clouds or fog in the valleys. As the pressure ridge continues east over the Cascades, south and southwest winds increase in return. This change break the inversion, mixing the moist surface air with drier air aloft. This turnover is ofter abrupt, resulting in dramatic changes in the weather and in the stability of the snow pack. The storm clock is ticking. During such air - mass transitions, extreme weather is likely. Winter weather returns as heavy precipitation and high winds again prevail.[13]

From the climatic data it is apparent that there are certain climate conditions that need to be looked at closely. Wind speed, temperature, humidity, sun paths, and solar irradiance are key factors in determining and executing design decisions (see Figures 10., 11., 12., 13., & 14.). Though of great importance is the peak season for climbers. Early May through late September is peak season for Camp Muir, analyzing climate data for this time provides a clear vision on how the design will use climate to its advantage at peak times and how the building will adapt to off peak season periods.

Wind is the greatest climatic factor for Camp Muir. The ridge sits exposed throughout the year, relentlessly battered by southern winds (see Figures 6. & 7.). Being exposed provides an advantage when it comes to solar irradiance. Camp Muir receives constant solar input throughout the year (see Figures 8 & 9.). These two climatic conditions are of greatest importance due to the need to protect users and for a constant supply of energy.

Image 23 & 24.
Weather Moving in on Camp Muir. Heavy Snowfall on Camp Muir.

Image 24.



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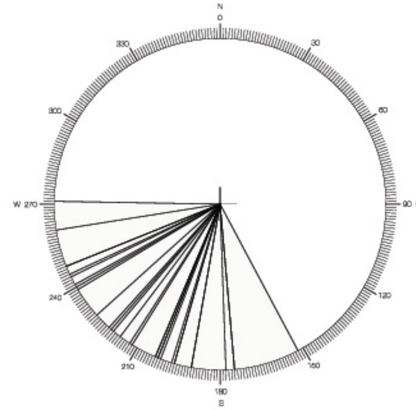
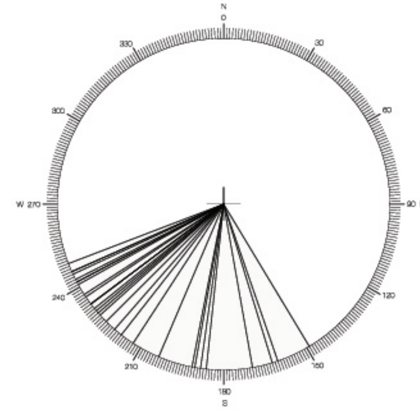
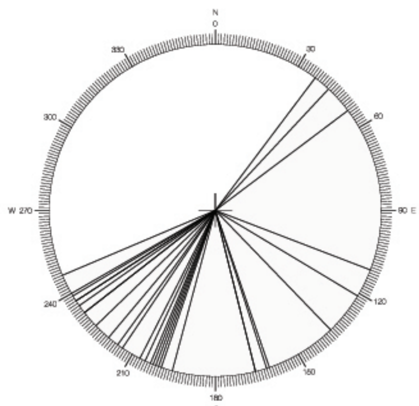


M



A

M



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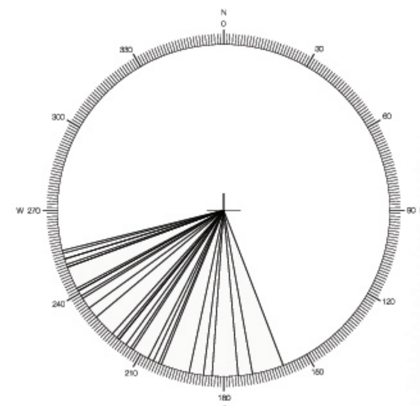
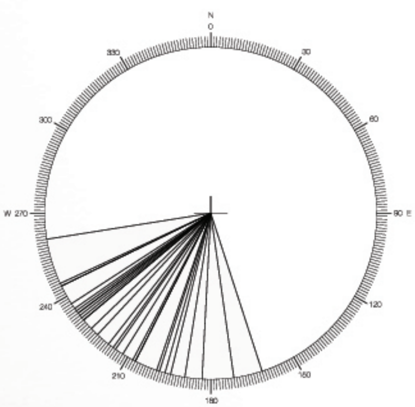


A



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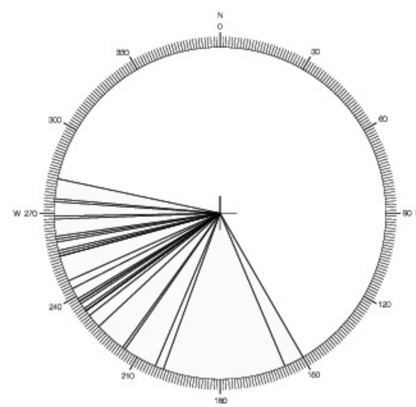
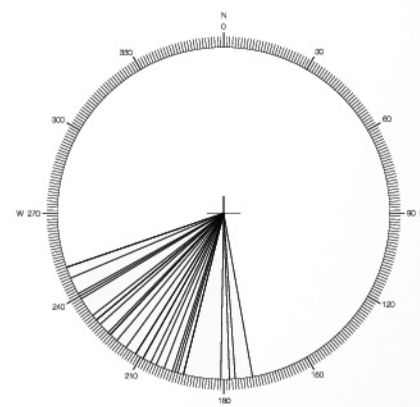


N



D

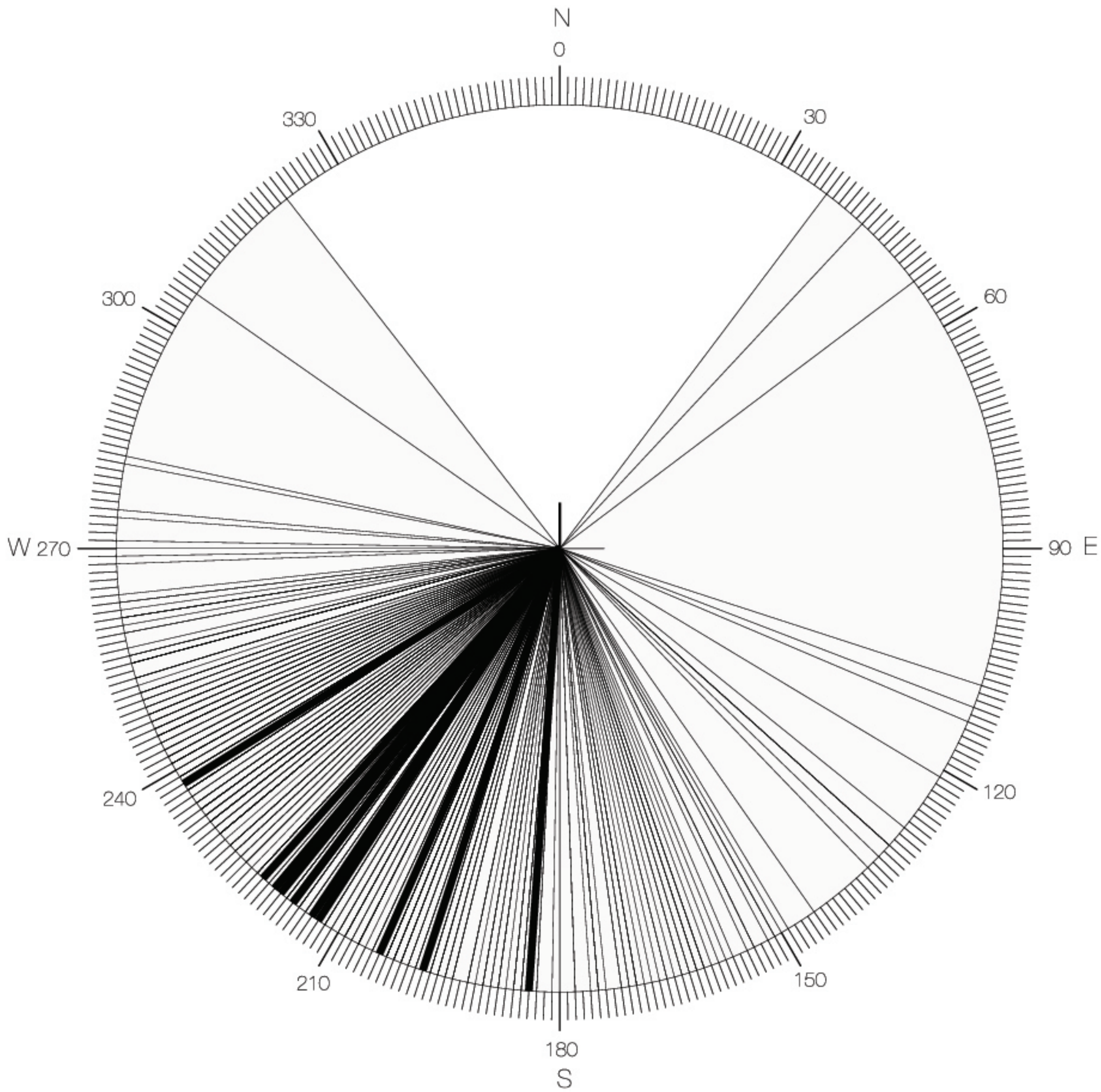


Fig. 6 & 7.
Monthly wind directions &
average wind directions
combined (12 mo.) 2012.

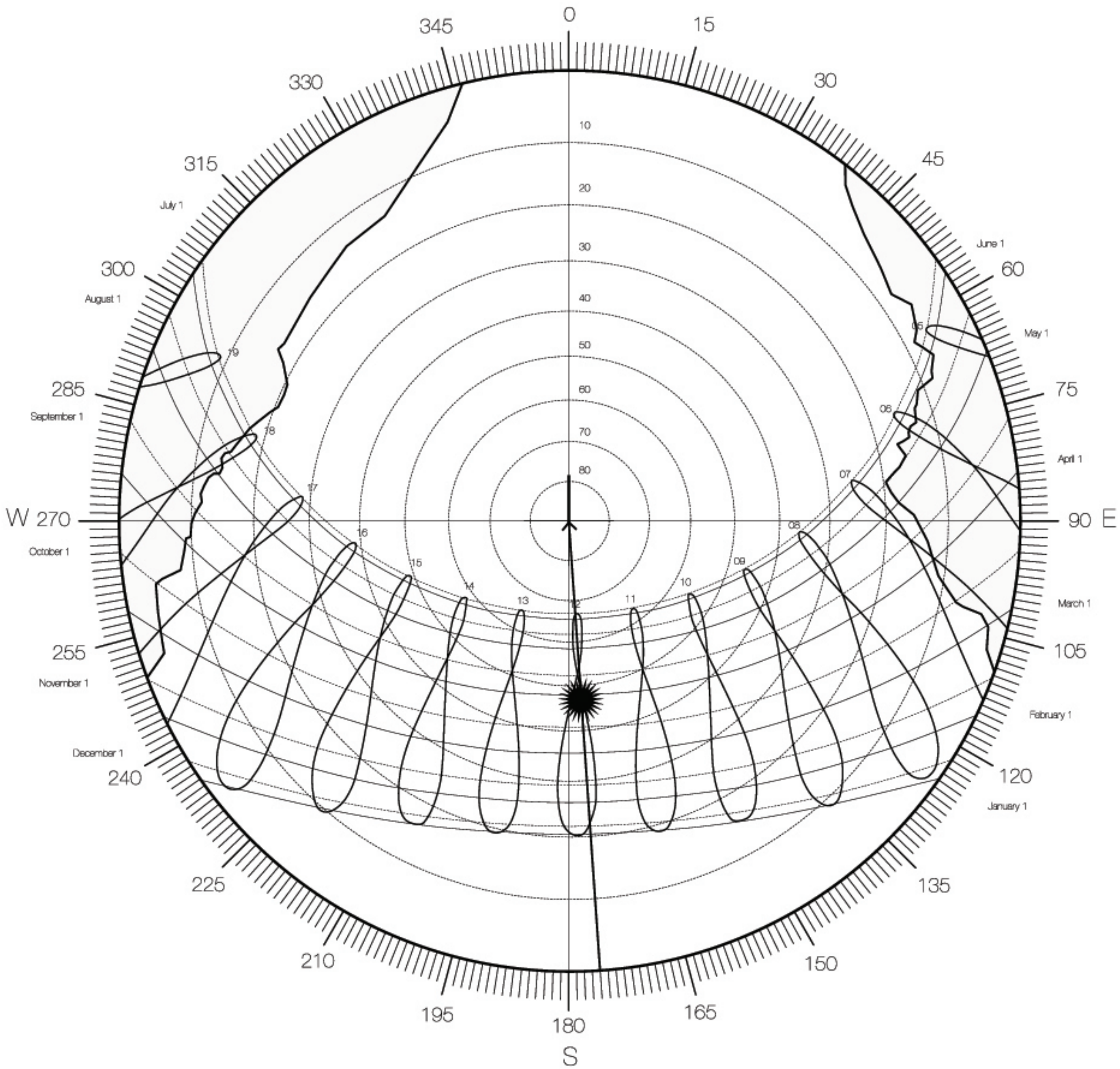


Fig. 8.
Path of sun as seen from
Camp Muir.

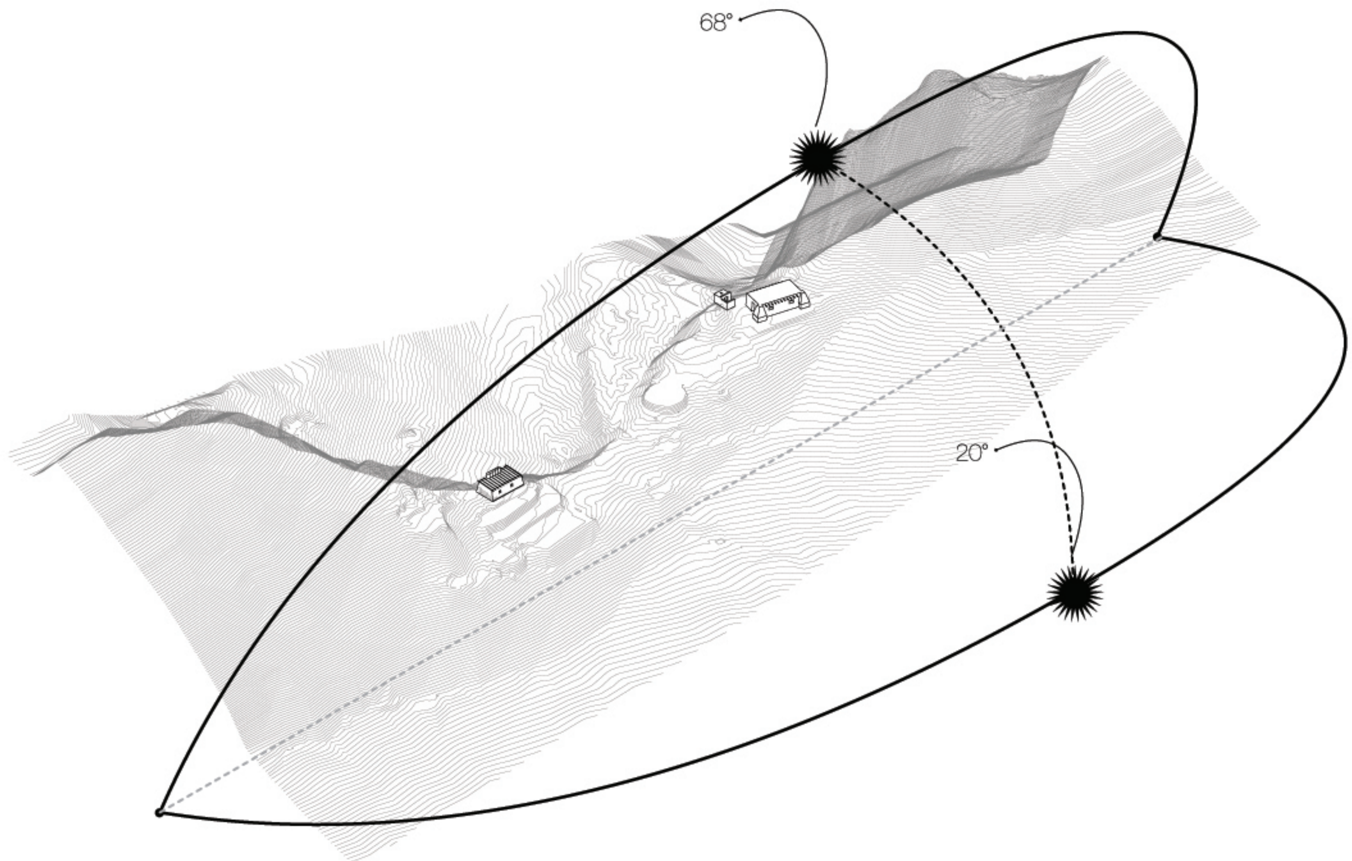
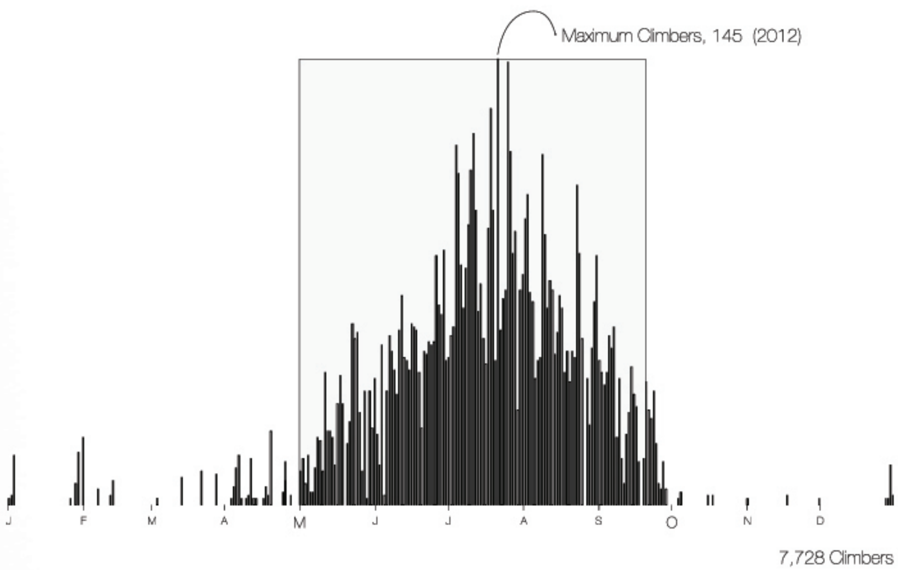


Fig. 9.
Max. & min. sun path
altitudes.



