I, Lucas B Munz, hereby submit this original work as part of the requirements for the degree of Master of Architecture in Architecture.

It is entitled:
Reclaiming the Napali Coast

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Reclaiming the Napali Coast

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Abstract

The Nā Pali Coast on the island of Kaua‘i, Hawaii is known world-wide for its stunning natural beauty, rugged landscape and lush towering peaks that rise boldly along the ocean. Tourists and hikers flock to the challenging eleven-mile Kalalau Trail that treks through this remarkable and sometimes dangerous landscape. Nearly a million people visit this beautiful coastline each year, with thousands obtaining permits to enjoy a week camping along the daunting trail. Due to such popularity, environmental damage has occurred at an alarming rate. As one of the first settlement points for the ancient Hawaiians, the coastline is not only sacred but home to some of the oldest archeological sites in Hawaiian history. In addition to environmental harm, many of the cherished ancient monuments have experienced severe destruction to the degree that the State of Hawaii has threatened to close the Kalalau trail if damage persists. This thesis is a solution that deploys a community of sustainable pods structures that are strategically placed into the lush landscape of the Kalalau Valley which effectively eliminates the environmental damage caused by tents and tarps. These pods provide shelter, electricity, freshwater, and a place to sleep during their week long adventures along the Kalalau Trail. In addition to the accommodation pods, a second larger structure is constructed to address the production of food, food service, educational components, and provides a social epicenter for guests during their stay. The design and execution of this thesis confronts landscape and monument damage, promotes cultural awareness, sustainability, and the importance of environmental stewardship through design.
Acknowledgements

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Fig. 13. Koren Cappozzo. *Stone Pile*. Photography. Digital Media. 1020 x 520 px.
Chapter 1: Introduction

The hospitality industry over the last ten years has become the target of intense scrutiny due to environmental harm, excessive water consumption, and raising levels of waste being produced. Countless hospitality companies have responded by joining the Green Hotels Association which promotes practices for the conservation of energy, water, and waste in companies globally. While initiatives and programs are in place to help reduce and eliminate the burden of trash and excessive consumption, the problem still exists. “Over the past ten years, the costs of water and wastewater services have risen at a rate well above inflation. Business owners can expect these and other utility costs to continue to increase in order to offset the costs of replacing aging water supply systems. Water use affects a hotel’s operating costs and environmental footprint. Industry estimates suggest that implementing water-efficient practices in commercial buildings can decrease operating costs by approximately eleven percent and energy and water use by ten and fifteen percent, respectively.¹ Most importantly, environmental sustainability is a leading factor in purchasing decisions and customer demand. A TripAdvisor survey found that seventy-nine percent of travelers look for eco-friendly accommodations. Adopting water-efficient practices also helps hotel owners meet local or customer requirements and earn recognition from programs that identify green hotels.²

Countless pounds of trash is produced every day in the hotel industry, and millions of gallons of fresh water is used for something as simple as laundry. The problem does not conclude with excessive use of water and production of waste, but continues with immense energy consumption and perpetuation of outdated business operations. Aggressive initiatives industry-wide are necessary to combat these global issues which include new design standards, operations, and services.

In addition, current hotel and resort construction standards wreaks havoc on global environments causing entire landscapes to be altered when a permanent resort is established simply to provide guests a sweeping vista of a beach or valley. One may think this is counterintuitive, to destroy the single aspect of why the resort exists in the first place: the landscape and the beach. Why remove the natural beauty of a site to replace it with concrete, non-native trees, if the main aspect of the location is, in fact the natural beauty of the site?

Massive luxury hotels are even worse in this instance. These enormous complexes are meant to pamper and spoil their guests which endless options on activity, room type, view, and service. Luxury comes with a price and that price is heavy environment damage, high energy consumption, careless water use, and excessive waste. There are, perhaps, a time and a place for such a hospitality typology, but what about the average guest? The non-spa-goer? What about the adventurer? The outdoor enthusiast? Current industry practices would argue that they need to build a resort in every beautiful location possible as to protect their profits and investors. Again, this is a outdated approach and industry standards are harming the very commodity that the tourists are looking to see and experience; the environment. The solution is clear: develop a sustainable hospitality unit that no longer impacts the land or environment in which it is located.

A paradigm shift will also be necessary on a global scale and an important aspect of the changes necessary for the future of hospitality. The standardized, highly-repetitive nature of the industry will exist in some form, but the wasteful practices of the past will need to give way to the new ethics of the future; the industry and public will need to adjust their standards to help protect our planets future. Four towels will no longer be a standard when one will suffice, and daily linens changes will give way to duration-based
linen services. The mindset of the global traveler in the future must adapt for the sake of sustainability.

In 2017, advancement in technology, available materials, and transport are occurring at a constant rate allowing for homes and businesses to consume less energy, require less water to efficiently function, and less material for a building to survive. State-of-the-art technology will be employed in this thesis to allow for a building to collect and purify water, harness and distribute energy from sunlight, and compose a structure to comfortably house guests in a remote location. The implementation of new technology along with the adaptation of existing building practices will allow for the development of a cutting-edge hospitality component that will seek to impact the surrounding environment as little as physically possible. Furthermore, the unit will be entirely self-sustaining in that it will collect rain water for showers and sink, employ a solar array for electricity, and deploy an advanced composing toilet prototype to address every need of the guests.

While it is the intention of this thesis to be adapted and altered to be suitable in various climates around the globe, a case study is necessary for the development of this project in order to generate a functioning solution. The case study location for this thesis is on the Hawaiian island of Kaua‘i at the Napali Coast Wilderness State Park where immense environmental damage is occurring due to the extreme popularity of hiking and camping exists. This thesis addresses the Park Service’s request for a of solution in order to provide guests with overnight experiences without damaging the natural and cultural beauty of the rugged landscape.
Chapter 2 | Eco-Tourism & Hawaiian History

The Nā Pali Coast, located on the island of Kaua‘i, is world renowned for its stunning natural beauty and extreme, Hawaiian landscape. Located on the oldest island in the Hawaiian island chain, this rugged, dynamic coastline has attracted visitors from around the globe since a single photo was featured in a 1960 edition of the National Geographic.¹ (Figure #1) Born from a plume of rising magma on the ocean floor, known as a hot spot, the Hawaiian island of Kaua‘i was once a towering mass of almost five miles. Nā Pali, meaning “the cliffs” in Hawaiian, was formed over the course of the last six million years due to nearly a hundred inches of rain a year² which has carved what seems to be bottomless valleys, towering waterfalls, and harrowing cliffs into an unforgettable coastal landscape that is eclipsed only by the power and grandeur of the Grand Canyon.

Winding through the rugged and organic topography of the Nā Pali Coast State Park, the Kalalau Trail attracts over a million visitors annually craning to experience the gorgeous scenery along the fifteen-mile stretch of remote coastline. The Hawaiian tourism industry favors the mesmerizing allure which relentlessly draw visitors to the island of Kaua‘i. Conversely, the Hawaii State Park Service is facing several crises due to the ramifications of the coast high popularity: the degradation and destruction of native, sacred landscapes found along the Nā Pali Coast. Over ten thousand backpackers and campers a year choose to spend up to five days, limited by permit, to stay amongst the wilderness of the Nā Pali Coast.³ Kalalau Beach, located at the end of a grueling eleven-mile hike (one way) is the hopeful destination of most hikers, and the tropical landscape surrounding the beach is the common victim of intense environmental abuse due to the use of tents, tarps, and illegal camp fires. Entire ancient Hawaiian archeological sites have been compromised or destroyed beyond recognition by the lack of awareness and care from backpackers occupying these sacred landscapes.

Record rates of destruction occurred in 2013 causing the Hawaiian State Park Service to limit and reduce permits as they actively investigated potential solutions to reduce or eliminate damage to the sacred, sensitive landscapes found within the park. This thesis aims to solve this extremely important environmental and cultural issue by providing a solution to allow the usual number of permits to be issued while providing self-sustaining overnight accommodations for hikers and campers along the Kalalau Trail without damaging the lush, sacred cultural landscapes in which they are placed.

2.1 A Brief History

The islands of Hawaii were first discovered by Polynesian explorers between the time of 200 and 800CE and were the first humans to colonize the islands. Polynesian navigators typically carried various types of plants, small animals, and other items with them on long journeys to Hawaii. Eventually their “canoe plants” inhabited the volcanic islands into the native landscape seen throughout the State today. Colonizers established vast groves of Taro, breadfruit, coconut, sugar cane, and sweet potatoes, and eventually even raised livestock such as chickens, goats, and pigs. A second, much larger wave of Polynesian and Tahitian voyagers arrived between 1219 and 1260, introduced salt, seaweed, and poi dogs. Abiding by Polynesian religious norms, the now Hawaiian people understood that no one individual actually owned land, they simply dwelled on and respected the sacred landscape. This then informed the belief that land was also godly, and therefore above mortal and ungodly humans, and humans therefore could not own land. The Hawaiians thought that all land belonged to the gods, or auk. This popular sentiment still lives through the Hawaiian people today, despite the opportunity and legal implications found within American cultural norms.

Due to the extreme coastal landscape of the Nā Pali Coast, Polynesian settlers were drawn to the region due to its fortified beaches and valleys encompassed by towering cliffs; both aspects granted them safety and protection from man and weather alike. The delightful combination of high average rainfall totals and extremely nutrient dense soils of the Nā Pali Coast and the Kalalau Valley allowed villages to flourish and food became plentiful and over-abundant for the small population that lived there.

Written records allege that the Nā Pali Valley was inhabited with hundreds of Hawaiians up until the late 1890s and into the early 1900s with the last rural Hawaiians leaving the valley shortly after 1905. (Figure #2) The famous Kalalau Trail came into existence in 1800 to bridge the gaps between Hawaiian communities still living along the coast. The trail was officially restored in 1930 as a destination for both history and outdoor enthusiasts alike, despite the native Hawaiians no longer occupying the coastal region. Evidence of their lifestyle and culture are captured within the numerous stone structures along the fifteen-mile coastline, and have since been rendered sacred and important to the colorful ancient Hawaiian who once

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inhabited Nā Pali. Realizing the importance and rare beauty of the terrain the Nā Pali Coast Wilderness State Park was established in 1983, and was expanded in 2009 to now encompass 3,578 acres of lush, tropical valleys, cliffs, and beaches. Today, hikers and backpackers still discover plentiful varieties of fruit and wild vegetables as they navigate the arduous trail-scapes throughout the entirety of the park.

2.2 Eco-Tourism in Kaua’i

Attracting nearly eight million people annually, the state of Hawaii is one of the most popular tropical destinations on the planet. Moreover, Kaua’i has been consistently ranked the best Hawaiian island to visit if outdoor activities are highly desired for families and couples alike. Due to the island’s unique and stunning rugged landscape, little to no major agricultural businesses have been able to thrive there when compared to other islands with more land and less mountainous terrain leaving tourism and hospitality at the forefront to lead the island’s economy. Furthermore, Kauai’s irrefutable reputation as the ‘Garden Isle’ only places even more importance on the role of the environment on tourism and the natural beauty that is being used as a commodity by the state. Due to this reputation, visitors are drawn to countless coastal reefs, towering hiking trails, and beautiful tropical gardens scattered across the island, year-round. It is worth noting that should harm continue to wreak havoc on important natural and cultural environments of Kaua’i, economic implications may occur. Considering Hawaii’s economy is primarily based on tourism and hospitality, a large environmental crisis at the Napali Coast would be far less than desirable for the state.
Figure 3: Kalalau Trail map from Ke'e Beach to Kalalau Beach, 11 miles. Kalalau Plateau indicates project site location. Note - North is at bottom of map.

