Prefabrication and the Individual

by
Meredith Atkinson

Bachelor of Arts in Studio Art
Concentration in Architecture
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Submitted to the Department of Architecture in Partial Fulfillment of the Requirements
for the Degree of Master of Architecture at the Massachusetts Institute of Technology, February 2004.

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Abstract

This thesis attempts to address the perceived failure of the manufactured housing industry to adequately speak to issues of universality and specificity. The universal is investigated and redefined according to two specific circumstances: two communities, two lots and two houses, in two very different places. Hillside sites were selected in Santo Domingo, Dominican Republic, and in Los Angeles, California. A set of principles (*the universal*) was derived through the analysis of conditions on the two sites (*the specific*), and a new prefabricated construction system was developed in response. The universal acts as a platform for the individual; the prefabricated components are combined with sitebuilt elements, both systems having their role to play in the evolution of life on a hillside.

Thesis Advisor: Carol Burns
Title: Visiting Associate Professor

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Introduction

The Origin of the Project

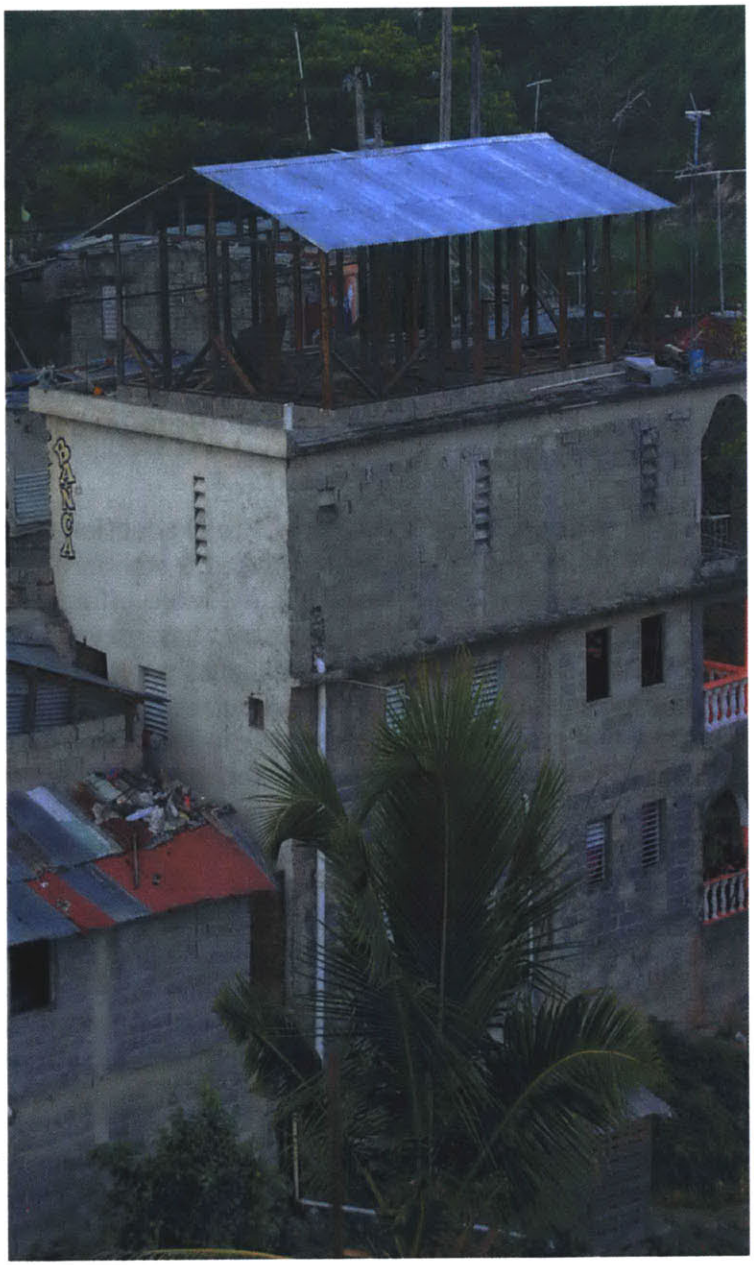
This project has its origin in January 2003 SIGUS Workshop in Santo Domingo, Dominican Republic. The two-week workshop focused on learning from informal settlements, as well as approaching problems from the perspective of the residents, government agencies charged with mitigating problems and managing growth, and NGOs working within the communities. More important than the specific knowledge I gained from the workshop was the profound shift in my own thinking: I began to have a new understanding of what dwelling requires and the means by which dwelling can be accomplished.