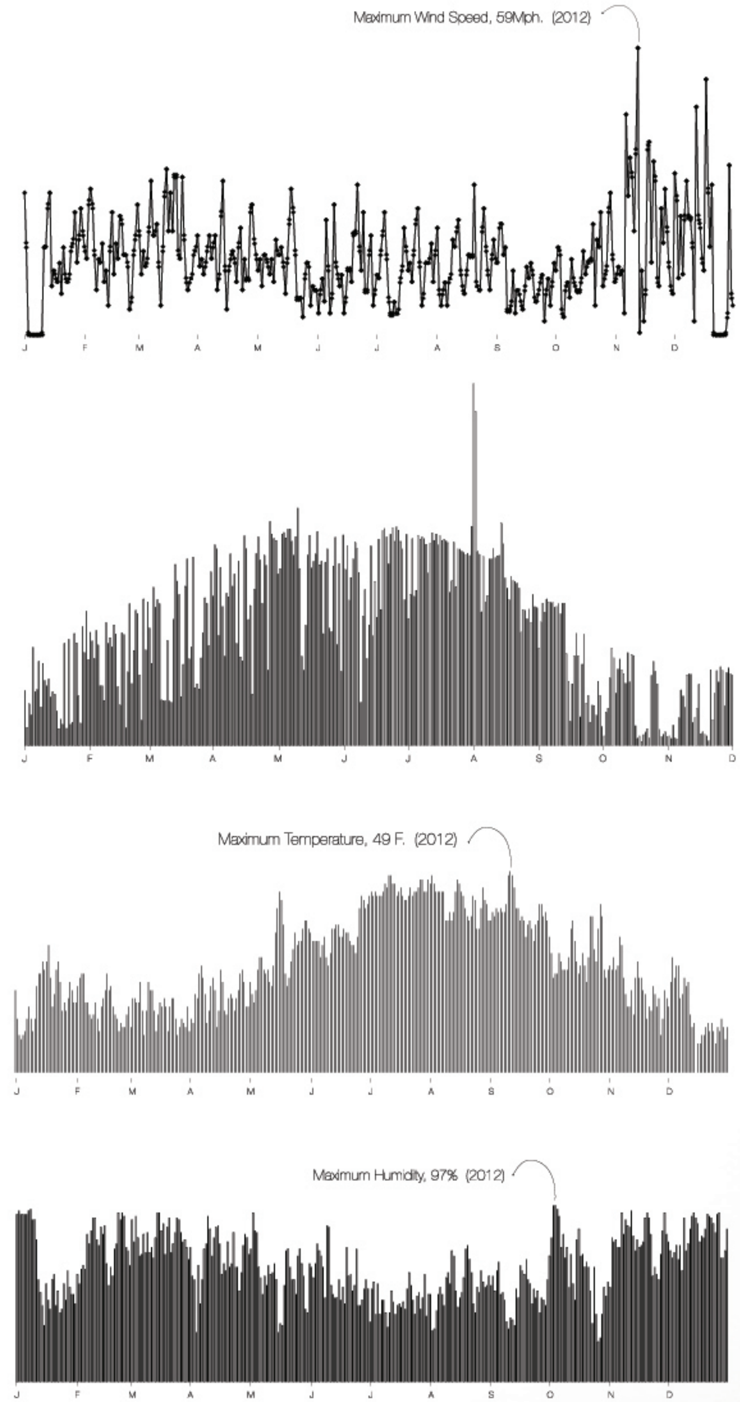


Fig. 10, 11, 12, 13, & 14.
Number of climbers, wind speed, solar irradiance, temperature, & humidity.

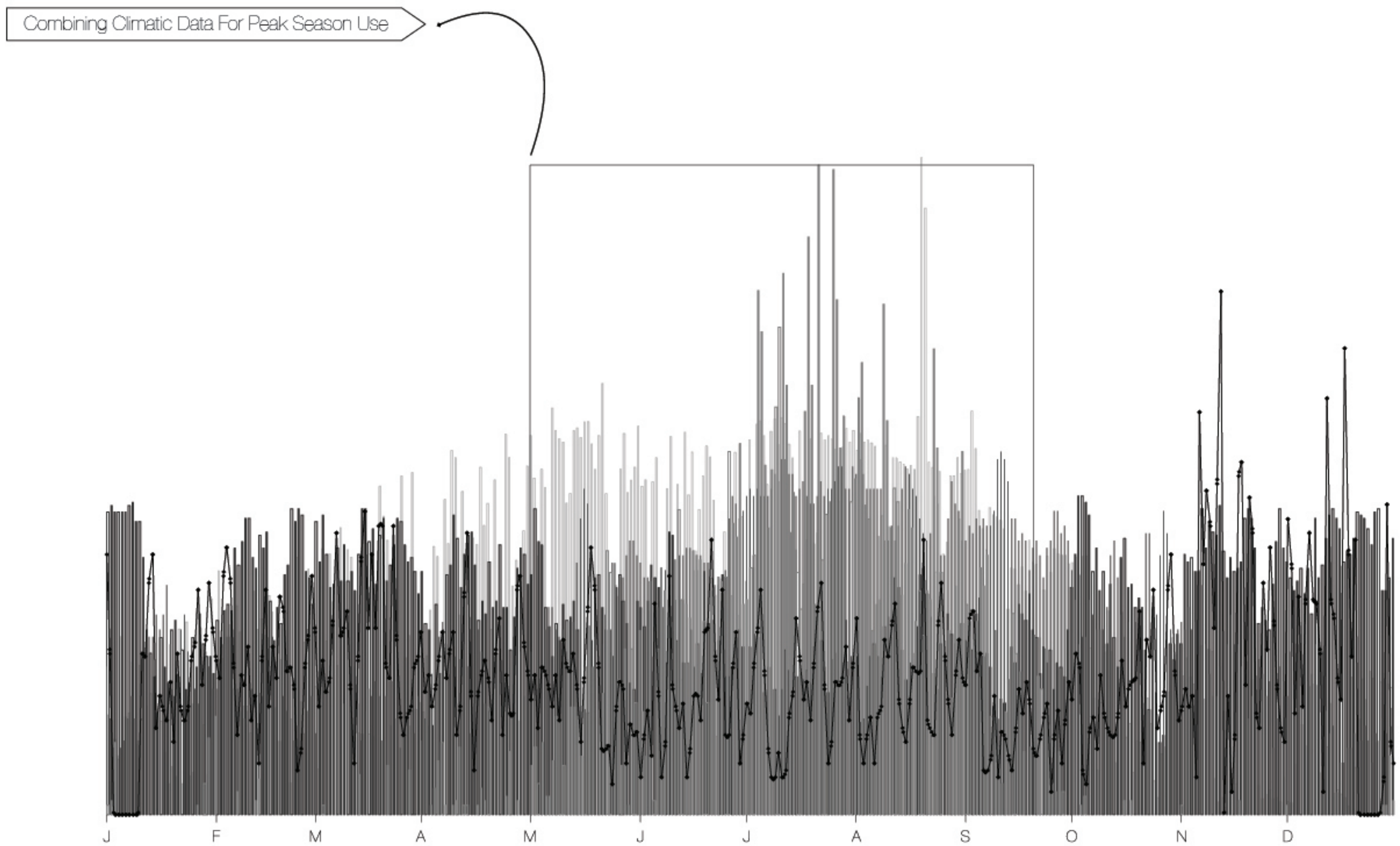


Fig. 15.
Combined weather data (2012).

Existing Site Conditions

Existing Site and Building Conditions

Camp Muir sits on an exposed rocky ridge between the Muir Snowfield on it's southern side and the Cowlitz Glacier on the north. It serves primarily as the base camp for ascents to the summit of Mount Rainier; while also serving as a destination for many day - users that climb trails from Paradise area. The existing facilities are used primarily by the public, National Park Service Rangers, and climbing guide services.

Generally, the climbing season is from May - September, with peak use in July and August. From early September, the numbers dramatically decline. With a maximum overnight capacity of 182 persons, 110 within existing structures, 36 on the Muir Snowfield, and another 36 on the Cowlitz Glacier. Peak use numbers is thought to be as high as 300 persons / day during the peak season (see Figure 3.). The large numbers of day visitors put a strain on the existing infrastructure, most critically the toilet facilities which are overwhelmed and pushed beyond their processing capacity on peak use days.

Over the years, construction at Camp Muir has been both planned and haphazard. In addition to the historic structures previously described, Rainier Mountaineering, Inc., constructed the Gombu shelter as sleeping accommodations for their clients. In 1969, the National Park Service constructed the Butler Hut, which serves the park rangers for lodging and storage. In 1986, the first solar - assisted toilet was added to the existing pit toilets. Between 1980 and 1984, much of the construction of the erosion prevention retaining walls occurred. In the early 1990's, significant efforts were undertaken to improve the existing structures, including new roofing, flooring, and additional retaining walls. Crushed rock was added to the heliport to reduce the dust and erosion caused by the rotor - wash of the helicopters.

Natural erosion processes are very severe in this harsh alpine environment. Over the years, certain parts of the ridge have lost in excess of fifteen feet of elevation, while other areas have lost only a few inches. While some of this loss is due to natural forces, human impacts and increased human use due to the popularity of climbing has accelerated the process. The loss of the fractured andesite stone scattered across the ridge, some of which was used to construct the various structures, has exposed a softer, volcanic tuff. When this soft material is exposed, and additionally walked upon by climbers (typically wearing metal crampons and plastic climbing boots), it breaks down quickly and is blown like powder onto the Cowlitz Glacier and the Muir Snowfield.

Some of the programmatic functions within the existing facilities are considered incompatible uses and are significant safety concerns. One of the biggest issues is the combination of cooking and sleeping in the same facility; separation of these functions is critical. Cooking not only creates a fire hazard, but potentially also creates carbon monoxide, a poisonous gas.[14]

Camp Muir Historic District/Mount Rainier National Historic Landmark District:

The Camp Muir Historic District encompasses the developed area at Camp Muir. The Public Shelter, Guide Shelter, and Men's Comfort Station are contributing buildings in the district, while the current Client Shelter and Butler Shelter are non-contributing.

The Historic District boundaries at Camp Muir are as follows (see Figure 16., site boundaries):

- North boundary: edge of the Cowlitz Glacier;
- South boundary: edge of the Muir Snowfield;
- East boundary: a north-south line 100 feet east of the Public Shelter; and
- West boundary: a north-south line 100 feet west of the Guide Shelter.

Existing Buildings

Historic Structures:

The historic structures were built in the early 20th - century. They are all constructed of rough stone and mortar masonry and the character of the stonework cab be described as rough at best.

Guide Shelter (1916):

Constructed first, the Guide Shelter was likely an inspiration transformed into reality by energetic and aspiring individuals who undertook construction without the benefit of tape measure or string. It is approximately nineteen - and - a - half feet by seven - and - a - half feet in interior floor space, and is a bunker - like building with a single door opening and four tiny window apertures in the north and south walls. Several notable modifications have been made to the building since construction including the addition of a small skylight and sheathing in the interior walls with an assortment of plywood sheeting over two - by - four nailers.

Public Shelter (1921):

Unlike the Guide Shelter, a higher level of planning and construction was executed.

The interior of the building measures roughly twelve feet by twenty - five feet, approximately 300 square feet, and there are two small windows in the south wall and a single door located in the west wall. The base wall thickness of the Public Shelter is about two - and - one - half feet, much less than the Guide Shelter, and the structure has a top of wall thickness approximately one - and - one - half feet.

Men's Comfort Station (1930's):

The Men's Comfort Station is the smallest of the site's historic structures, seven square feet of interior space, and is perched on the north edge of the Muir saddle above the Cowlitz Glacier. The building's location was a matter of convenience, as the aperture through which human waste passed was directed to expel material over the cliff and onto the glacier below. A companion Women's Comfort Station has long since vanished over the side and / or it's rocks incorporated into other structures. Only remnant walls remain on the northeast side of the Public Shelter

Non - Historic Structures:

The non - historic structures are wood frame buildings having dimensional lumber framing and variants of plywood for siding. The Butler Hut and outhouse buildings are engineered, architectural structures while the guide service's Gombu Shelter is ramshackle, having experienced numerous building episodes.

Butler Shelter (1960's):

The Butler Shelter is a tiny A - frame building having a floor area of approximately nine - and - one - half feet by seven feet. It is well built, resting on a cast - in - place concrete slab and masonry block foundation and with twelve - inch spacing two - by - four framed roof. Additionally, collar ties are located between every rafter pair, seven feet above the floor, and are bolted in place. The building is located adjacent to a very sensitive natural resource area.

Gombu Shelter (1960's):

The Gombu Shelter is the most problematic of the existing buildings at Camp Muir. It was originally constructed in the early days of guided service and was intended to be a temporary solution to domiciling guided public climbers. The current footprint of the building is approximately twelve feet by forty - one feet. However, the length was extended fourteen feet from the original twenty - seven feet, and the initial eight - feet height was increased through the addition of a four - foot pony wall, thus creating a twelve - foot tall interior space. Currently, Rainier Mountaineering, Inc. clients occupy the front twenty - seven feet of the building length, and the back four - teen - feet is partitioned into sleeping space for guides and dry storage.

Toilet Facilities (1980's):

The Camp Muir toilets are modular wood frame structures that resulted from expanded efforts to address increasing human waste problems on the mountain. They are modular and relatively inexpensive structures with a very limited useful life.[15]

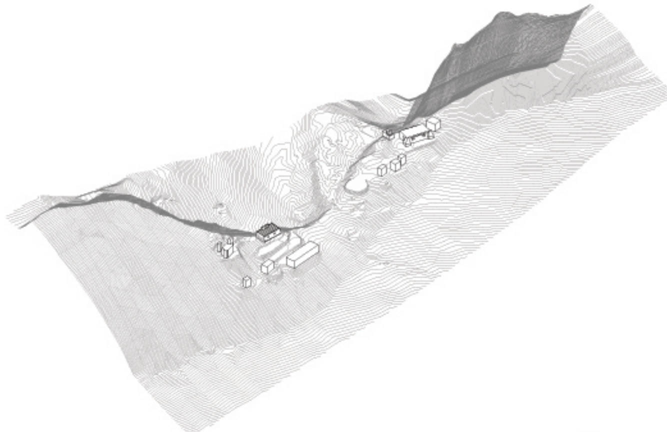
Existing Site Conditions Continued:

As the site exists now there is multiple safety and environmental concerns. The current structures do not accommodate the necessary program requirements with amount of square footage needed for storage, users, and utilities. Also of great concern are the environmental problems created by the overflow of users throughout the year, but mostly during peak season months. These problems have been created by the haphazard building approach taken at Camp Muir.

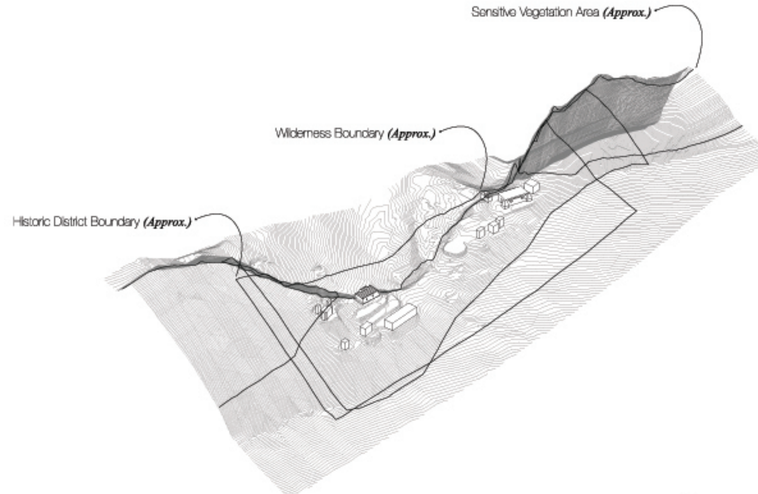
Breaking the site down and individually seeing the existing site conditions brings to light the necessary design approaches that can be executed with limited site intervention (see Figure 16.). The existing historic and non-historic buildings, site boundaries, outdoor tent areas, circulation, and existing water collection, are set in place due to the sites topography and response to climatic conditions. It should be stated again, that the existing climate was of great importance for design decision made at the site. Wind and sun position was key in the overall design process, giving rise to programmatic decisions as well as the form of the building (see Figure 17.).