Figure 4: Kalalau Valley’s with Kalalau Plateau (bottom right) and Red Hill (center) in the foreground, 3800’ peaks in the distance. Note scale of trail along bottom of photo.
Chapter 3 | The Nā Pali Coast Wilderness State Park

3.1 Introduction to Site

Throughout the 15-mile stretch of Nā Pali Coast, two sites have been selected to accommodate housing for hikers looking to camp along the Kalalau Trail. (Figure 2) Upon concluding an extensive site analysis of several possible camp locations along the eleven-mile trail. Approximately four miles from the permit check point at Hanakapiai Beach, at mile maker number six is the Hanakoa Valley, is the secondary mid-point camping site. 8) (Figure #3) This location has been chosen for its protection coastal winds, access to water, a composting toilet, and a low density of ground cover, as this will be a location for single night stays to occur without further damage to the coastal environment. Furthermore, the Hanakoa Valley is directly between the permit point at Hanakapiai Beach and the primary camping site located in the Kalalau Valley at mile number ten which makes the distance both manageable and achievable for inexperienced hikers. 6) Highly experienced hikers could potentially make it to Kalalau Valley in a single day should they manage their progress with moderate aggression.

Hikers wishing to stay in Hanakoa Valley will be required to sleep in post-hung hammocks that they will carry with them in their packs rather than in tents covering the ground. As such, hammock support structures with a roof, screen enclosure, and raised deck will be installed in designated areas to encourage this modified behavior. By sleeping in hammocks, this not only reduces impacts on the ground cover but also lightens the weight of hikers backpacks by not needing the cover of a tent.

The primary camp location has been selected at the Kalalau Plateau which is near mile marker number ten, in the low flats of the Kalalau Valley, only three quarters of a mile from the trail terminus at Kalalau Beach. 6) (Figure #4) This location offers a relatively gentle topography, access to the nearby Kalalau Stream for water, extensive coastal views, and a moderate-to-low density of trees with varying

densities of under brush and clearing. The geological form of the Kalalau Valley allows for a heavy southern exposure which is desirable for capturing solar energy, especially considering the staggering height of the surrounding cliffs. This location is also optimal for hiking due to its proximity to the beach, stream, and various additional secondary trails within the Kalalau Valley. For safety and accessibility, the primary site is also within close proximity to a helicopter landing pad just before Kalalau Beach.

In addition to ease of access to several important amenities, this site was chosen as a departure from the current camping site due to the extreme damage traditional camping has caused directly behind Kalalau Beach. This departure was also a desirable change due to the high visibility of Kalalau Beach compared to the lower visual impact with the protection of foliage at the Kalalau Plateau. A specific goal for the thesis was to eliminate harm to the pristine environment, which includes large visual impacts; this primary location has been selected to help achieve this initiative.

3.2 Climate & Topography

Known globally for its humid, tropical climate, the island of Kaua‘i stands out proudly as the owner of the second rainiest location on earth, Mt. Waialeale, which receives 486 inches of rain annually. In close proximity to Mt. Waialeale, the Nā Pali Coast typically receives approximately 240 to 280 inches of rain annually, which is over 20 feet of rain a year. Water is not in short demand along the Nā Pali Coast, especially in the Kalalau Valley which is formed by a horse-shoe shaped ring of towering cliffs. (Figure #5) It is certain that it will typically rain at least once a day in the Valley, and although it does not rain for more than an hour, the water is vital to growth and maintenance of the dense, tropical landscape. Fresh water will play an important role in the development of the unit development for the Kalalau Plateau solution. It

Figure 5: Kalalau Valley topography map, Red indicating zoom boundary (right) with black showing project site boundary. Note - North is at top of Map.
is important to state that rain water is both fresh and capable to be consumed by hikers and backpackers only as long as it is boiled and treated before consumption. Without treatment, users can become fatally ill due to bacteria and protozoa such as Cryptosporidium which causes severe diarrhea and vomiting.\(^\text{10}\)

The Nā Pali Coast is blessed with temperatures that range from mid-70’s during the winter to mid-to-upper 80’s during the summer.\(^\text{9}\) Due to its location on the northeast side of the island of Kaua’i, the location is considered windward, and receives a constant ocean breeze which offers visitors respite from the choking humidity throughout the day. This consistent yet small range of temperature is desirable for the cultivation and harvest of a wide variety of vegetables and fruits used for cooking. As proven by the ancient Hawaiians, the Kalalau Valley, with a nearly endless supply of water and heat, will allow for excellent growing conditions necessary to provide food for a large group of visitors and hikers along the trail.

### 3.3 Flora, Fauna, and Ancient Hawaiian Landscapes

Several rare and endangered species of plants can be found along the fifteen-mile stretch of Nā Pali coastline such as Brighamia insignis (Figure #6)\(^\text{12}\), Acacia koaia (Figure #7)\(^\text{12}\), Capparis sandwichiana (Figure #8)\(^\text{12}\), and Lobelia niihauensis (Figure #9)\(^\text{12}\). Several types of butterflies such as Colias eurytheme (Figure #10)\(^\text{12}\) and Udara blackburni (Figure #11)\(^\text{12}\), can also be found drinking nectar in the various protected valleys along the Kalalau Trail.\(^\text{11}\) These species are endemic to the Nā Pali Coast and are under constant threat due to their unique appearance or character. Hikers travelling along the Kalalau Trail often damage these delicate plants simply because they do not recognize them as endangered or rare. The Department of Forestry and Wildlife has been working to educate visitors hiking the Kalalau Trail to help recognize these rare species so that a better sense

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Figure 10: Orange Sulfer butterfly (Colias eurytheme)

Figure 11: Hawaiian Blue (Udara blackburni)

Figure 12: Damage discovered at Kalalau Valley and Beach, stones (bottom left) illegally moved from nearby haieu.

Figure 13: Trash and damage left behind by illegal hikers
of respect and protection will be fostered towards them. As a goal of this thesis, an educational component will be developed to aid the Department of Forestry and Wildlife’s protection initiative.

Similar in both scale and scope is the destruction of ancient Hawaiian sites. Scattered along the eleven mile Kalalau Trail are several ancient Hawaiian ritual and religions sites. These sites are considered to be sacred by the Hawaiian people, and to the common visitor would otherwise go overlooked. The archeological foundation Nā Pali Coast ‘Ohana has recorded moderate to severe harm on several sites since their founding in 1995. (Figure #12) The foundation itself was created due to the overwhelming cultural and environmental destruction that was being caused by visitors, over-use, and individuals illegally squatting in the Kalalau and Honopu Valleys. With efforts from the Department of Natural Resources, the Department of Forestry and Wildlife, and local police authorities, much of the harm has slowed until recently. Since 2013, locals have noticed an increase in damage to ancient cultural sites, especially near Kalalau beach including an entire heiau (temple) that was disassembled so campers could use the stones to construct a stone oven. (Figure #13) The foundation pledged to use donations to increase surveillance and join an initiative to educate those wishing to enjoy the remote Kalalau trail past the popular Hanakapiai Beach.

Once passed Hanakapiai, all visitors must carry a required permit issued by the Hawaiian State Park Service which allows them access to Kalalau Trail and the various beaches and valleys for up to five days total. Historically speaking, permit holders have caused the most damage to Nā Pali simply due to ignorance or carelessness. Promoting awareness and education along the Kalalau trail, where appropriate, will play an important role in the development of this thesis solution in order to protect rare natural and cultural entities.

3.4 Trails & Visitors

There are three main demographics that typically visit the Nā Pali Coast: Unaware tourists, enlightened native Hawaiians, and avid hikers/campers willing to learn. Due to the overwhelming difficulty of the Kalalau Trail, the population ranges from young teenagers with parents to adults in their mid-sixties--- all of which are generally in moderate to excellent physical fitness. It could be argued that most tourists that enter the site have little to no prior knowledge and are simply visiting to take in the stunning scenery rather than the important cultural aspects related to the coastline; in most cases this is accurate. Equally as provocative in nature, it would be foolish to assume that every native Hawaiian visiting the coast understands the importance of Nā Pali and the history associated with the landscape. In addition, we can assume that individuals looking to hike eleven miles, one-way, after obtaining a permit to do so, would be amenable to learning about the history and culture of Nā Pali at various points along their journey to Kalalau Beach and the Kalalau Plateau.

Chapter 4 | Programming

4.1 Education and Signage

Approximately a thousand feet past the initial signage of the trail head will be the first educational signage for the heavily traversed two-mile trailhead-to-Hanakapiai Beach trail. History of the ancient Polynesian and Hawaiian cultural sites en-route will be displayed as well as graphics regarding rare plants along the path to their beach destination. One additional sign will be displayed at a scenic overlook en-route; the location is to be determined.

Following the two-mile hike to Hanakapiai Beach from the initial trail head hikers with valid permits would encounter a kiosk that will provide them with rules of the trail, general safety guidelines, and an introduction to the history of the Nā Pali Coast and Kalalau Trail. This threshold will be monitored from sun-up to sun-down to increase safety not only for hikers and visitors, but for the protection of priceless natural and cultural artifacts. When hikers with reservations at the Kalalau Beach pods arrive at the Hanakapiai permit check point, an on-duty attendant will notify a staff member at the Kalalau Plateau Pod Camp of new hikers en-route. In addition, hikers will be given a GPS tag to monitor progress and provide a location in the event of an emergency--while these are additional costs, data regarding where hikers break or spend the night could provide important data on where to include further facilities and protection for the environment.

Once hikers are en-route to the the Kalalau Plateau pod camp, they are essentially on their own to assume risks, manage hiking speed, facilitate safety and health of their individual or group. Near important Hawaiian sites a sign will be placed along the trail to inform hikers and urge their care. Around the six-mile mark (four miles from the Hanakapiai Beach station) there will be a designated location at Hanakoa Valley for hikers to stop and stay the night should they need
rest and stay on the trail, however it will be highly discouraged. Due to the length and intensity of the Kalalau Trail, options to accommodate various experiences levels and speeds of hikers and will accounted for in the overall concept. Campers will no longer be able to choose where they wish to camp along the trail, and will be encouraged to use their best judgment of the amount of daylight, their level of fatigue and access to water before deciding to press forward when reaching each stopping point. Hikers found camping outside of a designated hammock camp location will be fined and their permit revoked. Signage will play a large role in facilitating these changes.

4.2 Pod Camp

Upon arriving at the Kalalau Plateau Pod Camp, campers will be checked in by staff at the Community House, a large open-air pavilion that is used for cooking, entertainment, and socializing throughout the duration of their stay. The Community House will also function as the educational center for the camp. As a requirement to staying in the Kalalau Plateau accommodation pods, the first evening of their stay hikers will be required to participate in a two-hour program devoted to the history of the Nā Pali Coast and the ancient Hawaiians that once used the land at their home. The accommodation pods will be accessed by a strategically chosen hiking loop bound by rope standards to ensure limited destruction of vegetation and landscape. In addition, these designated walkways will allow a stricter enforcement of environmental protection and mutual understanding to stay on marked pathways. Due to the remote, rugged location of the Kalalau Valley a variance for ADA will be granted and all risk will be assumed by the user.