During the workshop, I began to understand the full extent of what can be achieved with limited materials and means. Entire homes that served their inhabitants' needs were constructed piecemeal over time. Adaptation to changing needs was integrated as a part of the construction, deconstruction and renovation process. Some immediate health, safety and welfare problems were apparent, especially in the poorer sections of the neighborhood. But better-off residents were able to construct homes with indoor sanitary facilities, stable roofs and even multiple stories to house growing families. During the workshop, I began to consider the issue of the significance of the architect and the architect's influence on housing in a place like La Puya.

Upon my return to the United States, I realized that this same issue applied to my own country. Other professionals, backed by federal and local codes, can take on the burden of health, safety and welfare. The majority of housing constructed in the United States is considered sufficient and safe - without the help of an architect.

The question applies equally in both La Puya and the United States: what can an architect offer to housing that is not already there?

This thesis reflects my own shifting definition of dwelling by rethinking the housing delivery system on two sites and proposing a new system, one that is more sensitive to the realities of human habitation.



(All images by the author unless otherwise noted)

The Limitations of Prefabricated Housing

Housing in the United States is nearly always delivered in part using a prefabricated system. When one speaks of prefab housing, dingy trailer parks and rows upon rows of identical structures come to mind. But prefabrication also refers to a huge range of systems from component systems to modular housing and HUD-code single-wide and double-wide homes. Pre-hung doors and windows are a type of prefabrication, as are offsite-built roof trusses and structural insulated panels.

There is an economy of scale to offsite production that makes it attractive to builders. The more standardized the parts or even the final assembly, the more affordable the product. So a large industry has developed surrounding single-family HUD-code housing. HUD-code is a performance-based code that stipulates that houses must be 90% complete upon leaving the factory. While this requirement was stipulated for quality control reasons, the result is that houses must be made to fit a generic site, and that a specified palette of materials and styles is applied to each house. Any customer intervention must take place in selecting components and options from a list, rather than in bringing local or even personal elements to the house once it is onsite. HUD-code homes look virtually the same installed as they did on the factory floor, resulting in entire communities of similar-looking buildings.

But public reaction to cookie-cutter houses and entire neighborhoods has been one of disgust. Modern homebuyers are willing to pay for customization. Manufacturers do their best to make their products look less "manufactured." Local ordinances in the US frequently prohibit offsite-constructed housing from being introduced to a neighborhood. People feel alienated from both the process and the product, as acknowledged in *Prefab* by Allison Arieff and Bryan Burkhart:

> Affordable, mass-produced housing by and large has focused on the production and assembly of the parts, as well as the construction process that then assembles the whole. Architect Peter Anderson explains that the site and the people who live on it 'are perceived as abstract variables rather than as specific generators of form and space. In this process, modular housing systems usually reduce the assumed context and house dweller to some lowest common denominator, the assumed-to-be-most-typical site and customer.' In other words, the house may be produced in the factory but the land it's built on and the people in it aren't. The mistake of most producers of mass-produced housing is that they often fail to consider or acknowledge the unique factors operating when human beings and the environment are involved."[1]

And manufacturers have reacted. Silvercrest Western


THE TOUR
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Homes[2] in Corona, California, prides itself on its "affordable luxury homes" that use materials and construction methods typically used in sitebuilt applications and offer customers a range of options before assembly begins.

Once installed, these houses look as much like developer-built housing as possible. When asked where the future of manufactured housing lies, Bob West, President of the California Manufactured Housing Institute, pointed to Silvercrest as an innovator in the industry.

But does developer-built tract housing really "consider or acknowledge the unique factors operating when human beings and the environment are involved"? Developers gladly publish standard floor plans and "styles" on their websites and allow customers to choose from a palette of options before construction begins. Examples can of course be found of housing that does respond to the individual, but it seems that the vast majority of low-cost, quickly built single-family homes fall prey to some of the same problems as manufactured housing. If the manufactured housing industry is trying to emulate the sitebuilt housing industry, are we going to wind up with more of the same, rather than true innovation?

The waiting room at HUD-code home producer Karsten Homes in Albuquerque, NM projects an image of high design rather different from the product the customer sees in the model home lot (right).