Of concern was the existing user program set by the site conditions as well as by the nature of mountaineering. Sleeping, cooking, and storage are the three basic categories for users at the camp. Since the site is fragmented into a "village scheme" with limited interaction between existing structures there is a disconnect between the three main users of the site, the National Park Service, Rainier Mountaineering, INC. (Guide service), and the general public. From existing program analysis (see Figure 19.) there was an apparent need for a social input to create a link between the three main user for a social uniformity at Camp Muir.

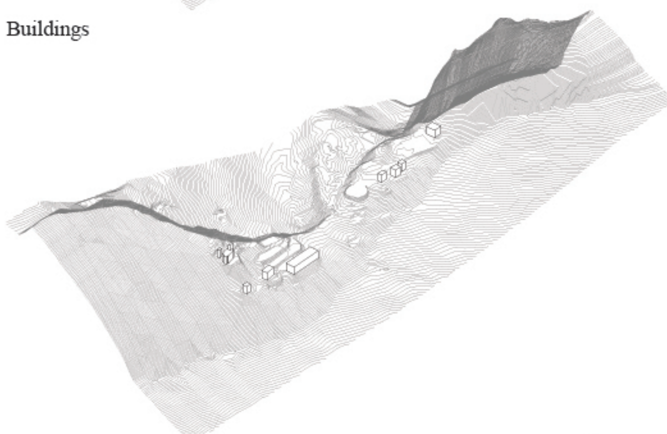
Fig, 16.
Existing site conditions.



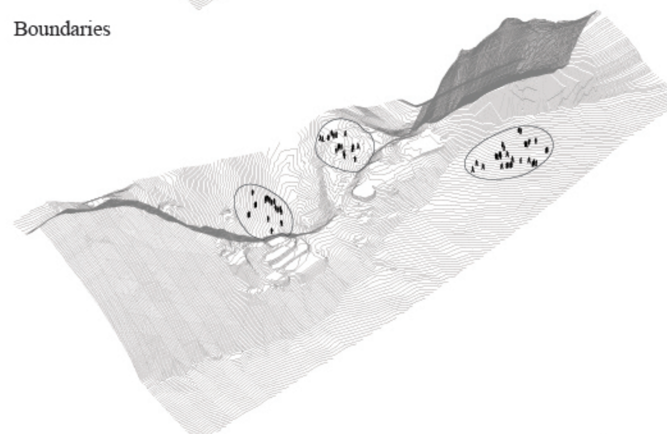
Buildings



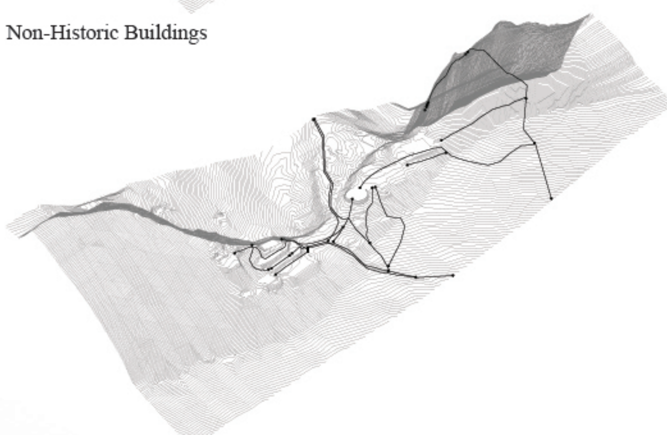
Boundaries



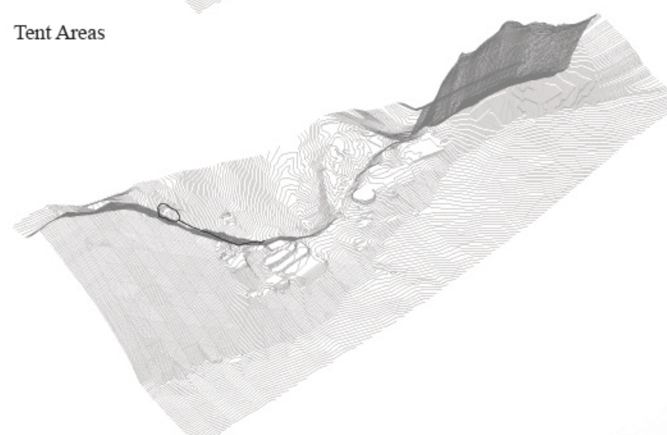
Non-Historic Buildings



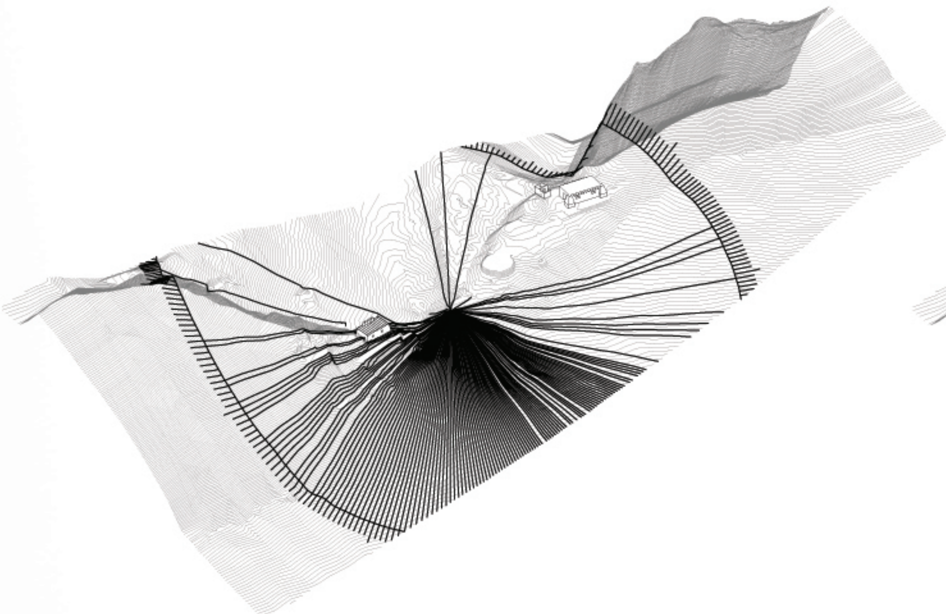
Tent Areas



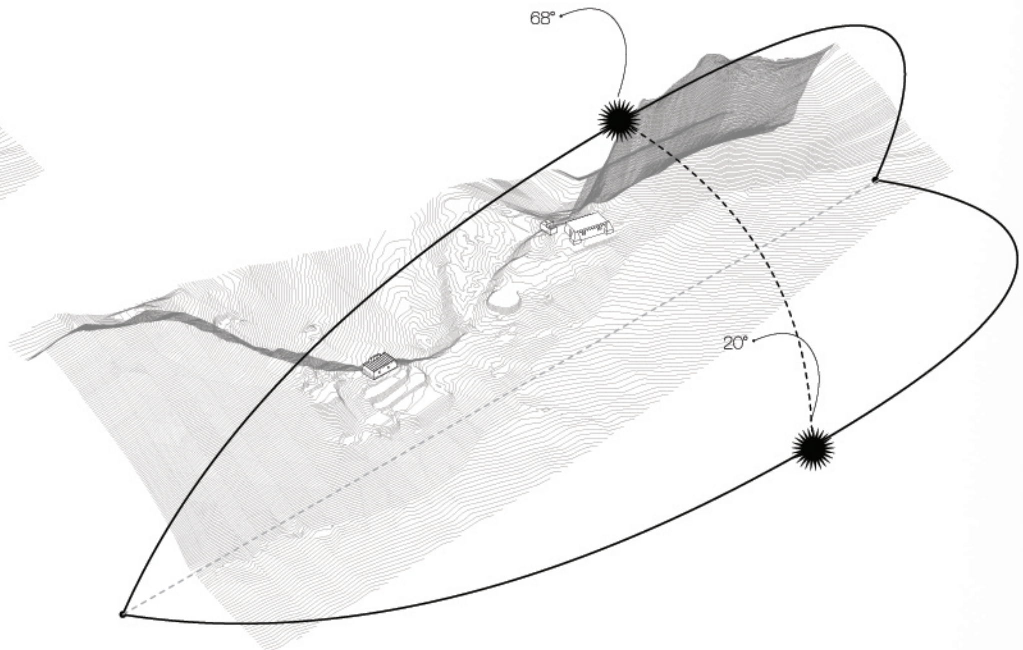
Ridge Circulation



Existing Water Collection



Wind Direction (2012)



Sun Path

Fig. 17.
Climatic conditions.

Image 25.
Camp Muir from Muir Peak.

Image 25.

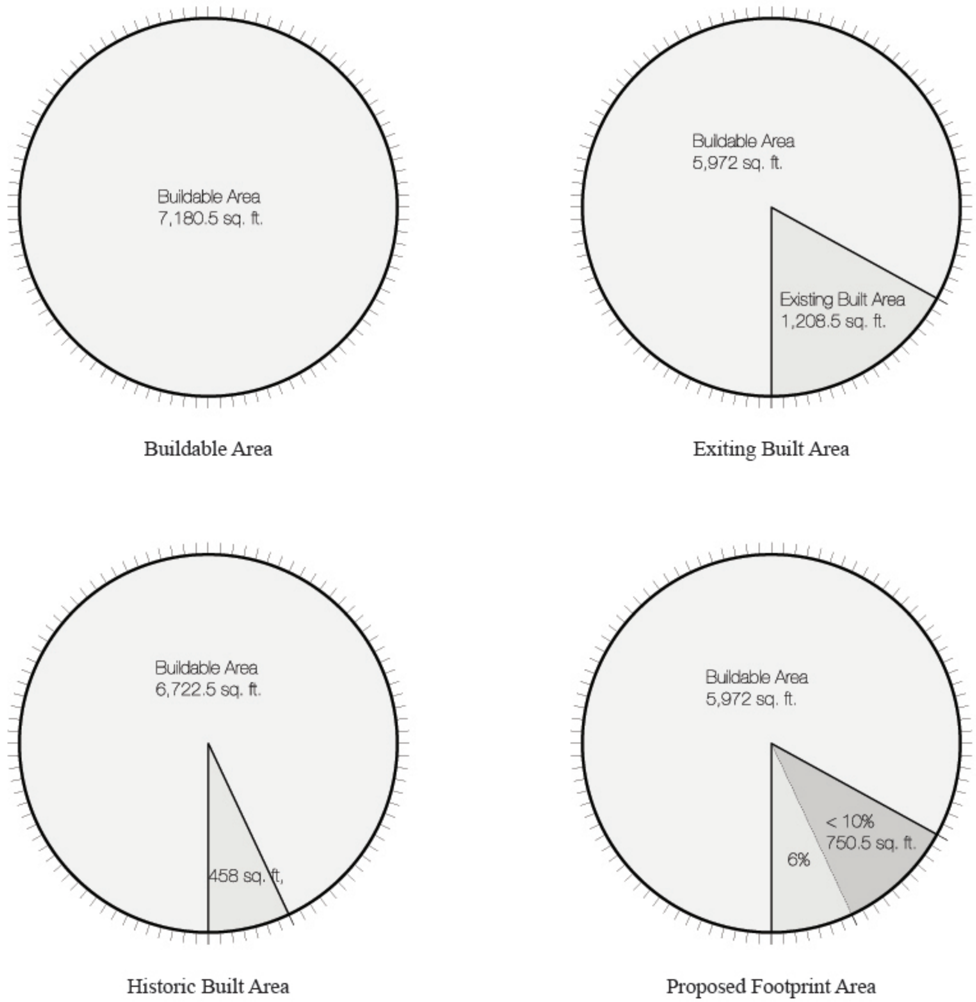


Fig. 18.
Existing built area charts.

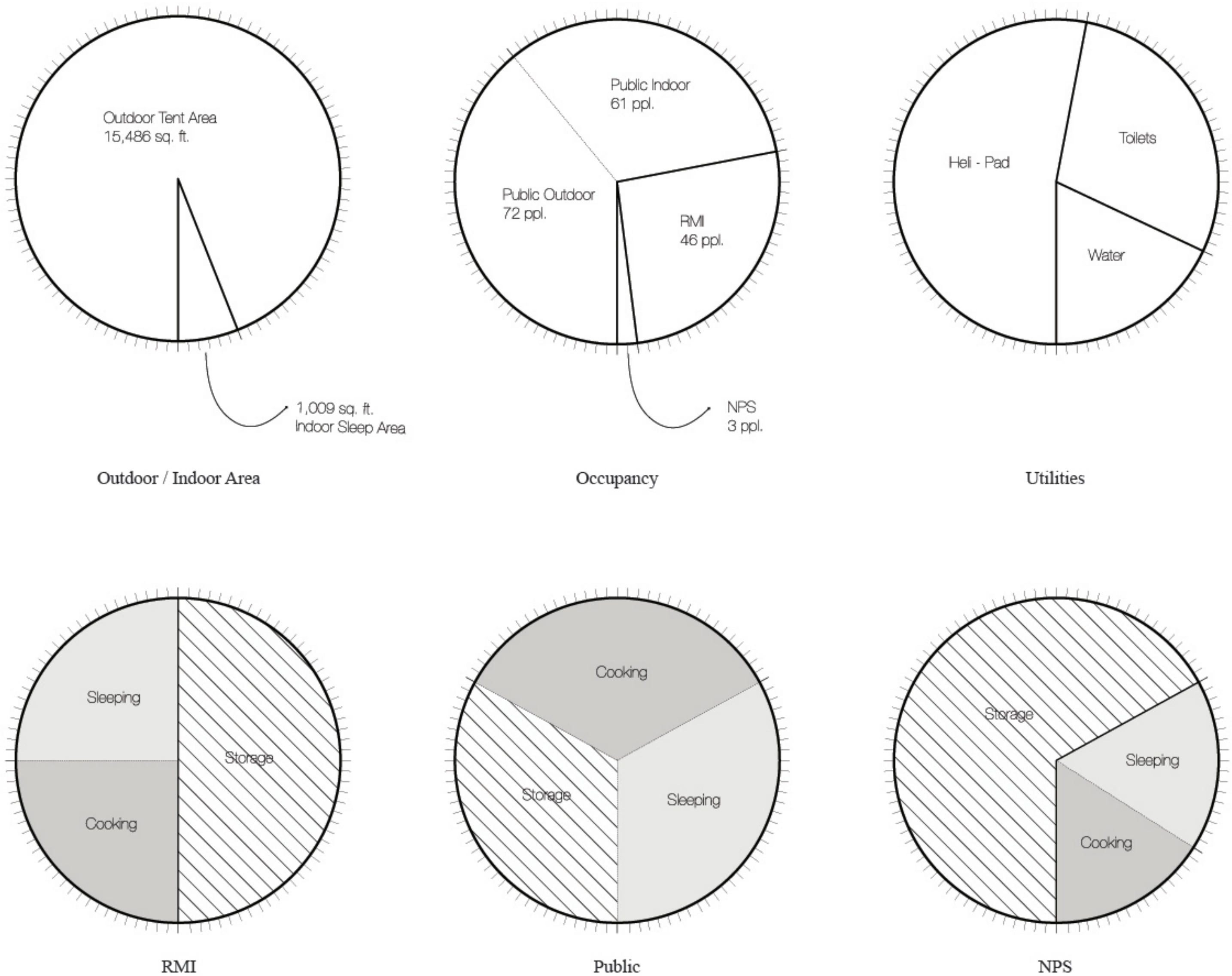
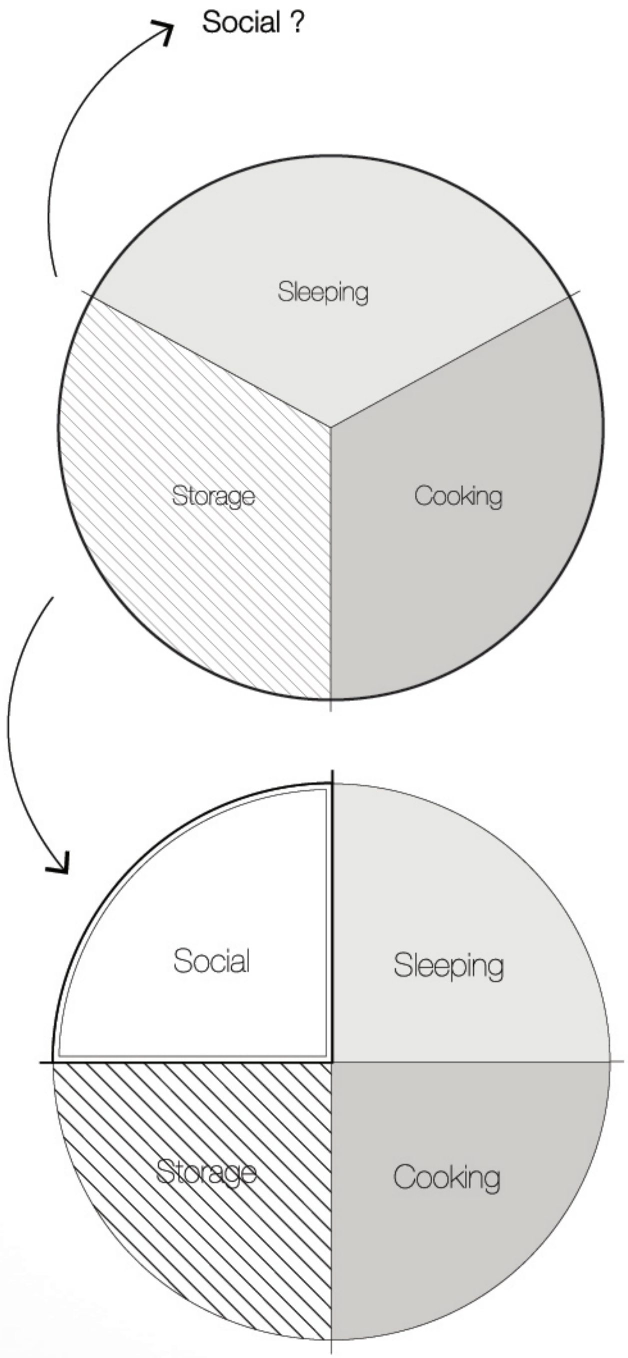


Fig. 19.
Existing program charts.