Arrangement methodology for the accommodation pod camp will be determined by
overall topography, Hawaiian community precedent, privacy, and most importantly, safety. The relationship between two pods will be designed to encourage community, safety, and in certain instances, privacy. Environmental impacts and respectful treatment of Hawaiian cultural sites will be heavily considered when determining the pod camps overall arrangement.

Each accommodation pod (explained in detail in the Design Development and Schematic Design sections) will appear to be visually the same from the exterior, but the interior layout will accommodate two or four people, depending on which configuration, with an option of hook brackets to allow an added hammock for odd numbered groups. (Figure #14) The Pods will also contain a bathroom with shower, vacuum sewer composting toilet, and closet space for storage. Access to electricity and potable water will be readily available in each pod via solar arrays and each accommodation pod will contain a large cistern to gather rainwater, which will be internally treated via UV and used for sinks and showers.

Food for the camp will be grown on the green roof atop the Community House structure and will act as the primary source of food for a primarily vegetarian diet for the Pod Camp. Staff travelling from the trailhead to Kalalau Plateau will occasionally bring in replenishments of dry goods as needed. As part of the accommodation package, food will be provided for guests with reservations at the camp as well as water-based non-alcoholic beverages.
Alcohol will be allowed for those of age, but only accepted if contained in a recyclable vessel.

Trash has been a constant issue for the Kalalau Trail in many locations along the Nā Pali Coast and as an initiative to combat the problem, all guests will be responsible to not only pack out what they have brought in, but while staying at camp, generate as little trash as possible. This initiative will be achieved by using durable, reusable cups, plates, and flatware. The small amount of trash, if any, will be contained and removed via boat from Kalalau Beach back to the trail head and disposed of accordingly to avoid trash moving back into the environment of the Nā Pali Coast.

4.3 Camp Staffing

Six to ten permanent staff members will be on hand at all time. All staff will not only act as cooks, but each are required to be Red Cross certified in both CPR, Lifeguard, and First Aid for the added safety of the camping community as a whole. Staff will also be required to participate in the educational and social aspects of the camp program as necessary. While these staff members are on hand to cook and assist in the education of guests, staff members will not be required to provide any further services such as trail guide or camp councilor as guests should self-manage their activities throughout their stay at the Pod Camp.

Regardless of the activity, the primary focus of all activity at the camp is to be respectful and aware of the local environment and to be mindful of the sacred, ancient sites throughout the Kalalau Valley and along the Nā Pali Coast. Staff will have the authority to remove any camp visitor or guest who is mindfully disrespecting ancient Hawaiian sites or the natural environment. In order to maintain and protect the environment within Kalalau Valley and near Kalalau Beach, camping outside of the pods will be strictly prohibited to encourage regeneration of the understory.
Figure 15: Ancient Hawaiian architectural styles
Chapter 5 | Bio-Mimicry & Culture

Outlined in this section are various initiatives and strategies seeking to be implemented in to Pod solution for the Nā Pali Coast. Varies technologies, both passive and active, will aid in the overall design of the Pod solution. References and anthropological histories of the Hawaiian culture will also be used as guidelines to the overall design for the Pod. In addition to technology and culture, influences found among nature and the animal kingdom will heavily influence camouflage strategies necessary to limit the visual disturbance of the Pod within natural and cultural environments of the Kalalau Valley.

5.1 Native Hawaiian Architecture

Hawaii’s benign climate meant that ancient Hawaiian’s spent the majority of their lives outdoors in the sunlight and gentle coastal breezes. Typically, housing structures, called hale, were built mainly for storage and sleeping, but also to provide protection from harsher weather events. Open air structures, with a roof, and three-to-four open sides were very common and were inherited from Polynesian and Tahitian cultures. (Figure #15) Common citizens within ancient Hawaiian society typically had a one room hale, whereas chiefs typically had multiple roomed structures, or even several houses. Arrangement and placement were determined by family structure, power, and the surrounding environment. In typical native Hawaiian culture, the structure of the village community would be about prevailing winds, slope of the land, and access to light all of which were connected by a network of paths. Due to these varying conditions, the location for each of the accommodation pod pairs will be placed regarding these same concerns so that optimal conditions for water and solar collection strategies to function efficiently. Hawaiian architecture was also extremely light on the land in both weight and in that ancient Hawaiians employed several natural and locally grown materials to create their structures. In efforts to reduce harm

on the Nā Pali Coasts natural resources, the structures for accommodation pods and the Community House will be composed of a ridged recycled aluminum framing and Ethylene Tetrafluoroethylene (ETFE) membrane pockets filled with air to enclose the structure. (Figure #16)

Once positioned onsite, Ipe (Handroanthus spp.) wooden shade fins will be bracket-attached to the exterior of each pod in a pre-specified arrangement to ensure both privacy and efficiency of the unit’s interiors. Ipe was chosen due to its ability to be locally harvested, its rapid growth qualities, and the beauty of its natural qualities of grain once cut.\(^{17}\) While large portions of the unit’s exterior will be enclosed with wood fin, small voids, dictated by the frame of the unit’s structure will be left uncovered with the ETFE exposed. These voids will provide focused views for guests on the exterior of the pod. Overall, the design for the pod will be designed to be as sustainable, light weight, and low-impact to the land as possible.

5.2 ETFE

The ETFE membranes will function as both a semi-translucent barrier with similar qualities to glass but will be a fraction of the weight. Through testing and research, ETFE has been proven to weight 1% that of an equally sized piece of glass while still providing a 95% translucency rating compared to glass.\(^ {18}\) Glass was not chosen in this instance due to the pods requirement to be both light on the land and ability to be air-lifted into specified locations across the camp site. The exterior membrane will be a composite of two layers of ETFE with a sealed pocket of air between which will function as a highly-efficient insulator which will aid in maintaining a comfortable interior temperature on warm, humid days.

\(^{17}\) Department of Land and Natural Resources. “Division of State Parks.” Division of State Parks | Nāpali Coast State Park Plants. Accessed November 17, 2016.

Figure 16: ETFE Diagram with air pocket shown.
**Figure 17:** Indentation Diagrams: Overall Indentation pattern (left) Enlarged view of stamp indentations. Mechanical Stamp movements during indentation process (right).

**Figure 18:** Butterfly Wing Light Reflection Diagram. All light entering wing structures with only blue light being reflected and visible to the human eye.

**Figure 19:** Individual Scale of a Butterfly Wing.
5.3 Customization via Bio-mimicry & Light

State-of-the-art technology pertaining to bio-mimicry will be applied to the ETFE panels to add both variety, interest, and color to the accommodation pods. A series of nano-scopic indentations will be utilized to capture the wavelength of light and to create a shimmering, radiant color to be reflected from the pattern punched within the outermost ETFE layer of membrane. (Figure #17) The influence and understandingofthis technology is inspired by understanding how the color of a butterfly’s wing is produced.

"Many types of butterflies use light-interacting structures on their wing scales to produce color. The cuticle on the scales of these butterflies’ wings is composed of nano and micro scale, transparent, chitin-and-air layered structures. Rather than absorb and reflect certain light wavelengths as pigments and dyes do, these multi scaled structures cause light that hits the surface of the wing to diffract and interfere. Cross ribs that protrude from the sides of ridges on the wing scale diffract incoming light waves, causing the waves to spread as they travel through spaces between the structures. The diffracted light waves then interfere with each other so that certain color wavelengths cancel out (destructive interference) while others are intensified and reflected (constructive interference). (Figure #18) The varying heights of the wing scale ridges appear to affect the interference such that the reflected colors are uniform when viewed from a wide range of angles. The specific color that is reflected depends on the shape of the structures and the distance between them. (Figure #19) This way of manipulating light results in brilliant iridescent colors, which butterflies rely upon for camouflage, thermoregulation, and signaling."19

Light can be employed and exercised in the same way to create color by identifying the measurement of the wavelength of the desired color and trapping the light at that specified length using an arrangement of circular indentations at that specified measurement. While these indentations

are extremely tiny, the wavelength of green light, 500 nanometers to be exact, can be captured using holes similar in size.\textsuperscript{19} (Figure #20) Via the use of technology and powerful magnification certain types of plastics are able to be patterned with powerful lasers and presses that puncture the plastic with several thousand indentations at a time. These indentations which would allow all wavelengths to enter the indentation but only the green light wavelength to escape and transmit the color into view. By varying the frequency, diameter of these indentations, any color is able to be reflected and displayed across the surface of the ETFE.\textsuperscript{19} In this way, customized patterns can be embedded into the outer layer of the ETFE allowing for each pod unit to be visually unique and in return creates a continuously changing experience depending on various levels of sun and moonlight cast upon the materials surface pattern. Through the daytime hours, patterns will be seen from the exterior of the pods, due to sun being the source of light. During night time, and early morning, interior lights will be the source of light, therefore the embedded patterns of color will be visible from within the pods and not from the outside. In this way, both interest, customization, and adaptability can be applied to the pods to create an ever-changing appearance to a standardized pod unit. (Figure #21)
Figure 20: Nano-scopic Design indentations reasing specified color and pattern pressed into plastic.

Figure 21: Interior view of nano-indentations pressed into ETFE.
Figure 21: Accommodation Pods Solar Panels mounted on support chassis.

Figure 22: Cross-ventilation diagram showing how air will circulate through the accommodation pod.
Chapter 6 | Passive & Active Sustainability Systems

6.1 Photovoltaic Panels & Array

As a key component to the unit’s services and functionality, four photovoltaic panels, per unit, will be mounted on a structural chassis atop the unit’s roof. (Figure #21) In relation to the slope of the unit’s roof beneath, the panels will only need to be adjusted twice a year; one time in the spring, and once in the fall.\textsuperscript{20} This minor adjustment relates to the slight variation of the azimuth as the seasons change. The arrays will then be linked to a battery pack located within one of the several floor compartments within the floor base of the unit. Directly next to the battery will be a converter transforming direct current to allow for the use of alternating current electrical components. Switches, outlets, and LED light fixtures will be fed by the battery for up to eight hours without sunlight, with typical loading, with infinite use during periods of sun.\textsuperscript{20}

6.2 Cross Ventilation

Design of the accommodation pods was directly influenced by the vast requirement of cross ventilation in the humid climate in which the pods will be placed. Cross ventilation establishes a flow of cooler outside air through a space which carries and replaces heat trapped within a building.\textsuperscript{21} By designing for cross ventilation, users can effectively remove heat in an energy efficient and viable manner. The effectiveness of cross ventilation as a cooling strategy is a function of the size of inlets, outlets, and wind speed.\textsuperscript{21} Outdoor air temperature is also important to note as is relative humidity. Air temperature inside Pod will be cooler due to the contained and closed nature of the unit’s composition. Cross Ventilation will play an active role in affectively implementing cooling to the Pods in the hot and topical climate of the Nā Pali Coast. (Figure #22)

A smaller south-facing door will give way to a larger, full-sized north facing door which will provide

21) Abid: Kwok. 139-144}
allow cooler air falling from the valley side of the unit to enter the unit. The doors, in combination with the ceiling surface raising from low on the south to higher on the north, hot air is efficiently and effectively removed from the unit with no mechanical energy other than the guests effortlessly raising the doors via pulley.