The Advantages of Prefabrication

Yet prefabrication remains a viable construction method and a vibrant business sector. In general, economies of scale dictate that products produced in larger batches are more inexpensive to produce despite shipping costs. But when traditional construction methods and materials are used, economy of scale is not the factor that drives costs down the most. In fact, in the United States, two other factors, financing and construction techniques, play a larger role in how cost effective offsite construction is in a given circumstance. Offsite construction can begin while a plot is being purchased and the financing secured. More importantly, houses built in a factory can move down a line from station to station so that necessary materials and tools do not need to move from house to house. When certain parameters can be standardized, labor can be effectively divided and work can be done in all types of weather, the work can be accomplished significantly faster. Silvercrest turns out three full houses per day in their Corona, CA factory. One 2,200 ft^2 home can be completed to 90% within 15 days. Installing the home on the site takes an additional 30-60 days. A typical developer-built tract home requires eight to ten months to complete. The speed of construction translates into thousands of dollars in savings on financing costs.

The cost of money is a larger issue in a place like California where construction is a highly regulated and bureaucratic endeavor than it is in the informal sector of Santo Domingo. Prefabricated housing is a less lucrative business in developing countries

The Corona, CA factory of Silvercrest Western Homes operates an efficient and safe business. They point to quality control and financing advantages as the reasons for their success.


NISSAN

like the Dominican Republic. There, other factors influence the feasibility of offsite construction. Quality control is more easily accomplished in a factory than onsite. For places that do not enforce building codes, this can be a life-saving advantage. Also, some materials that are not commonly available locally become more accessible when larger quantities are ordered.

These advantages have led both business and architects to continue to explore the limits of prefabrication all over the world. For architects, it can be a way to avoid being shut out of housing construction. In the United States, architects design only about 4% of the housing produced today[3]. If an architect can introduce good, sensitive design to the beleaguered prefab industry, a cost effective and responsive housing prototype could develop with the potential to change the way the housing market views architects and their services.

To that end, many architects have attempted to break into the industry in both the United States and Europe. *Prefab* outlines some of these projects, which take on issues from extreme cost savings to updating vernacular forms, as well as the oft-neglected issue of neighborhood creation. These designs are in various stages of prototyping and mass production today, and it will be interesting to see their effect on both the manufactured housing industry and housing in general.

The model homes on the Silvercrest lot are intended to look as much like typical sitebuilt houses as possible. The company markets to up-scale buyers through offering a range of choices for "personalization" of the factory product.

Prefabrication Combined with Sitebuilt

Rather than propose a new housing scheme that revisits the work that has been done in the manufactured housing industry, I have chosen to explore the possibilities in combining prefabrication with sitebuilt, user-generated elements.

The idea comes out of a sense of respect for what people already know about how they choose to live and how they interact with their built environments. It also implies that there is something that the architect can offer to an already quite developed system. Architects are trained to build structures that are safe, healthy and responsible, both to the user and to the surrounding community. They are also trained to respond to the intangible, to understand and bring out the poetics in a situation, to convey that sense of space to the user.

I intend to use prefabrication as a way of bringing the architect into the design and delivery process of large quantities of housing, and to use the sitebuilt to insure that the housing is infused with the individual.

One of the challenges was determining where one ends and the other begins; what is left up to the user, and where the architect maintains control.

Notes

[1] Arieff and Burkhart, P. 10
[2] Information about Silvercrest Western Homes Corporation gathered from a personal interview conducted in August of 2003 as well as the corporate website: http://www.silvercrest.com
[3] Beaudin, p.26

Two Sites

From the Specific to the Universal

> Industrialization needs no specific site or region. It begins with the ideal lot: flat, linear, clear-cut, firm, uniform, universal. Since nothing is less likely to be found than the ideal, one has to wonder if it wasn't the very difficulty of the site that demanded the invention of a sophisticated technology.[1]

Much of the design of prefabricated components is based on an average, the melting down of individual needs and preferences to a lowest common denominator. It becomes an average that, in the end, does not respond to anyone's real circumstances.

In developing a prefabricated housing component system, it is important to consider real needs, real living conditions, and real communities. Yet this component system is destined for mass production, to be distributed as widely as possible. It must contain an element of universality in order for it to satisfy basic needs for many people.