Social Intervention



From the existing program on Camp Muir it is evident that a social aspect is not present. What is found at Camp Muir presently is a disconnect between climbing parties and individual users. Though climate is a driver for this disconnect there is still no opportunity for conversation between parties when the weather permits (see Figure 21.). As stated above the typical program for a mountaineer falls into three basic categories, storage, cooking, and sleeping. These three principle program elements are found within the three main users at Camp Muir, NPS, RMI, and the public. This fragmented program calls for a intervention. A very basic intervention, one that allows for a social agenda, creating opportunity for gathering areas, kitchen areas, circulatory areas, as well as outdoor opportunities for gathering (see Figure 20.). This new social input provides a new framework and driver for a building type that accommodates the necessary program elements and more.

An approach was taken to conceptualize the new social input as a driver for arranging the necessary and required program (see Figure 22.). Taking the social input and using it as a means for circulation, kitchen facilities, and gathering spaces and placing this new formulated social mixture at the center with required program revolving around it allowed for an exciting development into creating a dynamic relationship between the existing program and its users.

Fig. 20.
Principle program elements
with a social input.

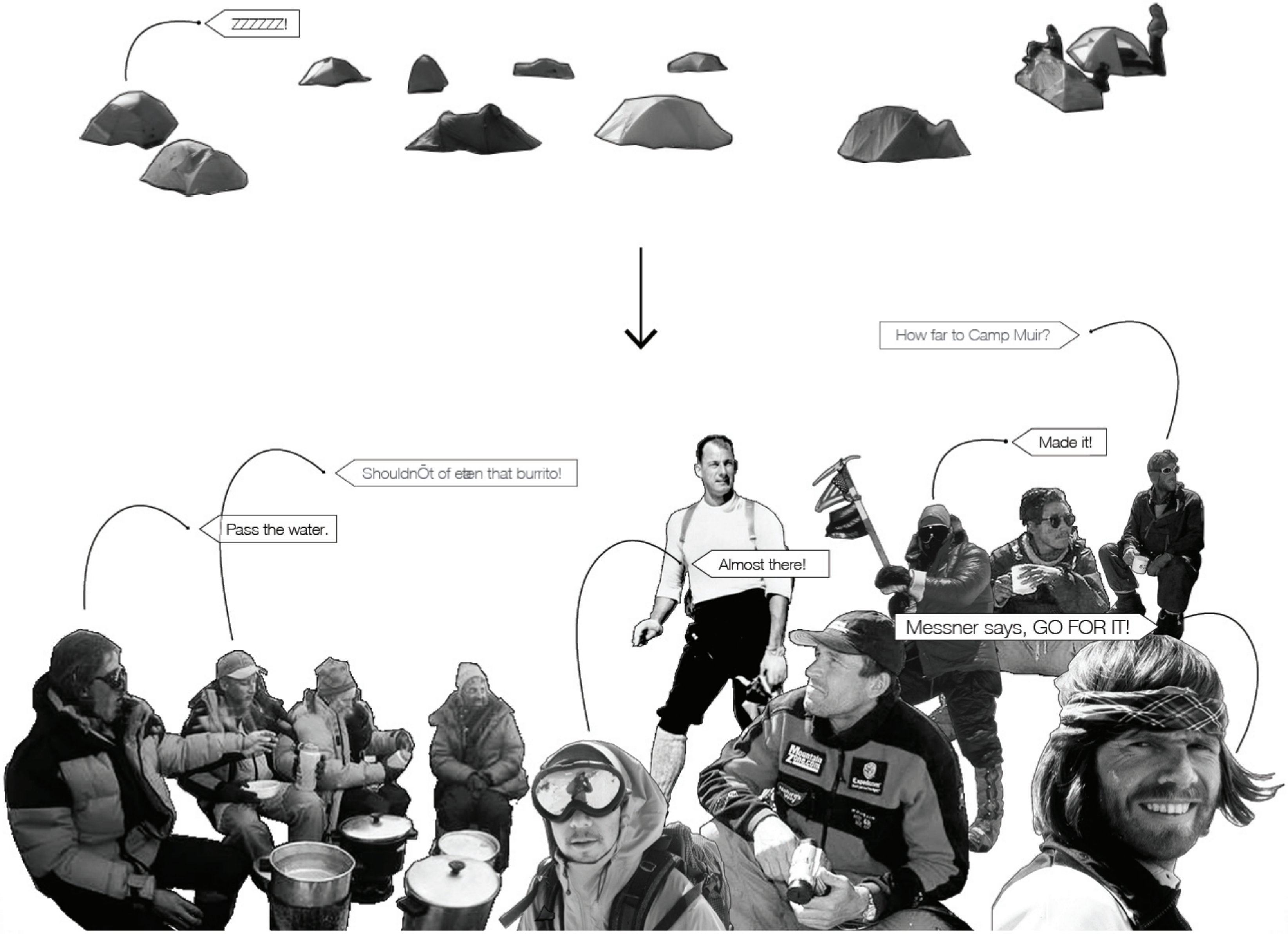


Fig. 21.
Introverted / extroverted
social diagram.

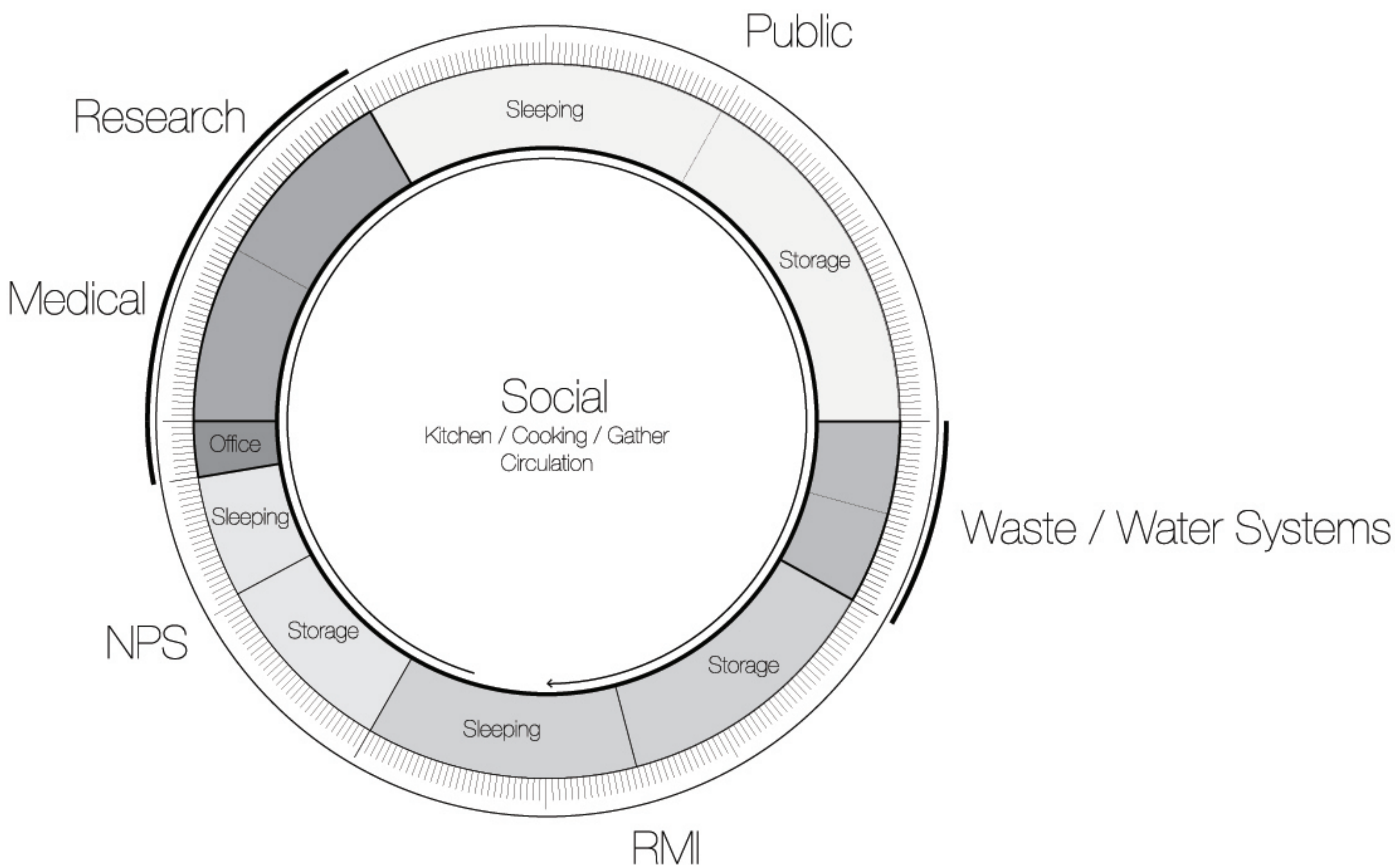


Fig. 22.
Conceptual program diagram
with a social driver.

Typology Studies

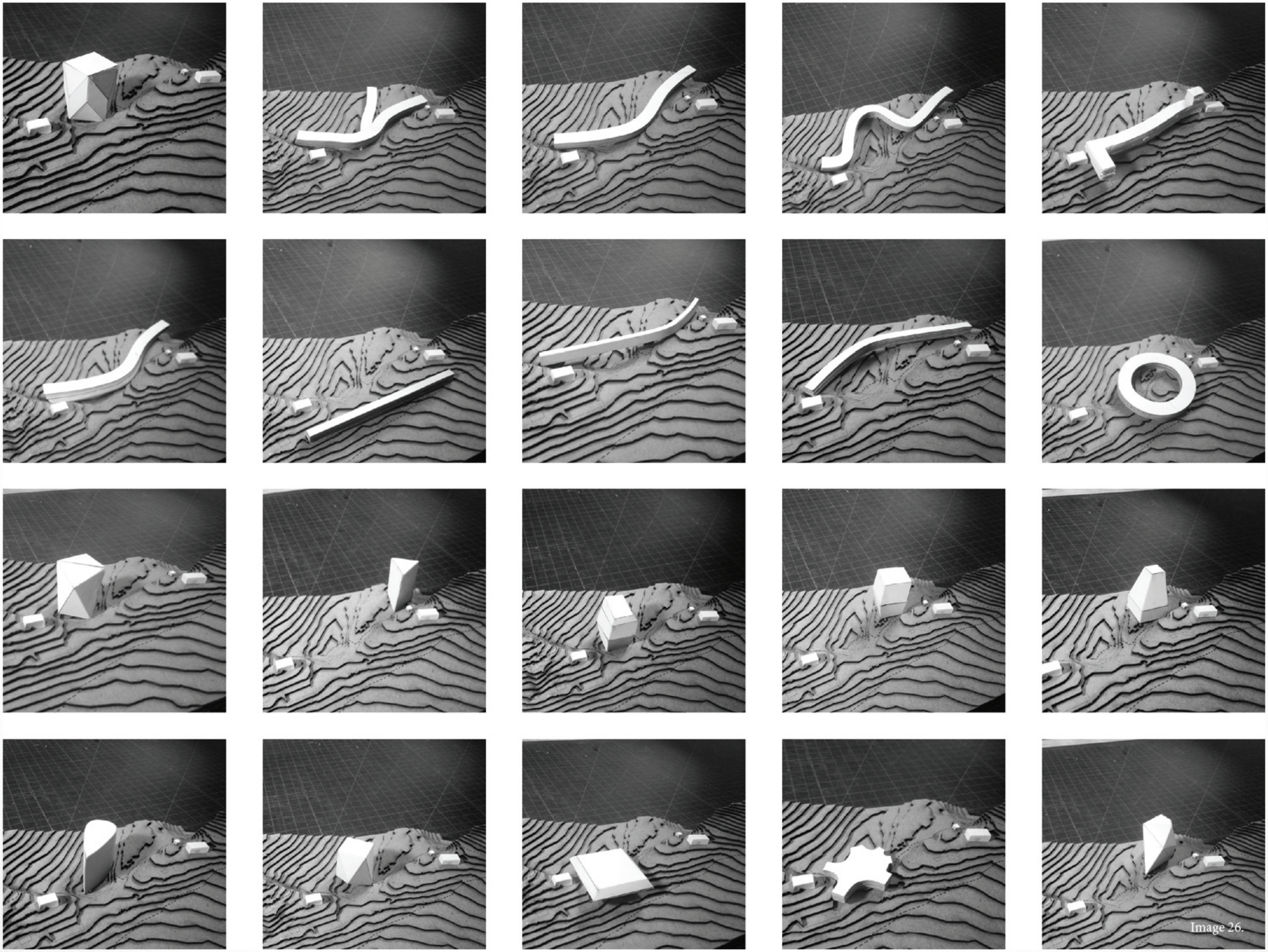


Image 26.

Compactness vs. Linearity

A basic study in form typology derived from climatic parameters, site topology, and program size was an initial step in the design process. Understanding the climatic conditions of the site, program elements needed, and influenced by alpine precedents (see section, Alpine Precedents), such as Town in the Arctic, Housing at Byker, The Refuge Tonneau, and New Monte Rosa Hut a series of models ranging from compact towers to ridge like forms were created (see Image 26.). At first a compact design seemed best. Taking into consideration the extreme climate of Camp Muir a compact approach seemed suitable for the site as well as having the ability for modularity. With further research and site specific design, variants of a ridge form began to produce results that captured the requirements needed to create an appropriate refuge for the site (see Figure 24.). Both compact and linear schemes had their advantages, but how could one scheme provide modularity, fit within the site, provide the adequate program space, allow for pre-fabricated techniques as well as modular construction, serve a social input, and work with the extreme conditions of the site.

What suited the site was the ability for a linear form to manipulate itself into the existing topography without having to disturb the site. Its ability to mold itself to the site and adapt to existing conditions gave credibility towards the linear typology and pushed the design into a playful yet complex stage (see Image 27.).

Image 26.
Typology Models in Site.

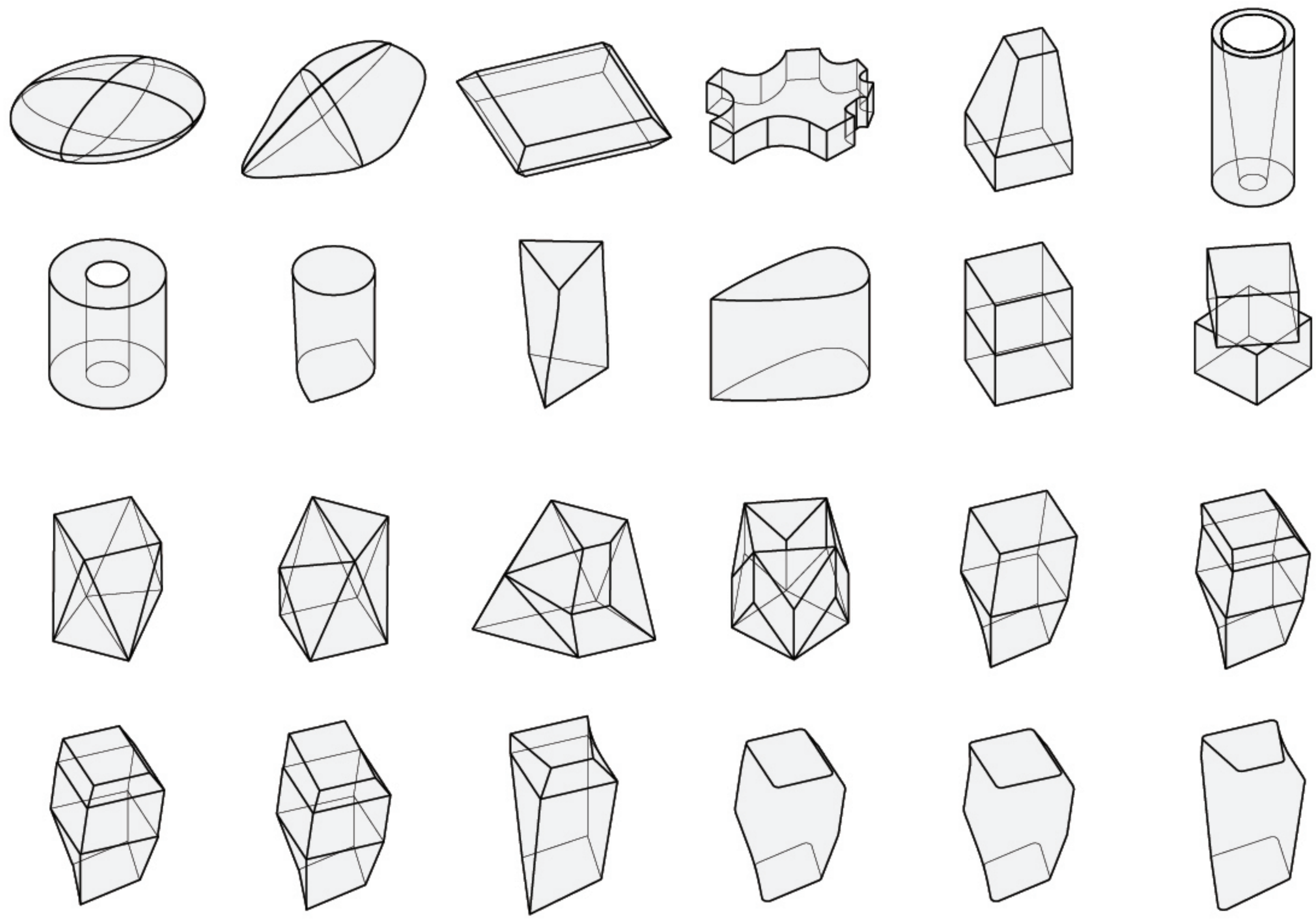


Fig. 23.
Compact typology form studies.