6.3 Composting Toilets

Sometimes called biological toilets, dry toilets, or waterless toilets, these devices successfully manage the chemical breakdown of human waste, paper products, food waste, and other carbon-based materials. Oxygenated waste is converted into “humus,” a soil-like product that can be used as a fertilizer on non-edible agricultural crops. Various benefits of using a composting toilet include reduced potable water used and reduced loads on central sewer and local septic systems. Due to the natural break down of organic matter, a minimum temperature of 65F is necessary. Catchment containers, while not needing regular maintenance should be addressed on a bi-weekly basis to insure cleanliness and regulate biological processes. (Figure #23) In addition, camp personnel will maintain, monitor, and properly dispose of all humus as specified by local and state regulations.

6.4 Cisterns & Rainwater Collection

Due to the 240” of annual rainfall experienced at the Nā Pali Coast, cisterns will be used to capture rainfall for the use in sinks and toilets. Within the cistern will be filtration and UV treatment technologies to eliminate the risk of sickness and the need to boil. It can be assumed that by using a low flow shower and a low flow bathroom sink that a maximum of 35 gallons would be necessary per person, per day to successfully provide water for each pod. (Figure #24) The cistern needed on a pod for four people would

22) Abid, Kwok. 229-237
Figure 23: Composition Toilet with vacuum sewer and mechanical exhaust options.

Figure 24: Rainwater catchment system. Water is funneled into a vertical gutter system, and through the a UV purification system and into holding tank for heating to be used in showers and sinks.
Figure 25: (Top) Community House green roof displaying solar panels. (Bottom) Community House displaying guest space below green roof.
be approximately 200 gallons, and a two-person pod would contain a holding potential of 100 gallons. Greywater will be distributed back into the environment following being filtered via distribution lines.

6.5 Green Roof

A green roof component on the roof of the Community House will used for the production of food for guests visiting the Kalalau camp accommodation pods. (Figure #25) This green roof system is based on the Omni Ecosystem™ design system. This system was researched and chosen due to the specially formulated soil composition used within the system specifically used to grow crops, known as Infinity Media™. The Omni system is also known industry-wide for its high-quality design, light weight, and low maintenance characteristics. The green roof at its deepest will be eight inches deep, which is neither an intensive (>8”) or extensive (2-6” deep) green roof, but rather deemed as a “comprehensive green roof” for its ability to foster flowers and crops without requiring a deep root base.24

The Community House when complete will be a modular structure, but more permanent in nature when compared to the moveable nature of the accommodation pods because the Community House will be anchored on concrete piers, with each unit being securely bolted to the foundation structure. When the modular support structure is complete, the green roof will then be installed. Upon completion, the roof will be approximately 1,012 square feet of vegetated area atop the Community House. The Omni Ecosystem™ composite allows for a large expanse of vegetated space, but at a weight of 34 pounds compared to greater than 50 pounds for roofs of similar crop output.24 In addition to the ability to grow plants, the roof will also function as a method of retaining rain water and using it to hydrate crops.25 The roof is designed to slowly discharge any unneeded rainwater back into the surrounding landscape.

25) Abid: Kwok. 47-54
via rain chain reaching from overflow compartment to the ground adjacent to the Community House.

As a functional means of providing food for guests and visitors, a large selection of crops ranging from potatoes, tomatoes, carrots, peppers, varieties of lettuce, celery, corn, eggplant, and squash can be harvested, as well as several varieties of fruits not already found within the Kalalau Valley. Staff of the Kalalau Camp will regularly access the roof via permanent ladders from the kitchen and education area of the Community House. While guests do not have access to the roof, information regarding sustainability and the various technology used on the roof have the ability to impacting the guest experience during the educational component of their stay.
Figure 26: PurePod, Christchurch, New Zealand
Chapter 7 | Pod Design & Precedent Studies

7.1 Unit / Modular Precedents

The following precedents have been chosen due to their highly-technologically advanced approach to managing the structures impacts on the site, their owners understanding of sustainability, and overall approach to facilitating a guest’s experience in a remote location. Individual aspects of each precedent can be found in the final solution of this thesis.

**Purepod; Christchurch, New Zealand** (Figure #26)

Purepod, a hospitality establishment composed of three all-glass units, each in a distinct, non-disclosed locations for a full immersion into nature. Each unit accommodates up to two adults and have amenities such as a gas stove, bathroom, and shower. Electricity is provided by an array of solar panels that can successfully power the needs of visiting guests. Locations of Purepods are privately held by citizens who have entered into a contractual agreement with the Purepod company in regards to privacy, maintenance, and housekeeping. While these pods are built to accommodate for the most luxurious needs, they are essentially placed in an obscurely remote location to obtain the utmost sense of place while providing privacy and seclusion. The company often boasts that there is no internet, no TV, just the beauty of location and the tranquility of nature.

This precedent is important due to the physical nature of the pod. An all-glass hospitality unit creates several challenges when designing a space for unfamiliar visitors to feel both comfortable and free while being environmentally aware to the surroundings in which the pod is sited. Plants and hydrology beneath the pod will experience little to no impact or harm due to the pods placement above it, especially due to its translucent qualities and “light on the land”

methodology. Several aspects of the final thesis solution stemmed from this precedent in that the pods created for Kalalau Plateau are highly transparent, and that the telescoping porches and access ramps have glass floor surfaces which allows for sunlight to access the ground below.

**Concordia Eco-Resort; St. John, United States Virgin Islands**  (Figure #27)  

This is a sustainable, island resort complex composed of 42 tent-like structures erected on wooden deck platforms lifts above the ground. Guests navigate the complex by using a network of raised wooden walkways which protect the environment from foot traffic. Powered by photovoltaics, this resort aims to be a self-sufficient as possible, and upholds other initiatives such as no automobiles on property (electric golf carts for journeys into town), resort-grown food, and no air conditioning in the guest units. There are no cellular phone services or Wi-Fi at Concordia, which according to the resort, is a benefit of staying at the resort. Located on a densely vegetated hillside, the guests are provided with sweeping views of the ocean and surrounding islands while becoming immersed in the natural landscape and local culture.

Concordia is an important precedent when regarding the overall mentality of the resort. The experience guests receive from the resort is something very similar to the culture and mindset being used for the solution at the Nā Pali Coast. Guests are encouraged to detach from technology, experience the joys and beauty of nature, and learn a new culture and by doing so, gain a great joy and sense of place. Architecturally, the resort is unique because of the raised platforms used throughout the complex, a typology adapted in the solution for this thesis. These units are composed of sustainably harvested wood, and with little harm to the environment, can be removed if needed.

The farming component to this resort is also intriguing because guests are provided with organic,

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Figure 27: Concordia Eco-Resort, St. Johns, USVI\textsuperscript{50}
Figure 28: WhitePod Eco-Luxury, Valais, Switzerland.
local produce grown on-site due to the tropical, humid climate which is beneficial when growing a large variety of crops, a solution that is both appropriate and beneficial to the solution at Nā Pali.

WhitePod Eco-Luxury; Valais, Switzerland 28 (Figure #28)

WhitePod Eco-Luxury resort is composed of fifteen pod-like geodesic domes that are raised above the ground. Capable of accommodating up to four guests each, each dome is large enough to provide two arm chairs, a queen-sized bed, a pair of bunk beds, and a full bathroom. The domes are used year-round in Switzerland and employ air conditioning during the summer or heated by a pellet-burning closed fireplace during the winter. The resort is unique due to its mountain-side location which offers skiing and sledding during the cold months, and hiking, and mountain biking during the warm months. Electricity is wired to each pod and is linked to the local electrical grid. The pod design is unique due to the light-weight ETFE skin that is used to encapsulate each geometric dome structure. An army-grade camouflage net is used to provide privacy to guests inside and to limit the visual impact of the pods on the surrounding environment. The resort achieves this by providing a white camouflage during the snowy months and a traditional green net during the heavily vegetated months.

The resorts use of color is an extremely important precedent making WhitePod essential to the solution at Nā Pali as well as the use of light-weight ETFE as the pods exterior membrane. The visibility of the Nā Pali coastline and its importance to Hawaiian culture should remain as natural and unaffected as possible. While the climate in Hawaii is far less dynamic compared the large temperature fluctuations of Switzerland, the camouflaging techniques will be applied to limit the visual impacts of the solution at Nā Pali.

Precedent Synthesis

These three precedents were chosen due to their awareness towards the environment in which they are located. Each of them are also raised which greatly reduces the overall impacts on the land below them. Purepod’s transparent qualities are arguably best for the ground beneath the pod structure due to the ability for light to access vegetation on the ground below. However, Purepod is also an outlier due to it being the only unit that is self-supporting where as the others are placed or built into a raised platform. Due to sanctity and ruggedness of Nā Pali, a self-supporting structure would not only help limit necessary materials, but it would also lower the overall impact on the land beneath the pods themselves.

Concordia’s natural and unconnected approach is admirable, however one could argue that the resort is able to disconnect due to the safety of the site and the resorts near proximity to a town. The Kalalau Valley’s extreme, remote location would lend itself to being connected to cellular or satillite service gaining access to authorities in the event of an emergency. Concordia’s off-the grid mentality is something that will be employed at Nā Pali, however in that the pods at Nā Pali will provide electricity, collect rain water, and the common house structure will be capable of growing food via green roof.

Purepod’s all-glass approach and White Pod’s clear ETFE skin creates a unique architectural conversation. The material’s light weight and impressive strength paired with its ability to form a wide variety of shapes and patterns allows for ETFE to play several potential roles in overall material palette for the pods at Nā Pali. By examining these three unique precedents, evaluating their materiality, and reasoning, conclusions can be drawn and examined to best approach the daunting of task of designing a solution suitable for the Nā Pali Coast.
7.2 Micro & Sustainable Precedents

Within this section, three precedents will be evaluated, all of which are self-sustaining and highly efficient. These precedents vary in both technological advancement and form while maintaining an important standard of specificity to the site on which they are placed. It is important to note that function and use also vary from precedent to precedent and should be evaluated accordingly.

Self-Sufficient Modules by Cannata & Fernandes Arquitectos 29 (Figure #29)

Originally conceived for the Concreta Fair, the architects set out to develop a self-sustaining module prototype that could be easily reproduced and was capable of being easily adapted. The units were intentionally composed of light weight materials allowing them to be transported via truck or helicopter to a remote destination without causing an environmental impact. The designers employ the use of photovoltaic panels and rechargeable batteries to run the electrical components such as lighting, kitchen appliances, and the built-in vacuum sewer system. The shower is supplied by a prefabricated water tank. The only shortcoming of this system is that the sewer system would need to be emptied, and the water would need to be refilled over a period of time. This precedent is important because of its ability to be moved and transported to various locations all while upholding the qualities of being sustainable. The units vacuum sewer and light-weight composition are qualities both noteworthy and essential to thesis development.

Figure 29: Self-Sufficient Modules by Fernandes Architecture
Fincube by Studio Aisslinger\(^{30}\) (Figure #30)

The 506-square-foot one-bedroom home sits nearly nine feet above the ground, and its lifted on a small footprint of only twenty-three square feet. The home boasts triple-glazed windows with a low U-value while still maintaining a 360-degree view of the environment in which the home is set. Larch-wood louvers wrap the structure which provide both solar protection and a sense of privacy without blocking the overall view. Every aspect of the home is designed with energy efficiency and sustainability in mind. The roof is outfitted with photovoltaic panels with the option of also housing a green roof to help mediate storm water runoff. All of the interior walls are pulled away from the glass exterior walls in order to provide efficient circulation of air and users.

Fincube combines the modern services of plumbing and electrical of the Self-Sustained unit while adding a passive shading feature all of its own. One commonality of all precedents thus far is the unit is raised above the ground which offers increased circulation, protection, and views.


Figure 30: FinCube by Studio Aisslinger
Micro Compact Home by Richard Horden 31 (Figure #31)

The Micro Compact Home is an experimental prototype for a small home, that is both highly functional and extremely efficient. Designed and developed by architect Richard Horden and his student at TUM, the Micro Compact Home came to fruition in a life-size model. Before gaining a clear understanding of the Micro Compact Home, an understanding of what Micro Architecture is necessary. Horden states, “Micro architecture allows us to tap into (an) area of innovation, and benefits not only from research in form and materials but the development of prefabrication methods. The micro compact home, and in the future, the compact family home, can be built in a factory where the construction and use of materials is much more controlled and efficient.” His assessment not only probes an understanding of both architecture and sustainability, but also how those items will transept technology in the future. He adds, “The factory method also offers the opportunity to fit furniture to architecture in a more integrated and functional use of space...The ‘micro compact home’ has integrated table, bed and seating and, as with a car, boat or aircraft, there is no need to buy furniture. This holistic approach is a fundamental part of micro architecture (teaching).” From this description, it is understood that micro architecture is not only small, but also highly functional by employing efficiently designed spaces.

The Micro Compact Home fits that description effortlessly. Modelled to resemble the high-quality spaces of modern-day airplane interiors, with direct ventilation, indirect lighting, and built-in flat screens, the micro home is not only functional but sleek. Precision and control were of the utmost importance due to the limited amount of space within the capsule. Folding, swiveling, and turning elements were exercised throughout the entire of the home to ensure that every possible inch of space was used efficiently. Two compact double beds, a sitting area, sliding table with bench seats all compose

Figure 31: “Micro-Compact House” prototype by Richard Horden
the living and kitchen area. A toilet cubicle, and shower unit are combined to save space. Heating and air conditioning are built into the walls and floor, as is electricity and water throughout. Horden finishes by stating, “The luxury is in the compact technologies that allow us the greatest freedom of movement…The ‘m-ch’ is both luxury and necessity on a small scale, a high-quality home space for short-stay living.”

Something not mentioned in his written text is the Micro Compact Home is raised by crane or helicopter, and set on a small, raised foundation or legs, depending on the model. The unit is light enough to be set on a boat, or suspended from the side of a mountain. The Micro Compact Home is important as a precedent due to its high functionality while maintaining is ability to be light on the land.

Swamp Hut by Keith Moskow

Created as an emergency transitional housing prototype for Habitat for Humanity, the solution is created using simple structures and a limited material palette. The Swamp Hut is a series of four wooden pod structures linked orthogonally by a square-shaped outdoor deck platform at the center. Each for the four, eight-by-twelve foot A-frame pods serves a different function; sleeping, eating, bathing. Ensuring the complex has limited impact on the site, each pod is set on wooden footings and lifted above the swampy land below them. Another sustainability feature is that the complex of huts does not have access to water or electricity. The design is simple yet affective in that the architect developed a structural unit that was replicated, added, or removed to accomplish a desired outcome dependent on the pod he was creating. Another outlier in the precedents is the Swamp Hut and is unique due to its compound-like arrangement. Although less technically advanced in comparison to Micro Compact Home, Fincube and Self-Sustaining Unit’s design, the Swamp Hut boasts the natural, passive qualities while engaging authentically with its site.

Figure 32: Swamp Hut
Figure 33: Sun - Site Diagram for the Kalalau Plateau showing azimuth
Chapter 8 | Environmental Design

Site Analysis

Previously discussed in the introduction, the Nā Pali Coast, more specifically, the Kalalau Valley, is a location of sweeping landscape, rugged terrain, and high, fluted peaks. The proposed Kalalau Camp location is on a 1600’ x 1600’ plot of land known formally for this thesis as the Kalalau Plateau. This expanse of land is fairly flat, located between contours 120’ and 200’, the Kalalau Stream to the west, and the lower portions of the Kaaalahina Ridge to the east. The overall vertical change from the lowest extreme of the site to the highest is approximately eighty feet. This site location is in the mouth of the Kalalay Valley which allows for ample sunlight, wind, rain, and water to be available onsite or directly adjacent. According to data collected at the Haena State Park, the azimuth of the sun at noon on the summer and winter solstices run between 88°S and 44°S providing the site ample sunlight without interference of the surrounding cliffs and peaks to the south and west of the Kalalau Plateau. (Figure #33) As mentioned previously, water on site is not an issue. Rainfall will account for much of the water used in both the pod accommodations and the Community House. In the unlikely even of a rain shortage, the Kalalau Stream is adjacent to the site and can provide water which will undergo a similar sterilization process as collected rainwater.

The site itself has reddish-brown soils, large boulders and rock outcrops throughout, but its overall gently slopping toward the Pacific Ocean to the north and the Kalalau Stream to the west. A variety of tropical foliage can be found on the project site ranging from low-lying tropical shrubs, dense brush, and in some locations towering palms. Due to the enormous size of the project site, exact location of each tree, shrub, and rock outcropping is not important, but used a guide to determine

future placement of the pods. The site grows more rugged as it slopes toward the Kalalau stream were low lying brush, flowers, and large boulders can be found flanking both sides of the stream. The Kalalau Trail runs from east to west through the project site which will offer access and convenience to guests and will function as a point of reference for hikers passing through the site. The site's location is approximately three-quarters of a mile from the trails terminus at Kalalau Beach due west of the site and will provide expansive views of the Pacific Ocean, Kalalau Valley and Kalalau Beach in the distance.

**Site-Influenced Design**

Every aspect of this project is to impact various project sites along the Nā Pali Coast as little as possible. As an overall standard for the project, all guest areas and accommodations will be raised from the ground, on a series of legs or columns. This design decision was to ensure that foliage and hydrology beneath the structures would remain un-impacted whenever possible. The site location for the pod accommodations was strategically chosen to ensure the pods had unimpeded access to sunlight, rain, wind, and in some aspects protection from the sea. The Community House is sited over the Kalalau Stream to provide guests an experience near the Stream and surrounding waterfalls without the dangers and risks associated with entering or engaging with stream water as flash flooding is a constant danger regarding the Kalalau and Hanikapi‘ai Streams.³⁴

The gentle sloping and sometimes rocky nature of the site posed as a design challenge, especially when lifting structures from the ground. In response, telescoping legs were developed for the pod accommodations so that when the pods are air-lifted onto the site via helicopter, their legs will be adjusted by ground team and firmly leveled in response to each unique site location. This adaptability provides

both safety for the guest and stability for the pod itself when dealing with the wide range of weather events experienced at the Nā Pali Coast. Furthermore, the telescoping ability of each leg allows for the component to be self-containing and stored within the pod’s upper structure while in transit or storage.

The butterfly-type roof design of the pod accommodation was intentionally chosen for two purposes; to efficiently remove and collect rainwater and to effectively use wind as a passive cross-ventilation strategy. Due to the site’s excessive annual rainfall, the roof’s design actively funnels rainwater toward the lower valley of the roof where it is collected, purified and stored for guest use in sinks and showers. In conjunction with the front and rear door locations, the interior surface of the roof allows for wind and fresh air to enter the south door and push hot, muggy air along the pods ceiling and to the front door on the north side of the pod. Cross ventilation in this situation is extremely efficient, especially in such a tiny space. This roof strategy is also employed in the design for the Community House and functions in a similar manner.

The roof zone was also selected to house the support structure for the four photovoltaic panels which provides energy for the pod accommodations. Photovoltaic panels are necessary to provide electricity for the accommodation pods and the Community House due to their remote location without wired access to power. The Community House differs in design from the pod accommodations only in that the structure supports six panels instead of the standard four.

Due to the photovoltaic panels support structure being directly connected to the pods structure frame four lifting brackets, one on each corner of the frame can be found here. These brackets are necessary when airlifting the pods into place. Lifting cables from the helicopter are fastened to the brackets and the force is effectively transferred from the brackets, through the roof to the rigid frame of the structure itself.
Telescoping front and rear sitting porches for the pods accommodation were chosen to allow the space to be packed away while in transit or storage of the accommodation pods. These surfaces were designed using a light-weight aluminum frame and glass inserts. This combination was chosen for both strength and rigidity while still allowing light and visual access to the ground below. Access ramps which typically serve two pods each are constructed in the same fashion to be both lightweight, easy to move, and to allow for sunlight to access foliage on the ground below. Design decisions pertaining to the Community House do not vary from the design for the accommodation pods besides in a few instances. One of these instances is that the floor structure is composed from responsibly harvested Ipe from a local grower. This material choice was chosen for its rapid growth and renewable qualities as well as its unique graining patterns which add interest. The wood floor structure was also chosen to associate the Community House to the site in a more permanent, natural, and less invasive manner compared to the bold, non-site specific design of the accommodation pods.

A green roof what chosen for the Community House as a solution of providing food for guests staying at the Kalalau Camp. A Community House without the green roof would require regular and very expensive deliveries of food to the camp via boat landing at Kalalau Beach or by helicopter. The green roof provides site-grown vegetables and fruits and reduces the need for frequent delivery trips.

Overall, the design for the accommodation pods and Community House are not specific to the site itself and could function in a location with similar orientation and climate which was something that was considered during the development of the pods themselves. The site does not directly influence the design, but rather the climate and environmental parameters in which the pods are located directly influenced the design. This flexibility allows for this accommodation pods to be sited at any location.
within similar climate and orientation to the Nā Pali Coast without a major alteration to the design itself.

**Resort Methodology**

Resort methodology pertains to the layout and orientation of the Kalalau Camp and the land on which the pods are located. The camps overall layout and design derives from the understanding of how ancient Hawaiians would have sited and located their homes in relation to others within their village. Pods are placed in groups of two because a typical ancient Hawaiian family would share a single home, or for large families expand into another home directly adjacent to the first. This arrangement fostered both a sense of community within the family while promoting safety and ease. As such, two accommodation pods will be linked together with a ramp and gangway structure which will form a complete assembly as a pair.