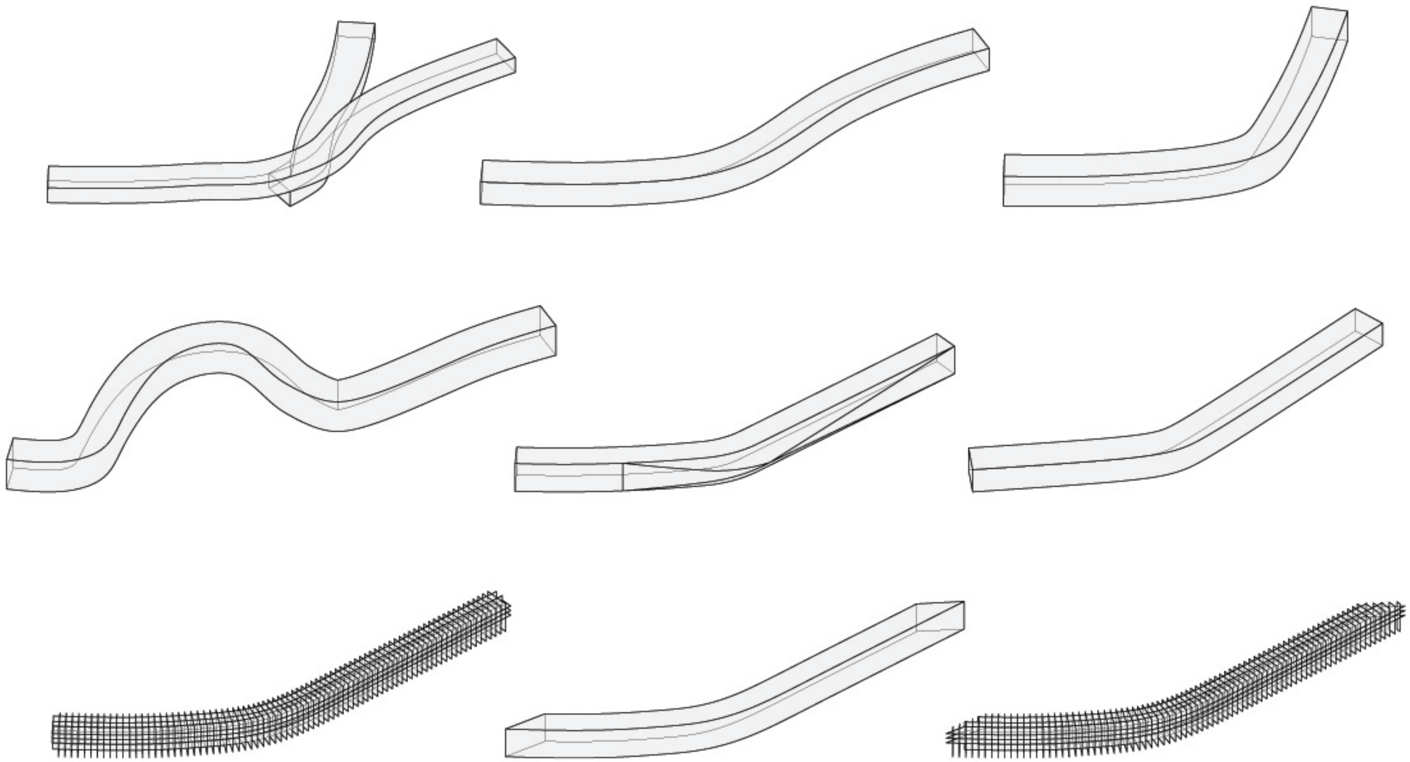


Fig. 24.
Bar typology form studies.

Image 27.
Concept Model.

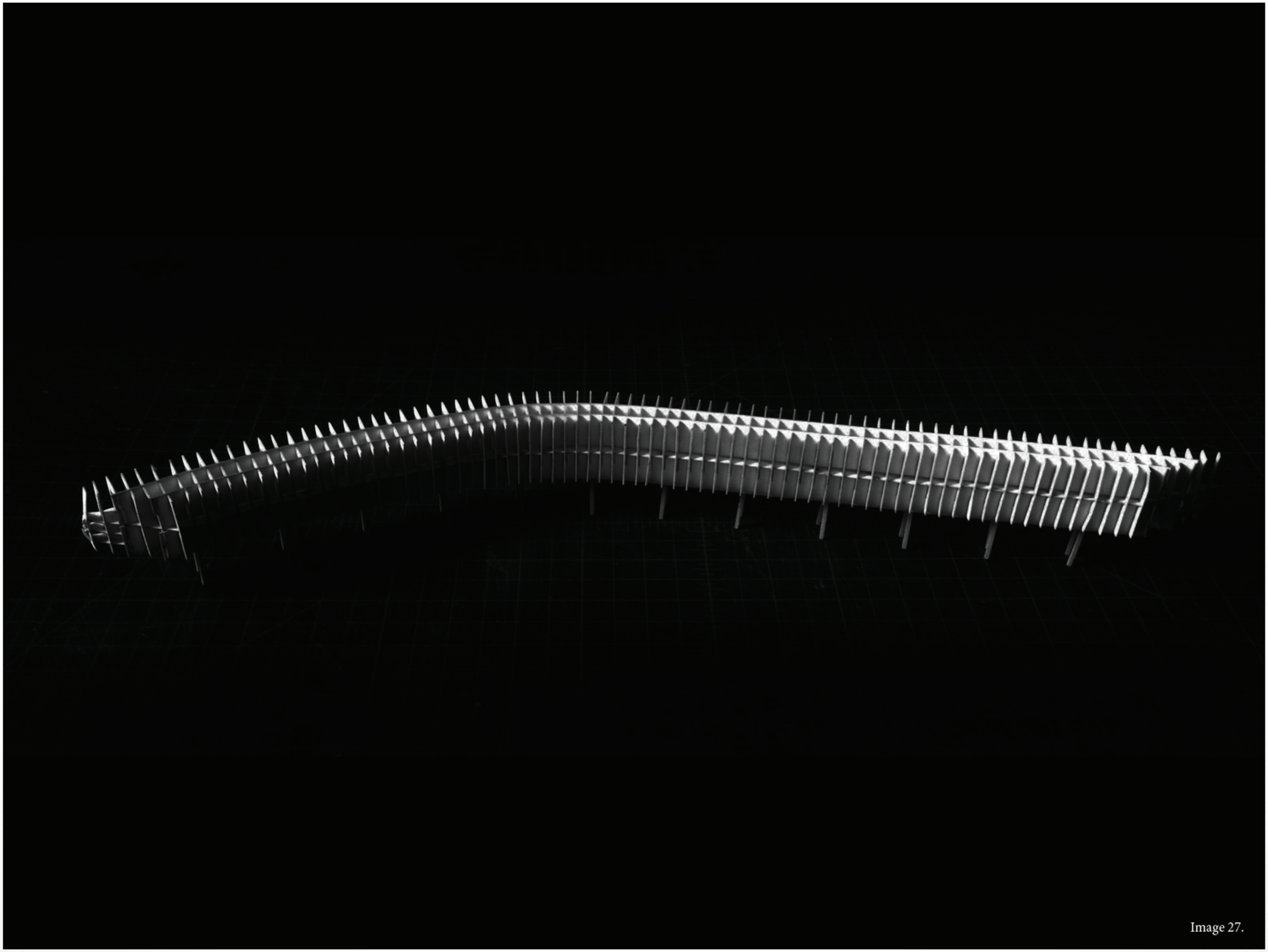


Image 27.

Embracing The Site

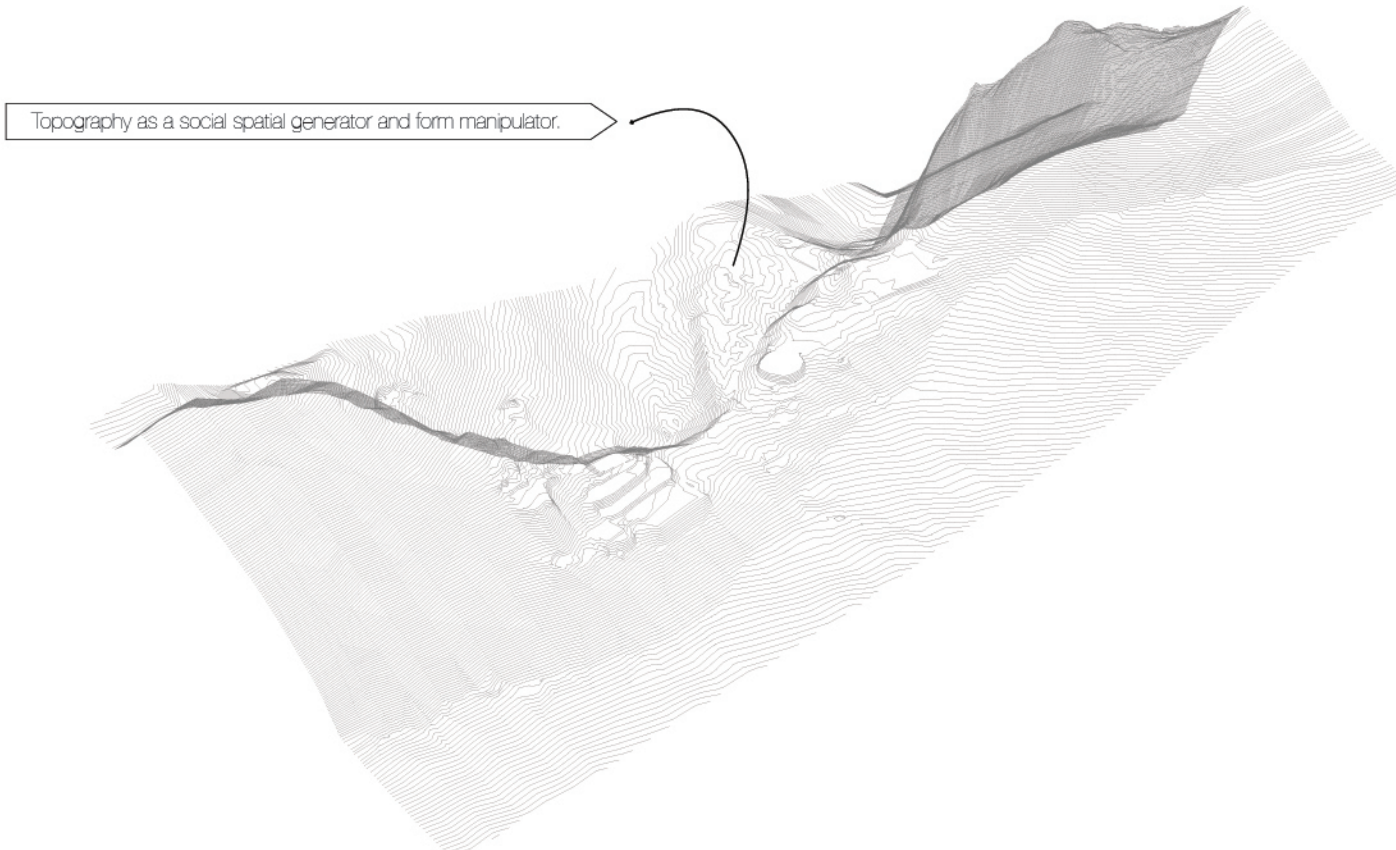


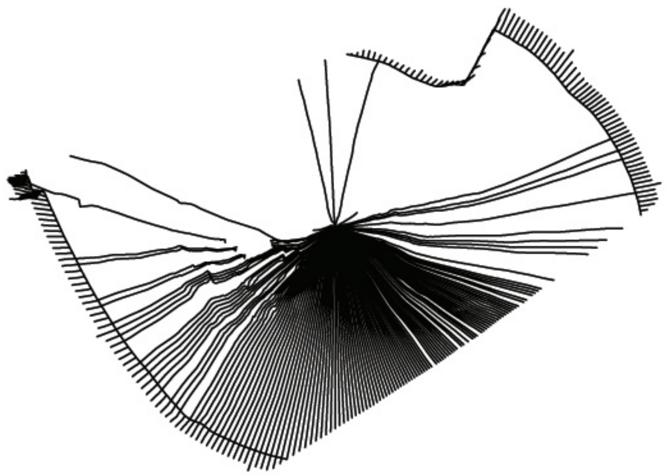
Fig. 25.
Exiting topography.

Historic Buildings

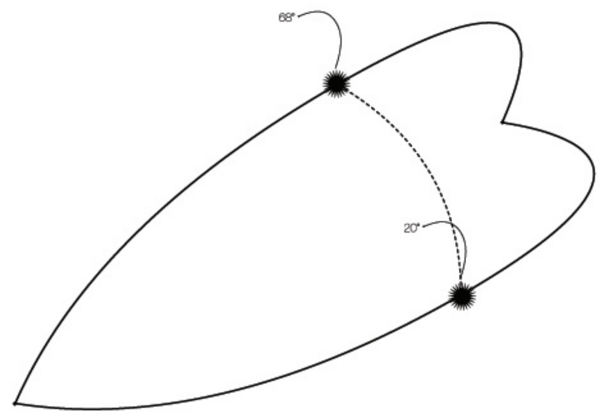
Ridge Circulation

Outdoor Tent Areas

Water Collection



Wind Direction



Solar Position

Fig. 26.
Existing site influences.

	Existing Buildings	Sq. Ft.	Use
*** Historic Buildings**	Public Shelter	304	Public
	Guide Shelter (Cook Shelter)	147	Public
	Men©Comfort Shelter	7	NPS
Non - Historic Buildings	Butler Shelter	66.5	NPS
	NPS Seasonal Structure	126	NPS
	Gombu Shelter	492	RMI
	Toilets	241	Public
	Buildable Area	7,180	

* Historic Buildings Remain

Existing Program	Sq. Ft.
Ranger Sleeping	66.5
Ranger Cooking	N/A
Ranger Storage	200
Guide Service Sleeping	242
Guide Service Cooking	N/A
Guide Service Storage	250
* Public Sleeping	16
* Public Cooking	N/A
* Public Storage	6
Outdoor Tent Area	15,486
Heli - Pad	442
Toilets	241
Water System	147

* Based on The North Face Mountain 25 Tent

Proposed Program	Sq. Ft.
Ranger Sleeping (6)	100
Ranger Cooking	N/A
Ranger Storage	200
Guide Service Sleeping (46)	800
Guide Service Cooking	N/A
Guide Service Storage	500
* Public Sleeping (133)	2,200
* Public Cooking	N/A
* Public Storage	750
Heli - Pad	442
Ranger Office / Entrance	100
Day Use Gathering Area	2,000
Research Facility	600
Meical Facility	300
Water System	200
Waste System	300
Circulation4	,025
Mechanical System (10%)	1,207.5
Building Footprint<	10%
Total	12,075

Branch	Occupancy
NPS	6
RMI	10 with 3 groups of 12
Public	133
Total	185

Fig. 27.
Program comparison analysis.

Image 28.