Ancient Hawaiian communities which thrived in the Kalalau Valleys were typically composed of several hale (houses) linked into a network with a path. Rarely was there a large cluster of hale in one location. Ancient communities have been arranged in both linear networks and circular networks depending on the villages orientation to the land. The accommodation pairs will be placed into a network with a large circular trail system linking each pod into the network. (Figure #34) The Kalalau Trail will slice the circle into two halves. Units on the ocean side of the Kalalau Trail will be the “Pacific Units” and those on the mountainous side of the trail will be the “Valley Units”, respectively. This demarcation will help with organization, numbering, and administrative purposes and regardless of which cluster the pod falls into views of both the ocean and valley will be seen from most units. The distance between each pod pair is not specified or constant, but rather is based on the amount of foliage between each unit for privacy, the steepness of the topography, and exact placement of trees and shrubs.

Branching west from the circular trail network will be the Community House extension which will gradually meander down to the Kalalau Stream where the Community House will be sited. The Community House is located off the Kalalau Trail to provide guests with exclusivity, privacy and tranquility away from the activity on the trail.

**Water Management**

Water management is going to be a tremendous challenge and is a driving force in the development of this thesis. As previously mentioned, rainwater will be captured and purified for guest use within the accommodation pods and the Community House. Showers for cleansing, and sinks for washing and cooking will be the primary uses of water at the Kalalau Camp. Cisterns and holding tanks for water will be of the utmost importance for the continual use and maintenance of the camp. All soaps and cleaners will be required to be organic and environmentally friendly in nature as to not pollute the water used. Very little black water is produced with the vacuum-sewer composting toilet system as specified in the accommodation pods which greatly reduces the environmental impacts of such a potential pollutant. Gray water from sinks and showers will be held within the unit and slowly released into the surrounding environment over time to eliminate environmental impacts. Both systems will be maintained and monitored constantly to ensure damage is not taking place.

**Waste Management**

The camp is designed in a way so that it encourages guests to bring only what they need for clothing, entertainment, and nourishment on their trip along the Kalalau Trail. Once at the camp, linens, utensils, and food is provided. This design decision actively addresses the trash issue currently being faced by the Nā Pali Coast Wilderness State Park. Hikers
currently have to bring in their own food which usually means the generation of trash which needs to be packed back out of the park. As of now, a large majority of people leave the trash at their camp because it is a hassle to bring back with them: this is a huge environmental issue.

As designed, guests will need the amount of food to last them the journey from trail head to the Kalalau Camp rather than food for the entire week. Flatware, glasses, and utensils will be washable and reusable to eliminate the generation of trash. Napkins, sheets, and towels will all be washed and exchanged on a weekly basis to once again reduce waste. These textile items will be among the few items that will be delivered via boat or helicopter to the site on a weekly basis. Humus and black water produced by composting toilets in the accommodation pods will be collected on a regular basis across the camp and disposed of in a designated area free from possible contamination of ground water or natural streams while abiding by all local and state regulations.

Visitor Safety & Communications

Visitor safety and wellness while hiking the Kalalau Trail and during the stay at the Kalalau Camp is of the utmost importance. Trails in the camp will be marked with fluorescent rope standards to allow a clearly marked path for navigation to and from the accommodation pods. Flash lights, a foldable nylon hammock, and geo-locator tags will be given to each guest upon arrival at the trailhead of Kalalau. These items ensure a place to rest, a known position, and the ability to navigate at night while at the Kalalau Camp. Guests will no longer need to carry a tent, sleeping bag, large quantities of food and water onto the Trail which will reduce the risk of injury or death compared to a tired hiker carrying a 30-70 pound hiking pack on a steep or rocky trail.
An emergency satellite phone will be located at the Community House, Beach Station, and at the eastern intersection of the Kalalau Trail and the Camp trail loop. These phones will immediately dial “9-1-1” to report an emergency and will not hold functionality for non-emergency phone calls. Due to the camp’s remote setting, a mode of communication between the camp and civilization is incredibly important; a connection does not currently exist.
Chapter 9 | Schematic Design

Mindset

Upon finishing research and the various associated tasks, it was finally time to create the first iteration for the solution. The mindset behind the project has been unchanging since research has come to an end. Various aspects of the project needed to be addressed or handled in a very specific manner, three of which are most important: Preserving and restoring the landscape, sensitivity to culture, and unit sustainability. Each of these components were tremendous forces that needed careful attention and execution to ensure the project adequately considers all the impacts on the final thesis outcome. Thankfully, each of these aspects are all linked by the care and respect for the land which is the foundation for the Hawaiian culture.

Development of the unit was something of a challenge because the intention for the thesis wasn’t to mimic or copy indigenous design styled originally used by ancient Hawaiians, but rather cast a clear distinction that the structures placed on the site are new, and do not relate to the ancient relics that exist along the Nā Pali Coast. As this problem was navigated through iterations, several times the idea was reintroduced to mimic ancient structures in form and even material. Each time, the designs felt fake and gimmicky. Finally, when one of the iterations seemed to blend completely into the landscape, it was decided that the only solution to the problem would be to stand out with a bold statement and introduce a new form and style to the Nā Pali Coast. The motive was to seem intentional without the need or fear of not blending into the surrounding landscape, but rather boldly celebrate the achievement of inhabiting the lush coastline without causing harm or destruction to the beauty that exists on site.

Discussions ensued and worries arose that the visual impact of the pods spread across the Kalalau Plateau would be so visually striking it may, for some, take away the beauty of the Kalalau Valley. This concern drove the pods down in scale, size, and scope maintaining that their height never towered over
the tree line, while still maintaining a minor visual presence on the ground. The pods size and scope were finally confirmed with a scaled model of the Nā Pali Coast was constructed and the proposed accommodation pods were proportionally placed into the model. Little to no visual impact would be apparent due to the landscapes towering cliffs, lush vegetation, and overall scale of the surrounding pali.

Exploring the pods relationship to the ground was also a tremendous challenge for the development of the thesis. The pods had to impact the environment as little as possible, and with that in mind, several series of legs and support structures were created to confront the problem. Minimal surface area touching the forest floor was the goal, and certain solutions were more efficient and effective than others. The sloping topography of the site added another layer of complexity as the legs had to adjust, level, and potentially even lock to ensure the pod was stable and secure for guests. It was determined from the very beginning that the pods would likely be airlifted and placed onto the landscape at the Kalalau Plateau. Not only did weight and structure become extremely important, but the pods had to be strong, compact, and able to be stored. This meant that the leg design needed to store itself within the pod itself.

This was a welcomed challenge to confront because this aspect of design development meant that the pod would need to remain, simple, clean, and light weight. Late one, instead of the legs being designed to fold outward, it was determined that a better use of space would be for the legs to telescope from a vertically- oriented structural component that was slightly larger than it could extend from to meet the ground. (Figure #35) This was an important design change because the interior of the aluminum structural framing for the pod is hollow, meaning the void was available and efficiently used when placing the leg inside of it. The space that the legs originally occupied would allow for larger
Figure 35: Original folding leg design (left). Updated telescoping leg design (right).
water holding tank, bigger battery for electrical supply, and more room for plumbing and wiring—once more making the design simpler and efficient. Cultural considerations were difficult to address for this thesis. During development the question arose whether or not the pods or this project should even exist, because in Hawaiian culture it is believed that all land is sacred. The response to that daunting question was if visitors continue to harm the land, is the land really being respected as sacred? The answer was a universal ‘no’. The outcome was clear that if visitors were to remain visiting the Nā Pali Coast and staying in Kalalau, the way in which they stay in the Valley needed to change giving this thesis both validity and potential. Several times during this thesis, the Hawaiian culture and ancient Hawaiian archeological sites are addressed and noted as areas of protection, restoration, and caution. These site are sacred and therefore untouched, as they were intended to be. The mindset when addressing the Hawaiian culture was to educate visitors, inform them of special archeological sites, and to otherwise respect the culture by limiting exposure to these various sites along the Kalalau Trail. The thesis outcome is directly influenced by the placement of these sacred sites, their relationship to the camp, and special attention was paid when placing the various components of the thesis solution.

Sustainability was the last key component of the thesis development. The design development process began with a pod consisting of a flat roof, a set of front doors that opened in a traditional manner and a pod that was capable of sleeping only two visitors at once. At first glance, in a hot, humid, rainy, tropical climate this first iteration was a complete failure. The flat roof was no an efficient mode of removing rain water, doors opening traditionally required the space in front of the doors to be clear of any objects, and a pod limited to two guests meant more pods needed to be produced to reach a desired number of weekly visitors. (Figure #36) The flat roof
Figure 36: Original Accommodation Pod with Swinging Doors.
was transformed into a sloping butterfly roof with a large sloping front wing and small rear wing which would efficiently remove rainwater from the surface. The traditional outward-swinging doors were replaced with bi-folding doors that could be lifted vertically via pulley system to ensure that the porch space beyond could contain items regardless of whether the doors were in the opened or closed position without needing to be moved. These doors in combination with the sloped roof provided an efficient cross-ventilation strategy to arise which further promoted sustainability initiatives.

Several iterations of configurations were explored to address a pod only being able to sleep two guests. Much concern was displayed about this piece of design development. What if a couple was honeymooning? Would they want to sleep with two other people in the same pod unit? What if there was a family of five? All of these questions arose during this exploration. It was determined then that there would be two types of pods. A two-person pod and a four-person pod with the room for one additional nylon hammock inside. This predicament only furthered the promotion and necessity of ensure that the pods were joined by ramp and gang way should there be a situation with a family or friend group with a party larger than five people in which the party would split between two pod units with a shared gangway between.

Design development came to life when the creation of the Community House began, because it was a moment of clarity for the project because within a small space each initiative is seen clearly and simply. The Community House would provide an educational component to the project that architecture cannot provide. Visitor education was always an important detail that needed to be included in the final thesis solution and by doing so, it further promoted not only the sanctity of the site, but furthered the understanding of place and Hawaiian culture that would enrich the visitor experience. This aspect ensured that the visitors staying in the Valley respected,
understood, and would hopefully work to preserve and protect the natural beauty that exists there.

The Community House the focus of another problem: Food. If this structure would be the focal point for all things social while visiting the Kalalau Camp, it would need to effectively confront how food would be provided, served, and consumed for visitors. The task of preparing food for fifty to a hundred guests would already pose several complexities, especially in a remote location such as the Nā Pali Coast. Additional design components needed to be added to address this dilemma. During the circular development of the Community House a green roof was added, and when the crop yields for the green roof were found to be too small, the Community House was expanded to boost the numbers.

The size increased caused concern for some stating that it was too large to be non-permanent. The concern was a valid one and measures were taken to increase the permanence of the structure without permanently harming the landscape in a destructive way. The Community house was lifted above the ground, just as the accommodation units had been developed, placed on a columned support structure and situated the stream valley to ensure that only two sides of the structure touched the ground. The rest of the the Community House was then supported by beams and laterally-cantilevered under its own weight. The concrete piers in which the Community House sits could be removed should the time come for the structure to be removed leaving little to no trace of the structures existence within the landscape. The same light-weight, modular design created for the accommodation pods was translated into a multi-pod venue that speaks the same language of the smaller, more intimate accommodation pod. The Community House development was directly impacted by the precedents such as the Swamp Hut by Keith Moskow and the reception space at the Concordia Eco-Resort in St. John, USVI. Both precedents allowed for natural materials to be present in the design
palette ensuring a welcoming and connected appearance to the landscape in which they are situated.