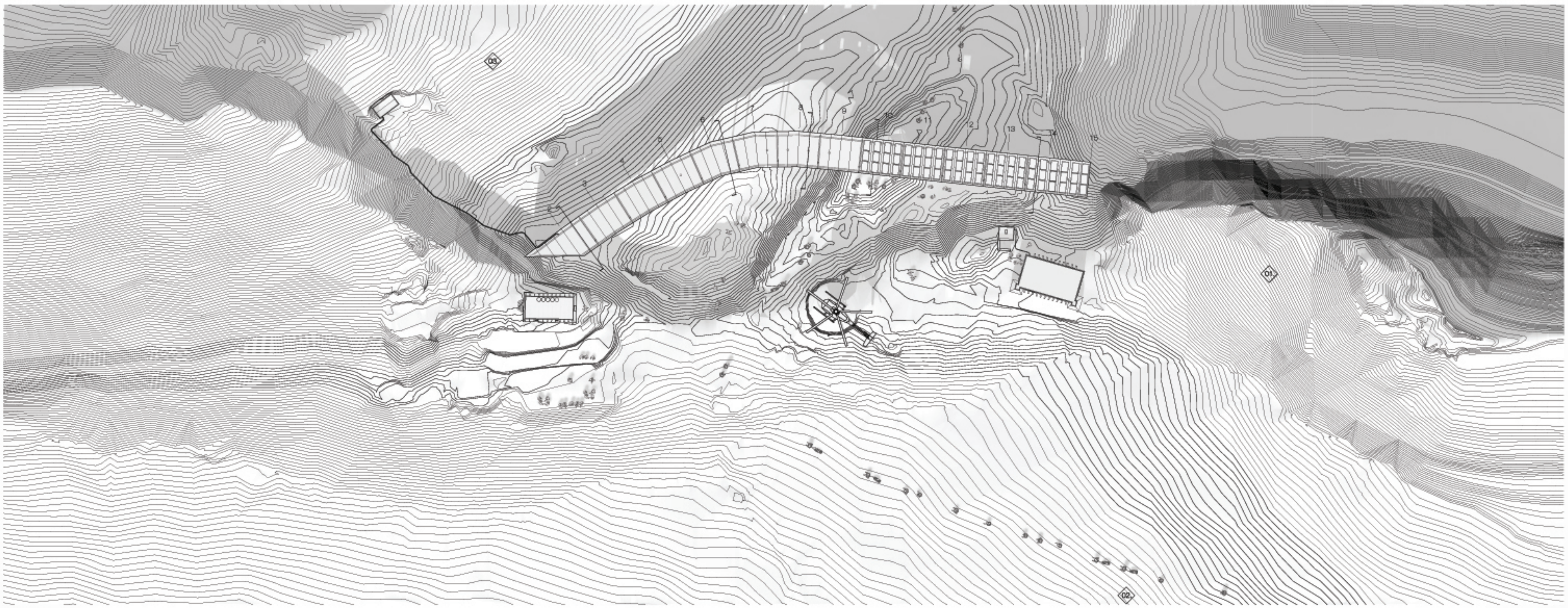


Fig. 28.
Site plan.

Image 29.
View from Muir Snow field.


Image 29.

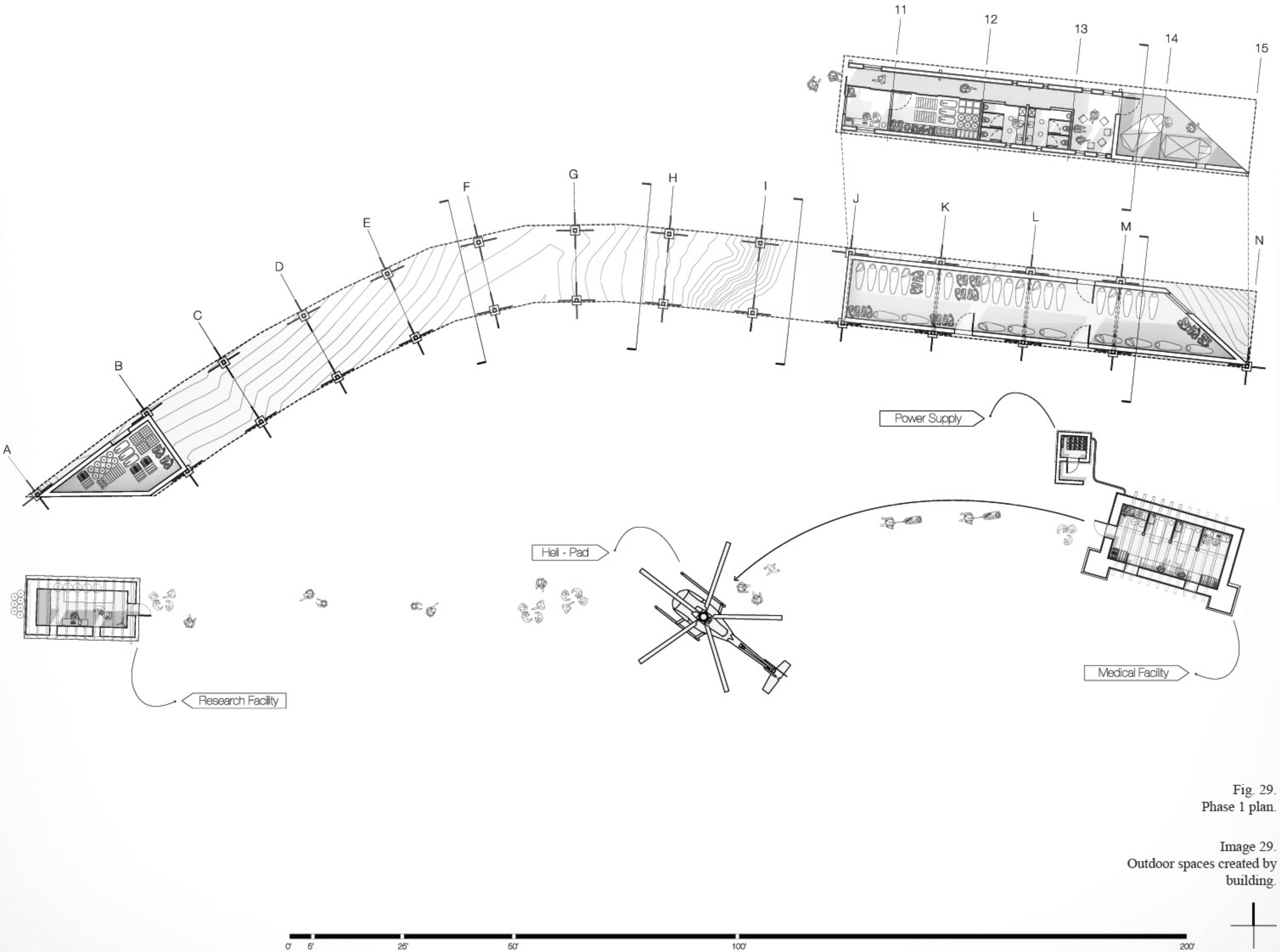


Fig. 29.
Phase 1 plan.

Image 29.
Outdoor spaces created by building.

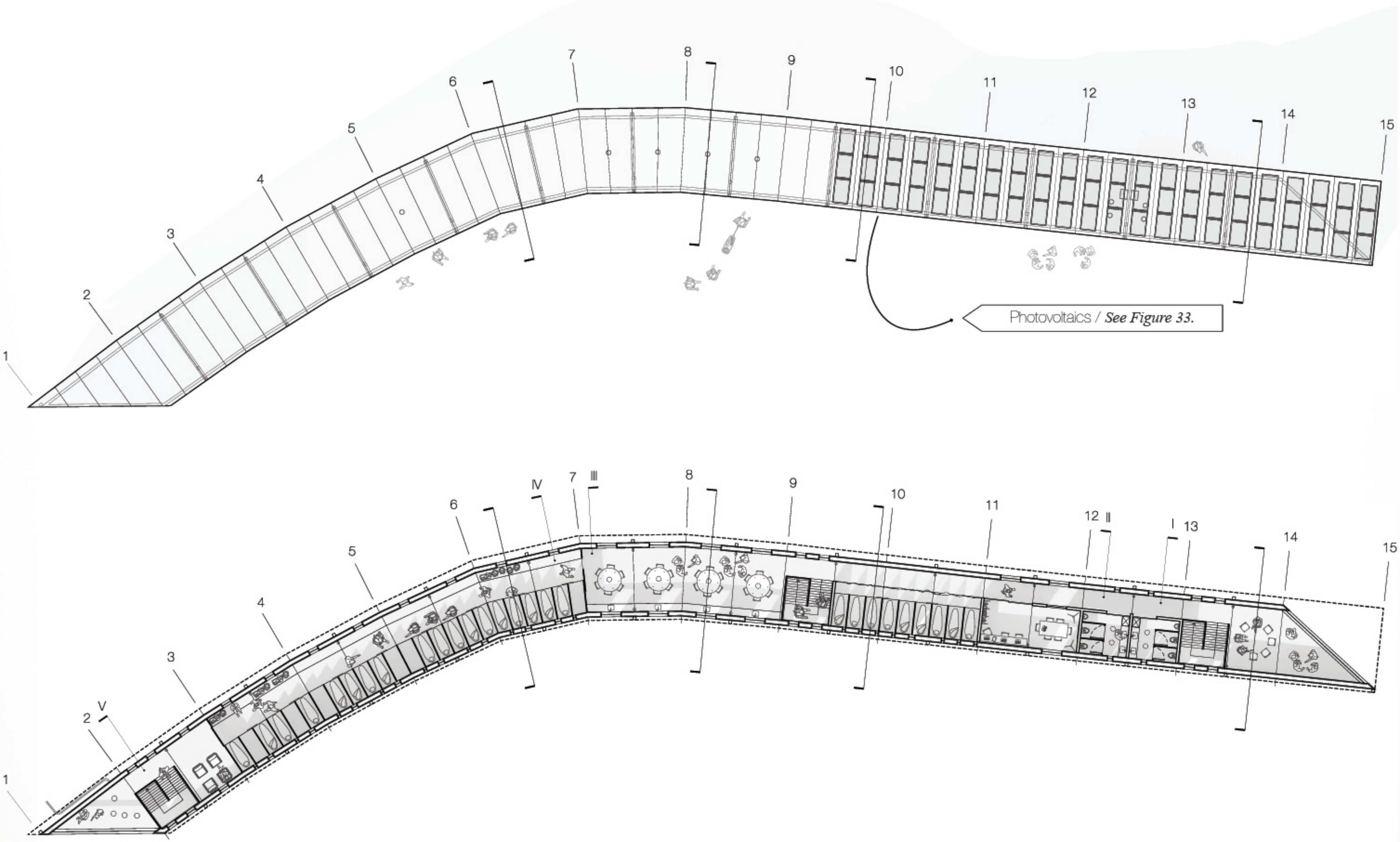


Fig. 30.
Roof plan (above), second
floor plan (below).

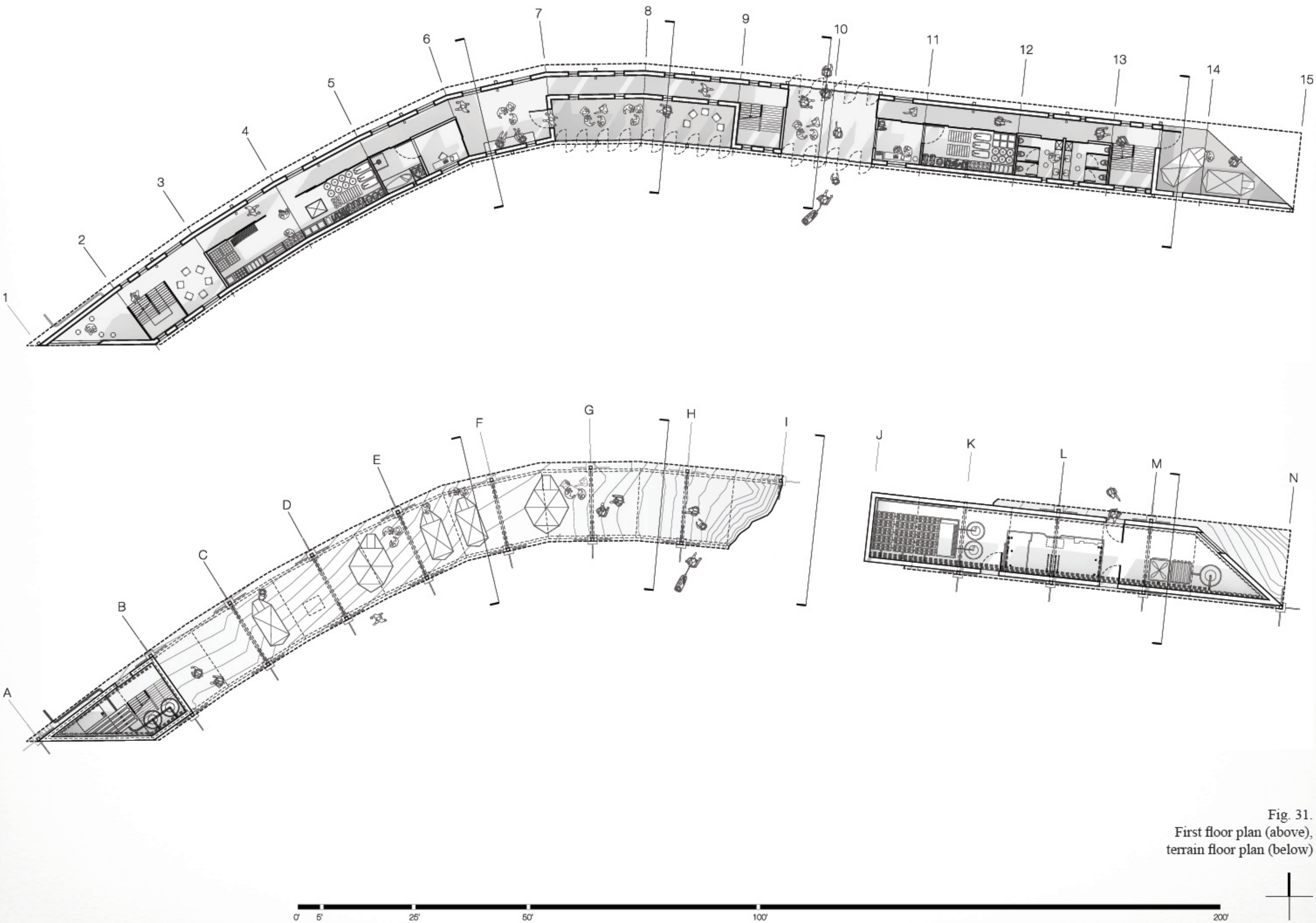
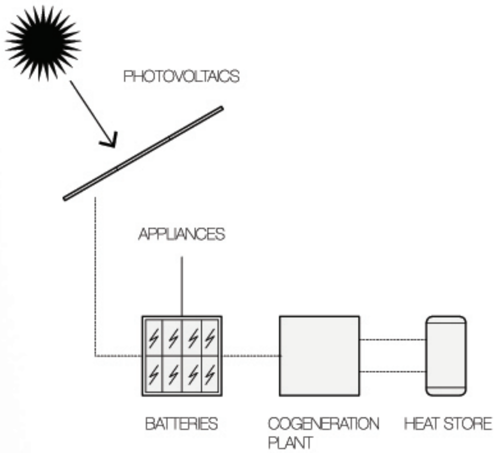
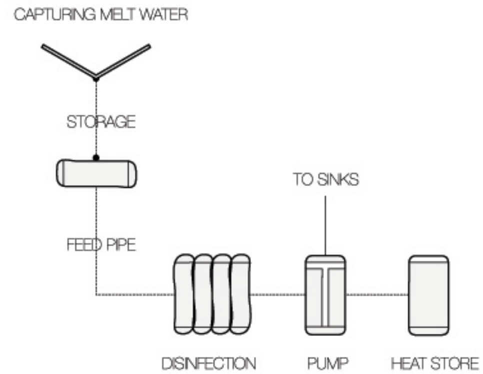


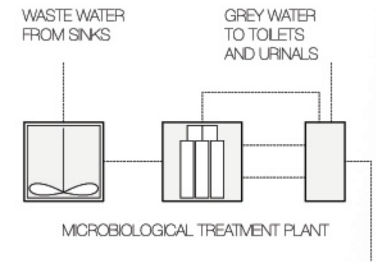
Fig. 31.
First floor plan (above),
terrain floor plan (below)



Electricity



Water



Grey Water

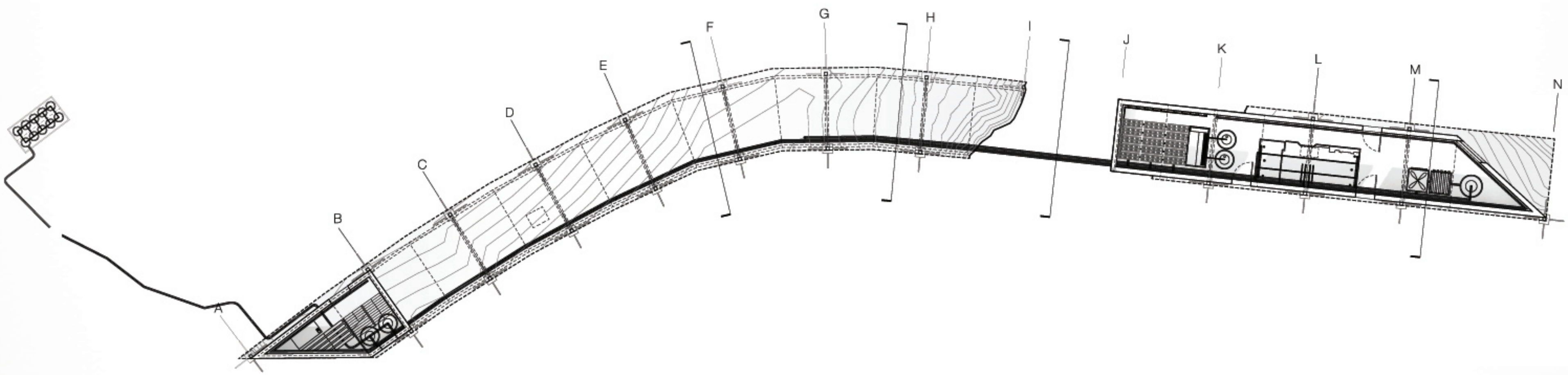


Fig. 32.
Utility diagrams & phase 2, mechanical plan.

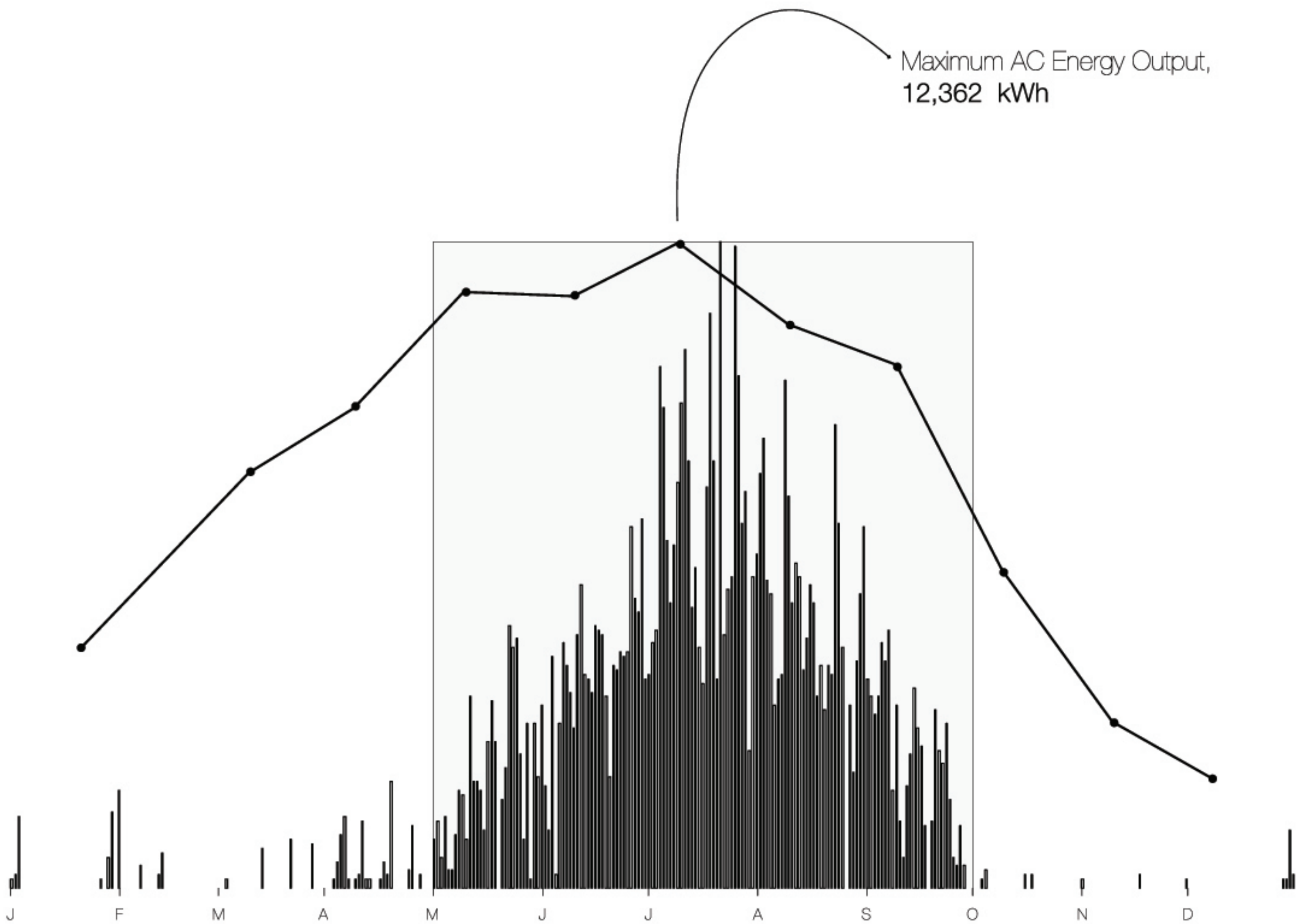


Fig. 33.
kWh per year produced by
the buildings photovoltaics.

Image 30.

Image 31.

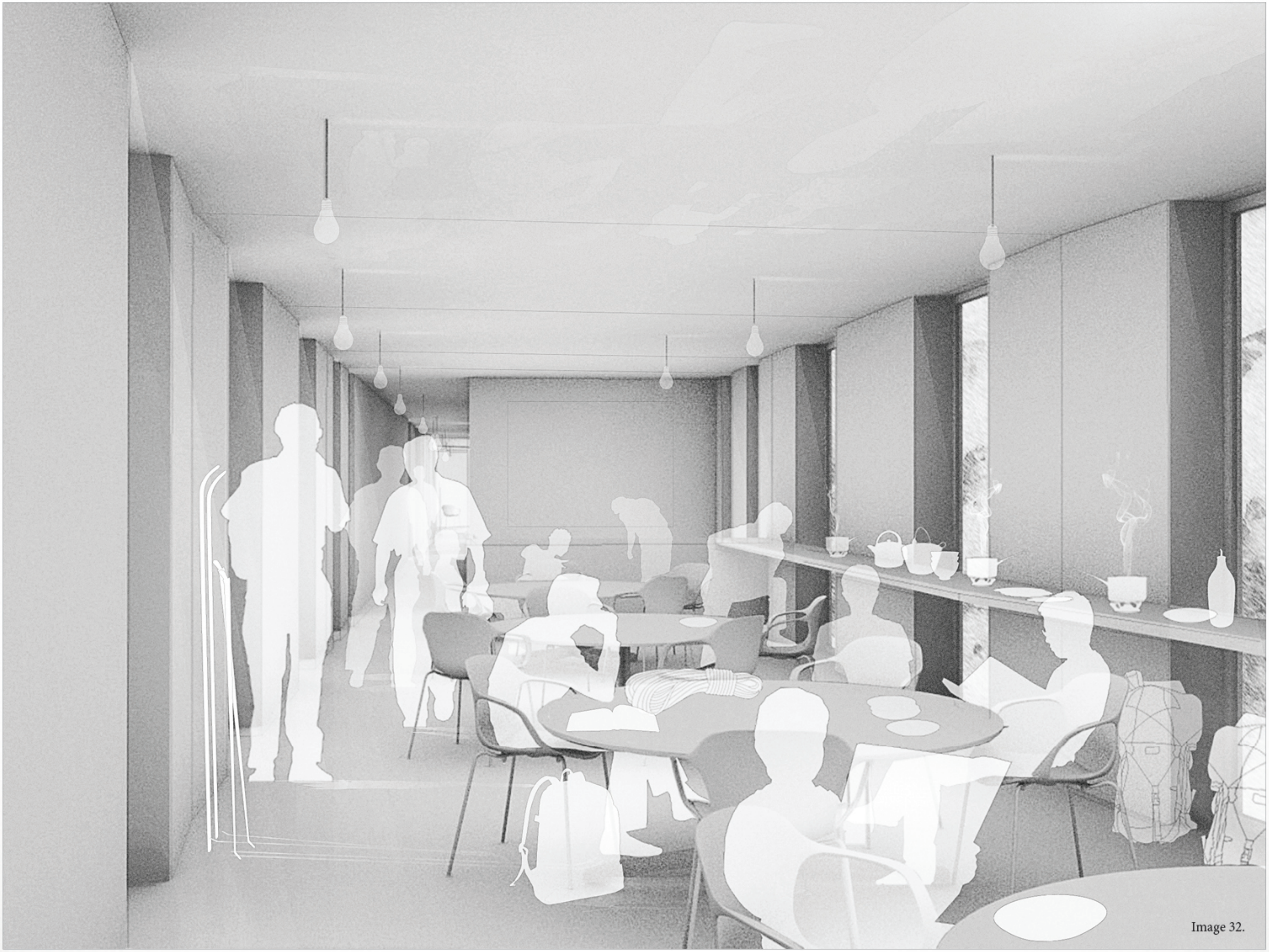


Image 32.

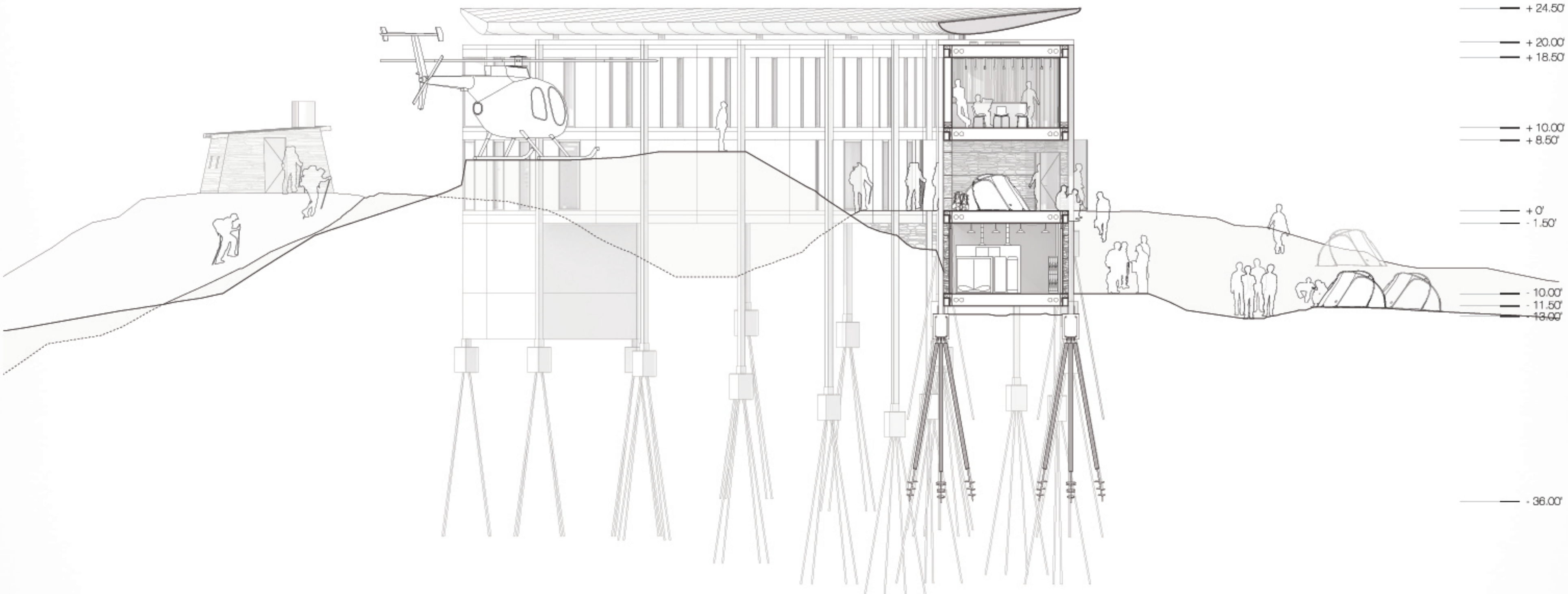


Fig. 34.
Section showing gathering space, outdoor tent area, and mechanical room.

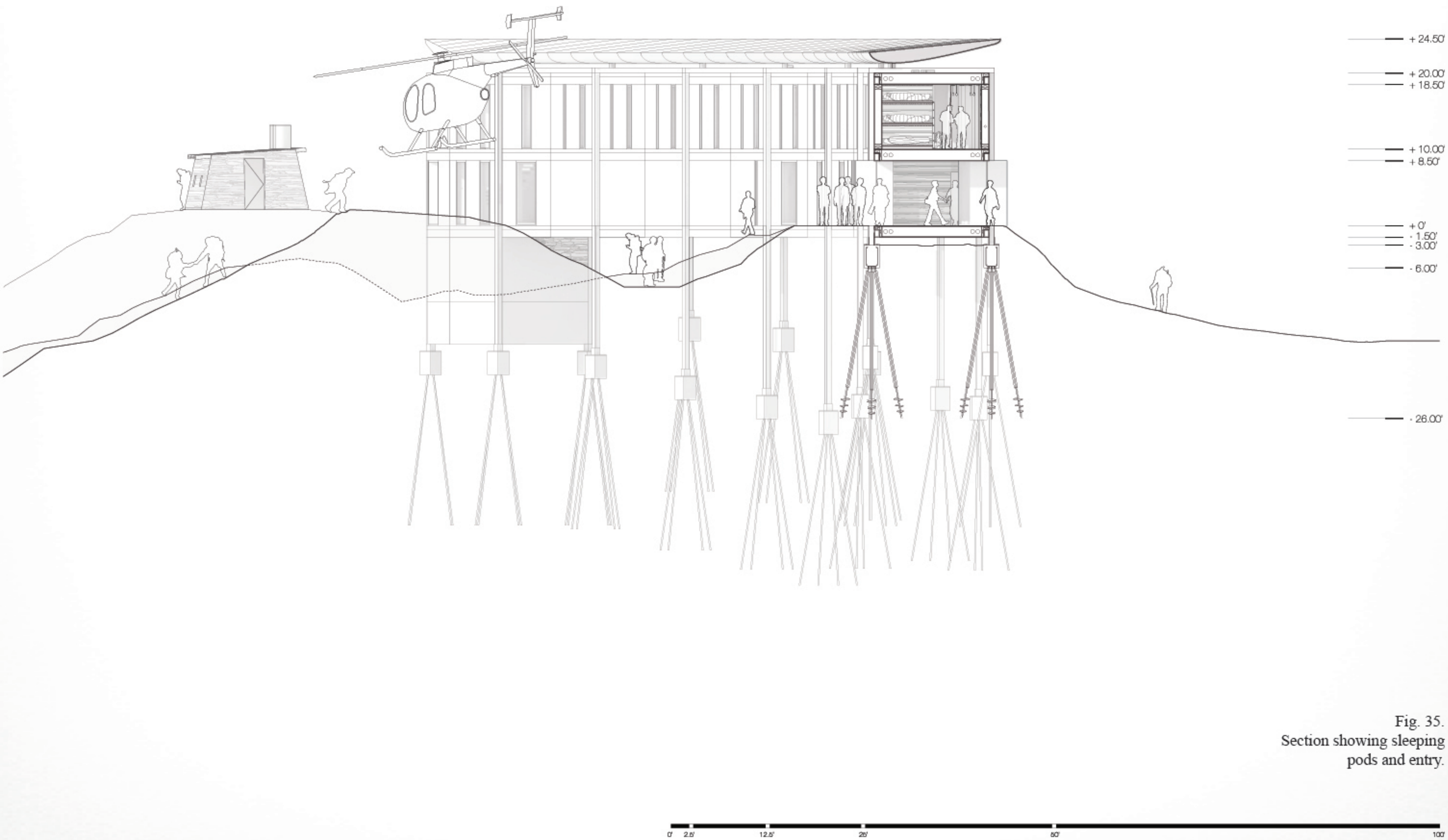


Fig. 35.
Section showing sleeping pods and entry.

Image 33.

Image 34.

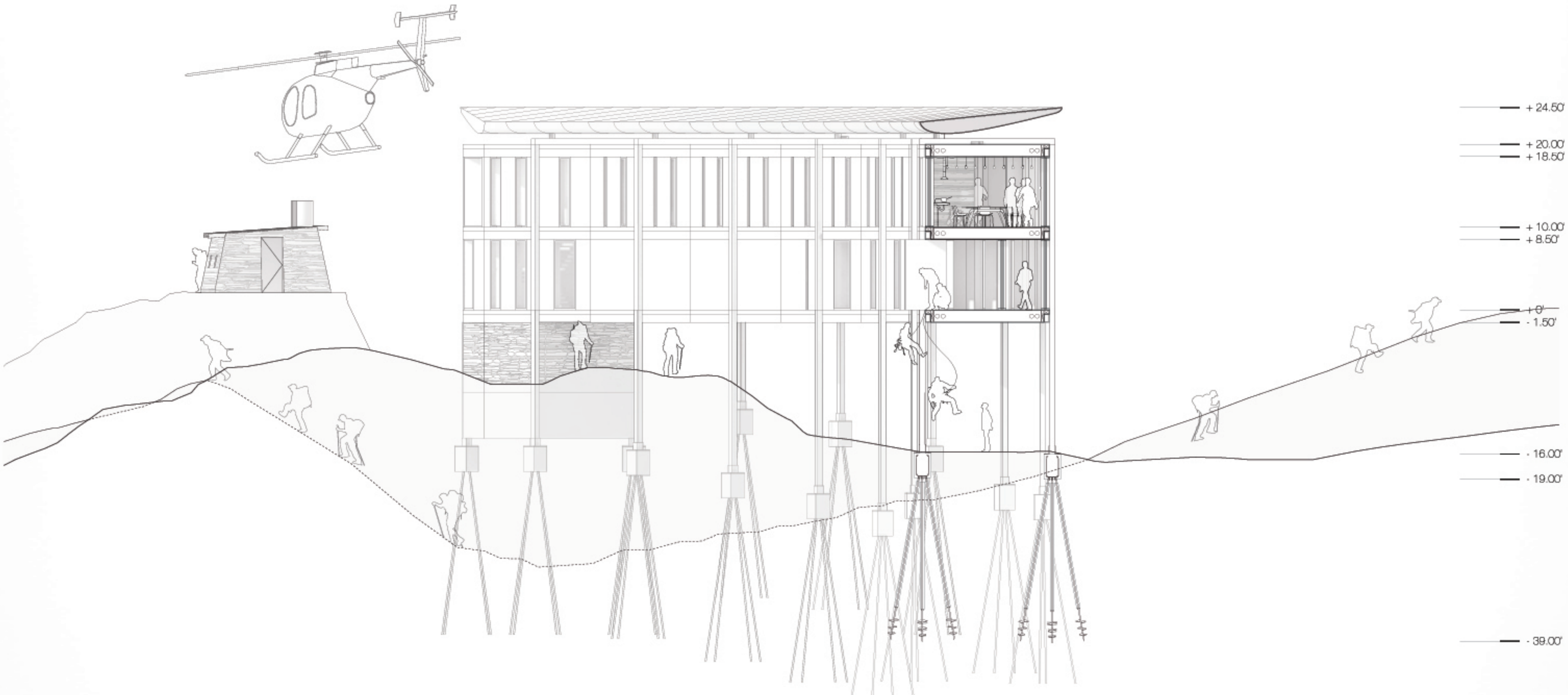


Fig. 36.
Section showing kitchen / social area and outdoor terrace.