Design development for this thesis was painstaking, because the threshold for error was so small due to the compact size of the pods themselves. A centimeter, an inch, or a foot could mean the difference between a system working, a door properly closing, or the proper stability of the pod unit itself. Materiality and appearance was something of joy and a chore to undertake. The same mindset of place, culture, and neutrality played out on a daily basis which pushed the project to remain simple, clean, and intentional. Most importantly, during the design development process, intentions remained constant, and project remained unbiased, aware, and willing to change should the reasoning properly present itself, and develop it did.
Figure 37: Interior view of Accommodation Pod Bathroom; daytime and nighttime with lighting scheme.

Figure 38: Four-person Pod displaying bunk beds with nighttime lighting scheme.
Chapter 10 | Design Development

During schematic design was when the project truly came to fruition. Countless aspects of the project were realized and clarified to the point that the thesis finally came to life on Kalalau Plateau. Details pertaining to joining, internal components, and functionality of the pods themselves were flushed completely. Material studies were completed and the final material palette was chosen down to the chrome shower fixture in the accommodation pods shower module. (Figure #37) Lighting scenarios, ETFE transparency, and wood grain direction were all taken into account during this time, and the design was pushed from something hypothetical into a realistic structure in which a human could comfortably sleep, relax, bathe, and marvel within.

Schematic design pushed the intricacies of the two-person and four-person pod to the edge of no return by requiring a simple mirroring of plumbing arrangements in the bathrooms for the systems to remain efficient and functional. (Figure #38) A set of bunks were introduced below the upper sleeping loft to increase the sleeping capacity from two to four in certain units. These changes introduced the need for more storage space for guest items, and the looming need for more water and electrical capacity. Countless hours were spent calculating the potential of deepening the pods base six inches to increase battery size, and water supply tank, but the changes directly contradicted the notion of living light on the land.

During this time an important revelation occurred; the pod is not able to provide hot water for four people to shower. This realization would allow the reality that these pods are actually situated ten miles from the nearest civilization and the camp is highly remote. While the accommodation pods are hospitable and suited provide amenities far superior than those considered to be “Glamping”, the actuality of the situation is resources are limited, they are precious, and need to be conserved. This revelation further promotes the ideals set forth at the beginning of this thesis to protect and cherish the landscape.
The Community House experienced a minor change during the schematic design process also by introducing the addition of fire. (Figure #39) The desire to experience a camp fire while visiting the Nā Pali Coast was high among those willing to voice their opinion on the topic. Most agreed that the remote location under the stars would be a magical moment for guests to experience a camp fire. This posed a challenge that needed immediate attention; the Nā Pali Coast Wilderness Park strictly bans fires while camping on site. Although photo records show this rule is regularly broken, by law, its illegal. After further research, a fire is able to be enjoyed if contained on five sized by stone, concrete, or brick. Following this discovery, the front and rear cantilevered decks were outfitted with a concrete-bottomed brick-encased stone-topped fire basin. This would ensure the evening social setting of the Community House had a focal point for all to enjoy as well as several options for programming such as s’mores, singing, or storytelling. In addition, this element would further prohibit and lessen the likelihood for an illegal camp fire to take place by a visitor staying at the camp.

Design Development concluded with the realization that the project was as developed as possible during the allotted time frame given. The notion that more could always be done is obviously challenging to accept when the solution has progressed so relentlessly over the course of several months. (Figure #40) As a conclusion, the current iteration will manifest as a series of illustrations that will boast the spirit of place, representation of culture, and importance of sustainability to further the motive, intention, and desired outcomes were achieved within the complexity of this thesis project.
Figure 39: Community House with the Firepit additions.

Figure 40: Interior of Accommodation Pod displaying a nighttime lighting scheme.
Figure 41: The Accommodation Pods have changed throughout the design development process.
Chapter 11 | Design Reflection

During the development of this thesis, the design has changed and morphed several times. Each iteration was furthered by new information and research that become available as it was discovered. While many of the iterations were unique in their own right, each were established by a set of parameters and requirements that drove the design forward into what it is today. Precedents and material studies played a major role in the overall design and outcome of this thesis in a way that both enriched and supported the design challenges they wished to address.

The Nā Pali Coast is a difficult site to design for in that the landscape itself is rugged, remote, and dangerous. In addition, cultural awareness, sensitivity to sacred sites, and religious restrictions added to the difficulty. The beauty of the site is what kept the design process moving forward. Understanding that the landscape and sacred sites were being destroyed was something of an alarm when putting forth the effort to create a solution to such a daunting and delicate situation.

This thesis proved to be multi-faceted in that it was highly fluid, technologically advanced, yet remarkably simple. At times due to the many complexities the final solution addresses, there was no obvious answer to the thesis question. A single change in materiality, program, or function would being to call into question all of the other decisions previously made in a domino-like fashion which required a set of parameters and rules to be created to further guide the project forward. These parameters and rules allowed for the complexity to be refined and choices to be more clearly made. In the end, the rules and parameters led the project to a clearly understood result of the project research, a responsible and logical use of material, and a highly-functional program that considers the site and project location.

Simplicity was an aspect of the thesis that remaining intact throughout the projects development. Too much complexity seemed to become cumbersome, unauthentic, and in many cases unrealistic.
The projects simplicity allows its functions, systems, and program to become the true focus of the design. Conversely, the complexity of technological components being used within the thesis allowed for services and functionality to remain high, while their presence and exposure to remain face-value. The solution harkens to a highly technical outcome that was refined which generates a front that is both welcoming and approachable despite its high functionality and adaptability. (Figure #42)

In the end, items such as costs, material sourcing, and internal operations would need further investigation. In the event of this project moving forward, the concept would enter a phase of highly detailed shop drawings, tests, and a prototype would be created. Due to the projects simple overall design, the prototype would address any large design errors before several pods were built and deployed although much of the design has been throughout flushed during its development.

Technology would play a large role in the reality of some aspects of the design. Advancement in micro technology would be necessary to fully and accurately execute graphic designs that generate color capturing rays of light within the ETFE. The technology exists today to fill as space of 1 cm x 1 cm with 500 million indentations, but not on a scale capable of undertaking filling several hundred feet with potentially billions of indentations. The practicality of such an undertaking is both highly daunting and expensive, but not impossible with the appropriate technological advancements in the future.

Reclaiming the Nā Pali Coast is possible by implementing this thesis as a solution. The project outcome would accurately address many safety, cultural, and programmatic problems the Hawaii State Park system is currently being faced with today. The thesis has the potential to save lives, protect cherished and sacred landscapes, and preserve one of the planets most beautiful coastlines from destruction and harm.
Figure 42: Accommodation Pods, doors open and closed. Daytime and Nighttime.
Definitions

**Active Façade:** A façade that responds to changing weather conditions by modifying its performance (by varying apertures, shading, etc.) 36

**Alternative energy:** Energy from a source other than fossil-fuel sources of oil, natural gas and coal (i.e., wind, running water, and the sun) 37

**Altitude Angle:** a solar angle that indicates the height of the sun in the sky.36

**Ambient:** referring to conditions in the immediate surroundings; sometimes used to describe naturally-occurring (or unaltered) conditions; in lighting, usually referring to general or area-wide conditions.37

**Array:** as assemblage of photovoltaic modules; PV manufacturers sell modules that are assembled on site into larger capacity units called arrays. 37

**ASHRAE:** American Society of Heating, Refrigerating and Air Conditioning Engineers. 37

**Azimuth Angle:** A solar angle that indicates the position of the sun relative to a reference orientation (typically solar south). 36

**Base Load:** a “typical” average electrical load for a building or generating system. 37

**Bilateral (Daylighting):** a daylighting system that introduces light into a space from two (generally opposite directions) 36

**Biodegradable:** A material (organic) that will degrade under the action of microorganisms; generally, describes a material that will decompose in nature in a reasonable time period. 37

**Biodiversity:** The existence of a large number and variety of species in a given geographic area; often used as an indicator of ecological health. 37

**Biofuel:** a fuel derived from unfossilized plant material (such as wood, garbage, rapeseed, manure, soybeans) 37

**Biomass:** unfossilized biological matter (wood, straw, dung) that can be processed (burned, decomposed) to produce energy (typically heat)\(^2\)  

**Bioremediation:** A process that uses microorganisms to break down environmental pollution. \(^3\)\(^6\)  

**Building envelope:** The exterior of a building’s construction—walls, windows, floors, and roof. \(^3\)\(^7\)  

**Building Integrated Photovoltaics (BIPV):** photovoltaics modules that are integrated in a building enclosure element (such as roof, shingle, glazing unit, spandrel panel) \(^3\)\(^6\)  

**Button-up:** The process where set mods are bolted down and finished. \(^3\)\(^7\)  

**Carbon Footprint:** A measure of the quantity of carbon dioxide expended through the burning of fossil fuels. A carbon footprint is usually referred to in tons of carbon dioxide of tons of carbon emitted, and provides a means of measuring the impact of human activity on the planet. \(^3\)\(^6\)  

**Coefficient of Performance (COP):** a dimensionless number used to express the efficiency of chillers (and heat pumps); COP is the ratio of the cooling output to the energy input (in consistent units) \(^3\)\(^6\)  

**Coefficient of Utilization (CU):** A measure of the ability of a lighting fixture and space to deliver light from a lamp to a task plane; the delivery efficiency of a fixture/ space combination; expressed as a decimal value. \(^3\)\(^6\)  

**Compact Fluorescent Lamp (CFL):** Small fluorescent lamp used as more energy-efficient alternatives to incandescent lighting. CFLs use less power and have a longer-rated lifespan. \(^3\)\(^6\)  

**Construction Waste:** Waste building materials, landscape debris, and rubble resulting from construction, remodeling, repair, and demolition of homes, commercial buildings, and other structures and pavements. Certain components of construction waste can contain lead, asbestos, or other hazardous substances. \(^3\)\(^7\)  

**Daily Heat Gain:** The amount of heat from various sources gained during the course of a 24-hour period. \(^3\)\(^6\)  

**Daylighting:** The use of natural light in an interior space to substitute for electric light. Daylighting is considered a sustainable building strategy because it reduces energy use and (when well-designed) can maximize visual comfort and productivity. \(^3\)\(^7\)  

**Daylighting Factor:** The ratio of daylight illuminance at a given point within a building to the horizontal illuminance at an exterior reference point; daylight factor represents the efficiency of a daylighting system in delivering daylight to a specified location; expressed by a decimal or percentage. \(^3\)\(^6\)  

**Deconstruction:** The philosophy and practice of designing a building to facilitate ease of disassembly to encourage reuse of components. \(^3\)\(^7\)  

**Deforestation:** The large-scale and long-term removal of trees from a region, typically due to over-cutting for fuel or building materials. \(^3\)\(^6\)
**Design Cooling Load:** A statistically significant cooling load (heat gain) that serves as the basis for system design and equipment sizing; expressed in Btu/h [Watts].

**Design Development:** A phase in the design process where design decisions are finalized; equipment and materials are selected, detailed, and specified; and construction documents are begun or prepared; design development follows schematic design.

**Demand Hot Water System:** There are hot water heaters designed to provide instantaneous hot water, rather than storing preheated hot water in a tank. These hot water systems can serve an entire home or be “point-of-use.” Benefits include less energy and water waste.