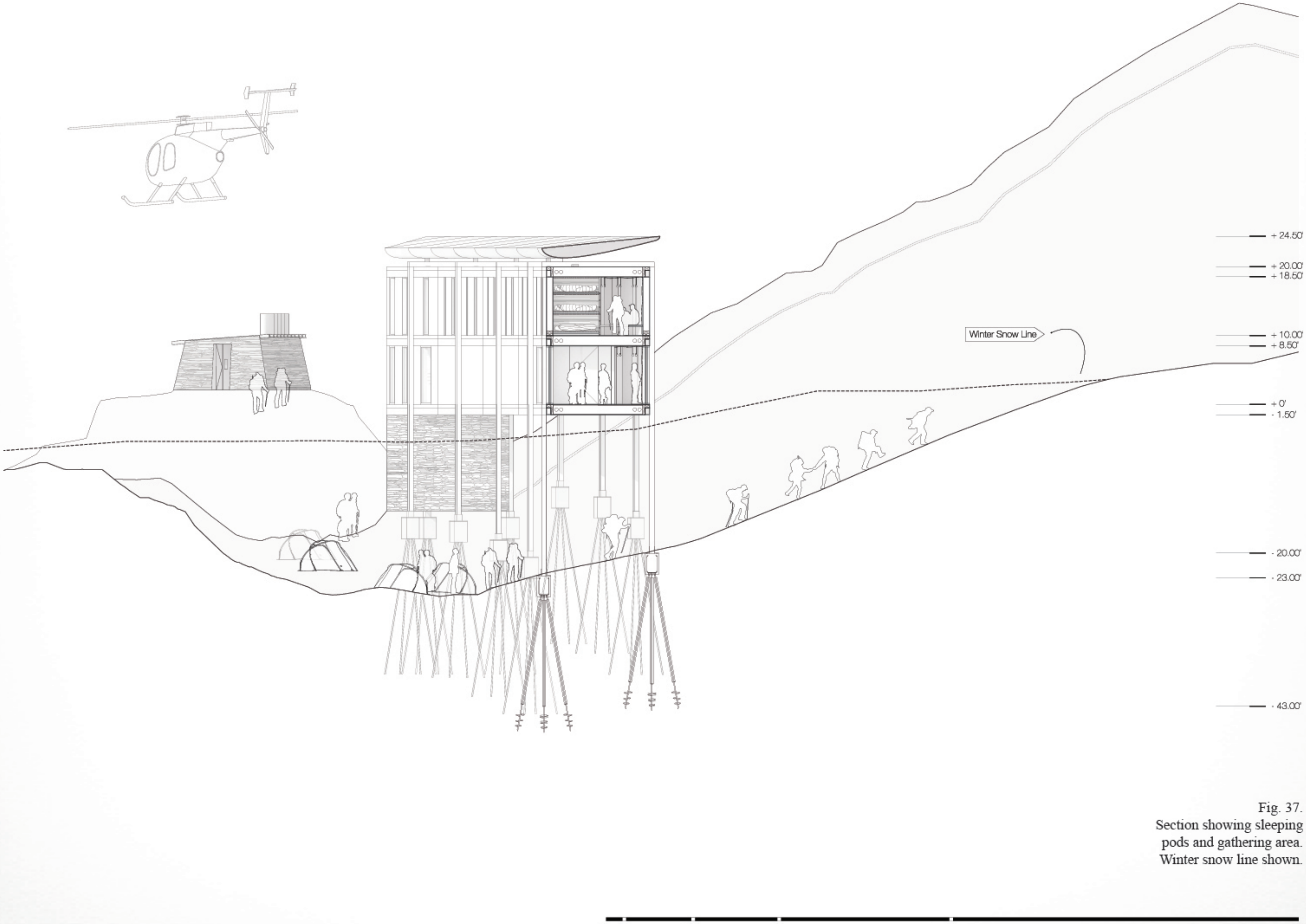


Fig. 37.
Section showing sleeping pods and gathering area. Winter snow line shown.

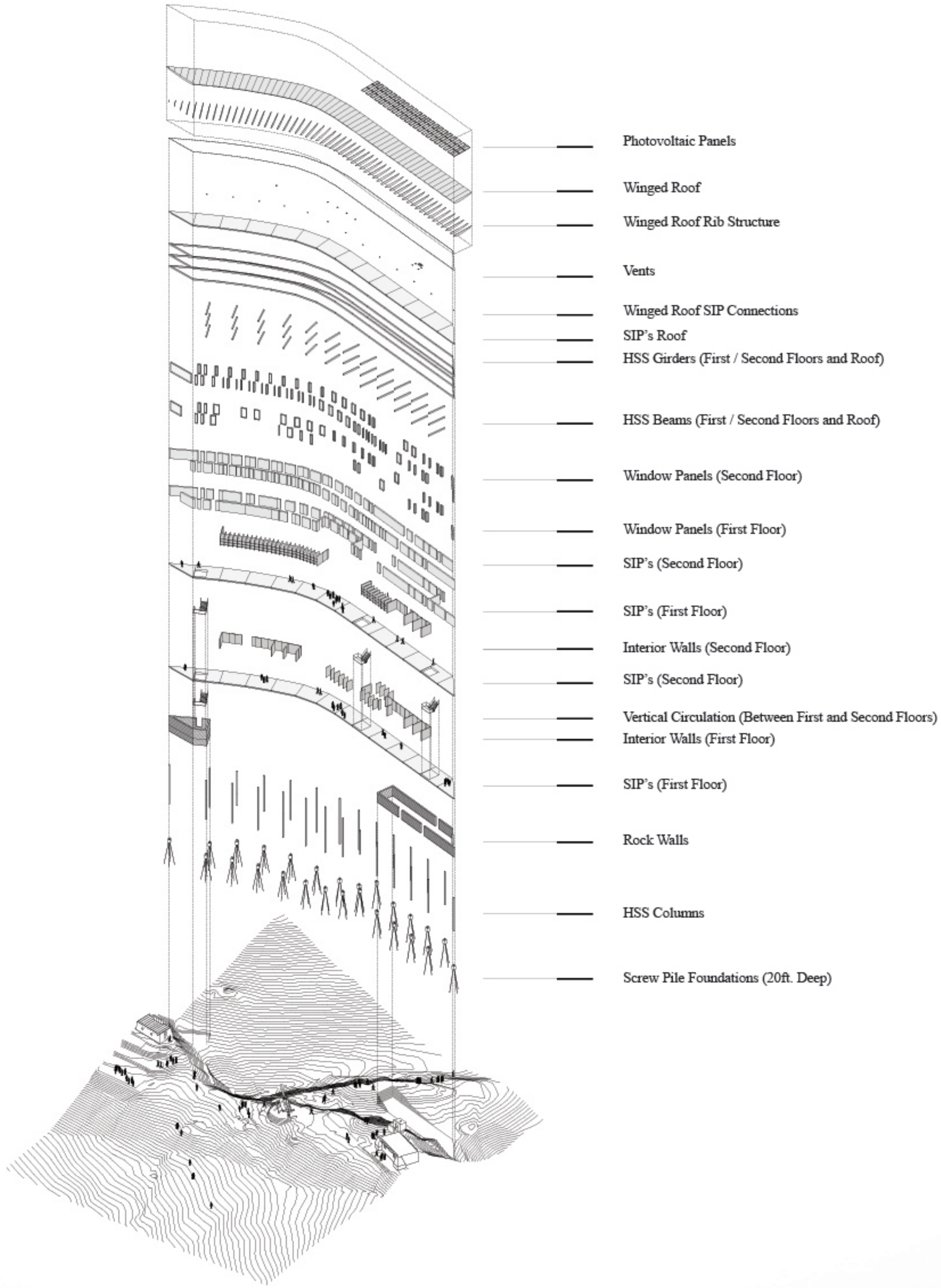


Fig. 38.
Exploded axonometric of pre-fabricated assembly of parts.


Image 35.

Image 36.

Image 37.

Image 38.

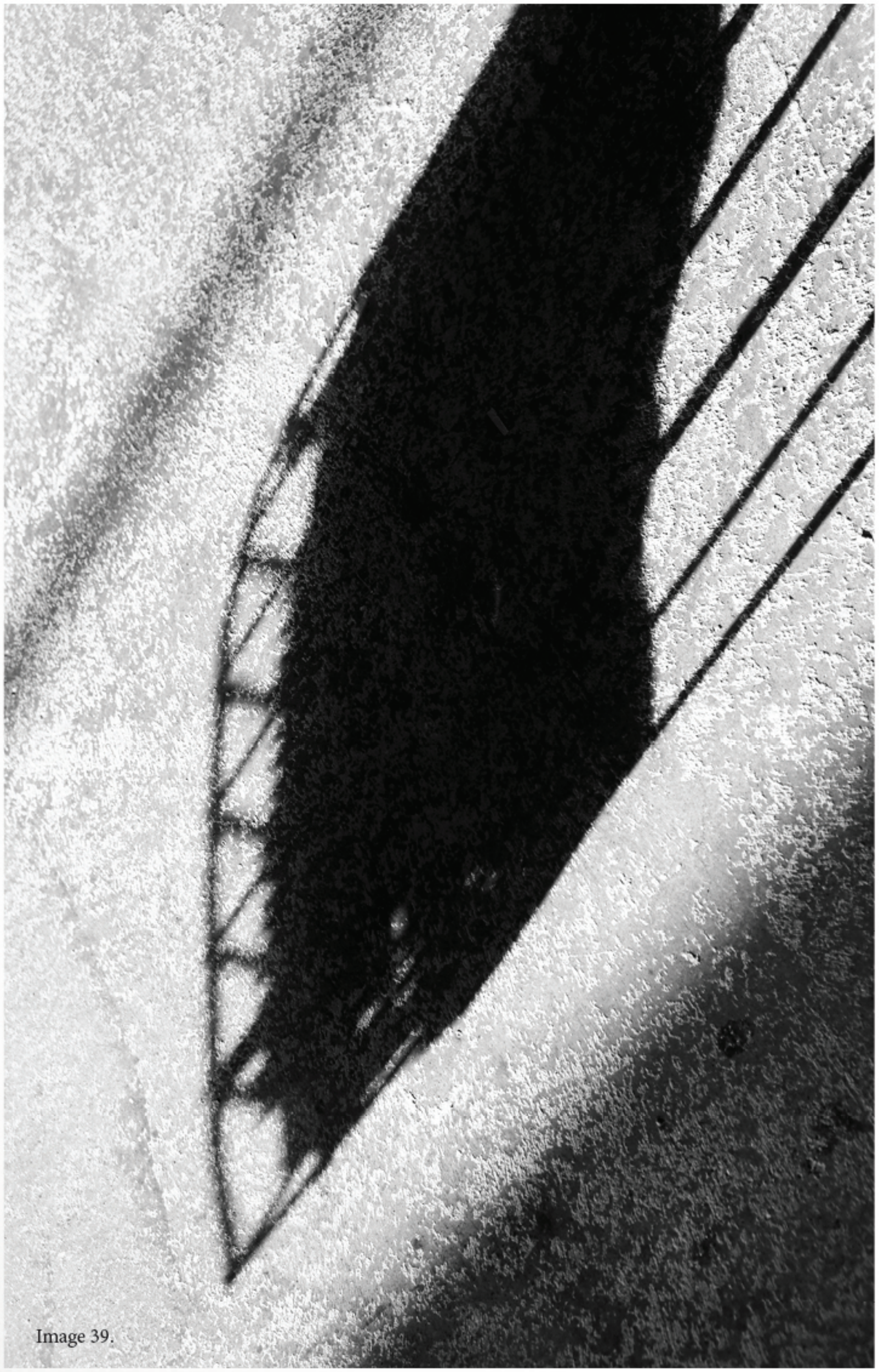


Image 39.

Image 40.

Image 41.

Image 42.

Image 43.

Image 44.

Conclusion

Conclusion

This thesis tackles the challenges presented in designing in extreme alpine conditions. Through user assessment, historical, environmental and climatic research, precedent site visits; pre-fabrication techniques and self-sufficiency in energy, water and waste, the design tests current methods of deployable architecture in extreme alpine conditions, building technology, materiality, rapid assembly strategies, as well as social connectivity among mountaineers on this pristine landscape. The design process relied on structured intuition, an assimilation of the existing site and its constraints translated into a formal expression. Furthermore, the design process put forth acquired skills and knowledge to a testing ground for achieving a elegant solution within a site impacted by a multitude of constraints.

List of Figures

All figures created by the author unless noted below.

Image References

All images taken by the author unless noted below.

Image 1. Bishop, Devin (Photographer). (2013). The final leg to Camp Muir (Photograph), Retrieved November 17, 2013 from, http://www.denalidevo.net/2013/05/rainier-3-day-muir-1-may-24-26-2013.html

Image 2. Bishop, Devin (Photographer). (2013). The final leg to Camp Muir (Photograph), Retrieved November 17, 2013 from, http://www.denalidevo.net/2013/05/rainier-3-day-muir-1-may-24-26-2013.html

Image 3. Hodges, J. Randall (Photographer). (2009). Sunrise Wildflowers (Photograph), Retrieved, December 10, 2013 from, http://farm9.staticflickr.com/8190/8431023084_0b8c91d0ff_o.jpg

Image 4. [Map of Mt. Rainier National Park]. Retrieved December 10, 2013 from, http://www.mount.rainier.national-park.com/map.htm

Image 5. [Untitled photograph of Seattle skyline]. Retrieved October 23, 2013 from, http://waywardtraveller.com/wp-content/uploads/2011/07/skyline.jpg

Image 6. [Map of Mt. Rainier National Park]. Retrieved March 26, 2013 from, http://www.mytopo.com/

Image 7. [Untitled photograph of Camp Muir]. Retrieved October 8, 2013 from, http://images summitpost.org/original/214532.jpg

Image 8. [Untitled photograph of south view from Camp Muir]. Retrieved October 8, 2013 from, http://images.summitpost.org/original/214532.jpg

Image 9. [Untitled photograph of Camp Muir from Muir Peak]. Retrieved October 8, 2013 from, http://images.summitpost.org/original/214532.jpg

Image 10. [Untitled photograph of Camp Muir]. Retrieved April 16, 2013 from, http://aaronmercado.blogspot.com/

Image 11. [Untitled photograph of John Muir]. Retrieved December 1, 2013 from, http://neitshade5.wordpress.com/Image12.

Image 12. Morse, Jason (Photographer). (2010). Untitled (Photograph), Retrieved November 26, 2013 from, http://www.flickr.com/photos/jasonmorse71/5025185510/

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Image 15. Perrian, Charlotte (Photographer). (1938). Refuge Tonneau (Photograph), Retrieved September 17, 2013 from, http://www.designboom.com/architecture/charlotte-perriand-pierre-jeanneret-le-refuge-tonneau/

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Image 19. [Untitled photograph of New Monte Rosa Hut]. Retrieved September 5, 2013 from, http://www.architectural-review.com/view/sustainable-mountain-hut-by-studio-monte-rosa-monte-rosa-switzerland/8600663.article

Image 20. [Untitled photograph of New Monte Rosa Hut]. Retrieved September 5, 2013 from, http://www.architectural-review.com/view/sustainable-mountain-hut-by-studio-monte-rosa-monte-rosa-switzerland/8600663.article

Image 21. [Scanned image]. Retrieved December 11, 2013 from, The Architecture of Ralph Erskine, Collymore, Peter, pg. 23

Image 22. [Untitled photograph of Housing at Byker]. Retrieved December 11, 2013 from, Google Earth

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Image 24. [Untitled photograph of Camp Muir]. Retrieved December 10, 2013 from, http://www.flickr.com/photos/rdog/4589956377

Image 25. [Untitled photograph of Camp Muir]. Retrieved April 16, 2013 from, http://aaronmercado.blogspot.com/

Image References

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Image 32. Interior render, main gathering area facing east.

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End Notes

1. Molenaar (1979), 6.

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