**Direct Current (DC):** The flow of electricity from high potential to low potential in a continuous, unidirectional stream; electricity from a battery or directly from a PV module is DC.

**Diurnal:** Typically referring to a 24-hour (daily) cycle.

**Diurnal Temperature Range:** A daily range of temperature; the daily maximum temperature minus the daily minimum temperature; expressed in degrees F.

**Ecological Footprint:** A measure of land area required to sustain an individual, community, or country; typically expressed in acres [ha] per capita.

**Eco-friendly:** Little or no impact on a native ecosystem.

**Engineered Lumber / Wood:** Composite wood products made from lumber fiber, sawdust and glue. Engineered wood products can be environmentally preferable to dimensional lumber, because they waste wood and small-diameter tree to produce structural building materials. Engineered wood products can be stronger and less prone to warping from humidity than typical lumber.

**ETFE (Ethylene Tetrafluoroethylene):** A fluorine-based plastic that is typically lightweight, strong, flexible, and highly transparent and that becoming a common building material.

**Equinox:** When day and night are of equal length (approximately March 21 and September 21).

**Extensive Green Roof:** A vegetated roof.

**Forest Stewardship Council (FSC):** A third-party certification organization that evaluates the sustainability of forest products. FSC-certified wood products have met detailed criteria in areas such as forest management, worker conditions, and fair trade.

**Formaldehyde:** A colorless irritating gas, CH20, used primarily as a disinfectant and preservative and in producing other compounds like resins.

**Global Warming:** An increase in the global mean temperature of the earth that is widely believed to be a result of increased emissions of greenhouse gases trapped in the atmosphere.

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Grey Tank: Domestic wastewater composed of wash water from kitchen, bathroom, and laundry sinks, tubs, and washers.  

Grey Water Reuse: A strategy for reducing wastewater; diverts the grey water to productive uses such as underground irrigation and non-potable functions such as toilet flushing.

Green: A widely-used term to describe buildings or products designed and constructed with minimal negative impact to the environment. Green building and manufacturing can utilize renewable, raw, and recycled materials or energy sources but emphasizes the conservation of resources, energy efficiency, and healthful interior spaces.

Green Roof: A planted green space on a building roof. Green roofs maintain living plants on top of a membrane and drainage system. Green roofs are considered a sustainable building strategy because they can reduce storm water runoff from a site and modulate temperatures in and around the building. Green roofs also have thermal-insulating properties and can provide habitat for wildlife and open space for humans.

Greenwash: A term used to describe disinformation distributed by a person or an organization in order to present an environmentally responsible public image.

Hale: A Hawaiian word for “house.”

High Efficiency: A general term for technologies and processes that require less energy, water, and other inputs to operate. A goal in sustainable building is to achieve high efficiency in resources when compared to a conventional practice.

Heat Gain: A flow of heat that will decrease the temperature of a building or space; heat losses include radiant, convective, conductive heat flows through the building envelope and the flow of heat from lights, people, and equipment within a building; cooling load is heat gain that directly affects air temperature (excluding stored radiation gains).

Heiau: A Hawaiian word for an ancient Hawaiian religious site or temple.

HVAC System: Heating, ventilation, and air-conditioning; an active climate control system.

Hybrid System: A on-site power generation system that includes alternative devices (such as PV, wind, or fuel cells) as well as conventional devices (such as a gas or diesel generator).

Hypothesis: A formal statement that predicts the behavior of a system; a testable statement.

Illuminance: The density of light falling on a given surface; expressed as fc [lux], which are lumens per unit area.

Indoor Air Quality (IAQ): The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) defines acceptable indoor air quality as air in which there are known contaminants at harmful concentrations. IAQ can be affected by microbial contaminants such as mold, or bacteria, chemicals, or allergen. Ventilation to dilute indoor contaminants is a way of improving IAQ.

**Intensive Green Roof:** a vegetated roof with some tall plantings and a fairly deep soil cover typically more than eight inches deep.  

**Internal Daylight Illuminance:** The illuminance caused solely by daylight at a defined location within a building.

**Kit House:** A home that is comprised of prefabricated parts, delivered, and then assembled on the site.

**Latent Heat:** Heat that is connect to an increase or decrease in moisture content of air in a building; heat is absorbed by the evaporation of moisture and released by the condensation of moisture; the heat required to change the phase (state) of a material; the latent heat of vaporization is related to a change from liquid to the vapor state, the latent heat condensation is related to the opposite phase change; in buildings latent heat is typically experienced as an increase or decrease of the moisture content of air.

**Life Cycle:** All stages of a product’s development, from extraction of the fuel for power to production, marketing, use, and disposal.

**Light-Emitting Diode (LED):** A long-lasting illumination technology used for many different applications, including residential and commercial lighting. One of the advantages of LED-based lighting is its high efficiency.

**Low-Emissivity (Low-E) Windows:** Window technology that lowers the amount of energy loss through windows by preventing the transmission of radiant heat while still allowing adequate light to pass through.

**Luminaire:** A lighting fixture.

**Marriage Lines:** The area where two mods come together.

**Microclimate:** A localized area of differential climate relative to the larger surrounding macroclimate; examples include the climate under a shade tree (versus in the open).

**Modular Home:** A highly engineered home built on an off-site facility in modules or sections and then delivered to the intended site of use. The modules are assembled using either a crane or trucks.

**Natural Ventilation:** Ventilation design that uses existing breezes on a site and natural convection to move and distribute air through a building or space. Strategies can include placement or operable windows and doors, thermal chimneys, landscape berms to direct airflow on a site and operable skylights.

**Non-potable Water:** Water that is not fit for human consumption.

**Nonrenewable:** Refers to a material as well as an energy source. A nonrenewable resource uses materials or energy that, once used, are gone forever and cannot be renewed through natural processes. Examples would include certain species of wood, some minerals (for materials), and petroleum and natural gas (for energy sources).
**Off-gassing:** The release of volatile chemicals from a product or assembly. Many chemicals released from materials (such as carpeting) impact indoor air quality and occupant health. 

**Panelized System:** A system including wall, roof, and floor sections/panels that are made in factory instead of on a construction site; SIPs are an example of a panelized.

**Passive Solar:** An approach for using the sun’s energy to heat (or cool) a space, mass, or liquid. Passive solar uses no pumps or mechanical controls to function. A solarium is an example of a passive solar technique.

**Peak Load:** The maximum electrical load for a building or generating system in a given period of time.

**Potable Water:** Water fit for human consumption.

**Prevailing Wind:** The predominant direction from which wind blows; this is often seasonal sometimes changes diurnally.

**Prefab Home:** A dwelling constructed off-site, usually in standard sections and then shipped to a site.

**Radiant Heat:** Heat transferred in the form of light energy. The radiant heat energy is emitted from a warm element (floor, wall, overhead panel) and warms people and other objects in rooms rather than directly heating the air. Radiant heat allows the air temperature of a room to be lower, yet occupants remain at a comfortable temperature.

**Rainwater Catchment/ Harvest:** Rainwater harvest and storage systems captures and used on-site to offset drinkable water needs for a building and/or landscape. Many different systems exist, most consist of a surface for collecting precipitation (roof or other impervious surface) and a storage system (cistern). Depending on the end use, a variety of filtering and purifying systems my also be employed.

**Reclaimed:** Reclaimed materials are similar to recycled products because they have been diverted from waste to be used for something else. An example would be reclaimed lumber, taken from an old building and refurbished for a new purpose.

**Recyclable:** A recyclable material can be reused again and again in the making of another product.

**Recycled:** Collecting, separating, and processing, a material that might otherwise end up in a landfill. A recycled material contains some percentage of these recovered materials in the finished product.

**Reflectance:** The characteristic property of a material (or surface coating) that allows it to redirect incident radiation without changing the nature of the radiation; expressed as a percentage of incident radiation.
**Relative Humidity:** A measure of the moisture content of the air; the amount of moisture actually held by the air compared to the maximum amount that could be held at the same temperature; expressed as a percentage. 36

**R-Value:** A measure of thermal resistance; the inverse of the thermal conductance of a material; expressed as ft² h °F/Btu [m² K/W]. 36

**Sanitary Drainage:** Building wastewater that contains biological pollutants and must be treated before discharge into the environment. 36

**Set:** The action of removing the mods from their transportation onto the site foundation, usually via crane. 37

**SIPs:** This is an acronym for “structural insulated panels”, a factory-made panelized system used to replace standard stick framing and usually created by sandwiching a thick layer of foam (polystyrene or polyurethane) between two layers of Oriented Strand Board (OSB), plywood, or fiber-cement. 37

**Skin-load Dominated Building:** A building the climate control needs of which are determined principally by exterior climate conditions acting through the building envelope; also termed “envelope-load dominated”. 36

**Solar Loads:** Cooling loads resulting from the impact of solar radiation on a building. 36

**Solar Panels:** General term for an assembly of photovoltaic (PV) modules. Using solar panels is a sustainable building strategy that reduces a building’s dependence on nonrenewable sources of power distributed through the grid system. 36

**Stack Effect:** Air, as in a chimney, that moves upward because it is warmer than the ambient atmosphere. 36

**Stand-alone:** An on-site power generation system that is not linked to the local utility system; also known as “off-the-grid”. 2

**Stick Built:** A home built using conventional methods entirely on-site; also called site-built. 37

**Storm water:** Rainwater that is not immediately absorbed on site and must be dealt with through on-site or off-site means. 36

**Sun Angle Chart:** A two-dimensional plat that represents the position of the sun in the sky vault over the course of the year; horizontal and vertical projection charts are readily available. 36

**Sunshades:** Devices for blocking unwanted sunlight and solar heat gain. 37

**Sustainable:** The concept of sustainability can be traced back to President Theodore Roosevelt, who stated in 1910: “I recognize the right and duty of this generation to develop and use natural resources of our land; but I do not recognize the right to waste them, or to rob, by wasteful use, the generations that come after us.” Sustainable materials and development should, in theory, last indefinitely,
without compromising the resources of the future. Sustainable products and materials are those that decrease their environmental impacts at each stage of their life cycle.  

**Thermal Capacity:** The heat storing capacity of a material; the amount of heat stored by thermal mass.  

**Thermal Mass:** A mass (such as stone, concrete, or brick) used to store heat. When used correctly in a building, it can be a useful technique for controlling the flow or storage of heat for occupant comfort.  

**Ventilation:** The deliberate movement of air outside a building to the inside.  

**Volatile Organic Compound (VOC):** Organic compounds that fade away at room temperatures, cause poor indoor air quality, and are dangerous to human health. Sources of VOCs include solvents, and paints. Many materials commonly used in traditional building construction such as adhesives, carpets, furniture, and paint emit VOCs.  

**Wastewater:** The spent or used water from a home, community, farm or industry that contains dissolved or suspended matter.  

**Wet-bulb Temperature:** A temperature measurement taken using a wet-bulb thermometer; an indicator of sensible heat density and air moisture content; wet-bulb and dry-bulb temperatures are identical at saturation (100% relative humidity); expressed in degrees F [C].  

**Wind Turbine:** A device for converting the kinetic energy of the wind into electricity.  

**Windward:** In the direction (or on the side) from which wind is blowing.
Bibliography