I chose to develop the prefabricated component system (*the universal*) as a result of the study of two particular circumstances, lots and neighborhoods (*the specific*). A set of universal principles was derived through the analysis of specific conditions on the two sites, and a new prefabricated construction system was developed in response.

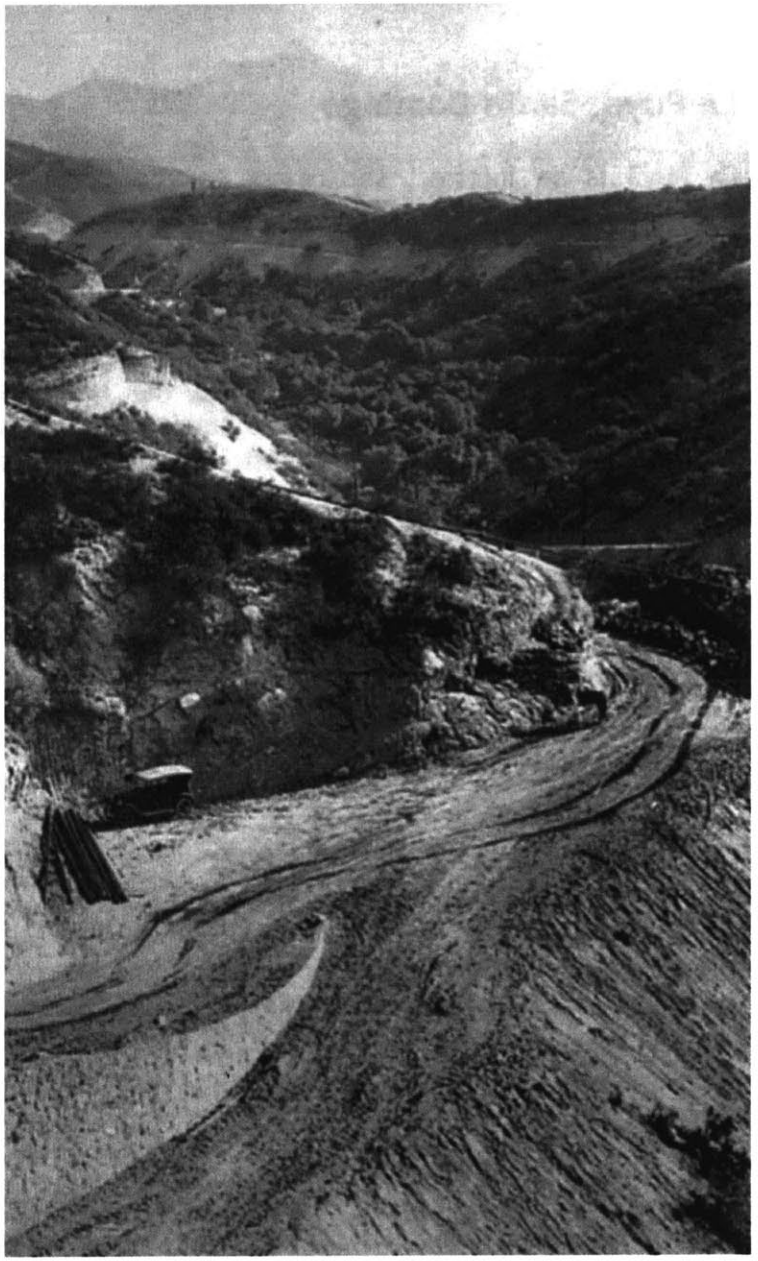
Narrowing the Problem

The two sites needed to share a mutual thread in order for common principles to be distilled. Yet the more different the sites were, the better they could serve to check one another, to test the system's universality.

One area of prefabricated housing that is little explored is hillside construction. There are, of course, difficulties inherent in standardizing a system for variable slopes, yet a real need exists. In many areas of the world, squatters settle sloping land because it is most available. But in transferring construction systems best used on flat sites, the houses become unstable and disaster can and often does result. At the same time in other areas of the world, hillside land is coveted and only the most exclusive homes occupy it.

> Living in the hills attracts people for many reasons: There is more privacy than in the crowded cities or usual suburbia.... The view is often spectacular. Wildlife abounds.... The attraction is so strong that most hill-dwellers return to the hills even if fire has destroyed their homes.[2]

The common thread between the two sites is their slope. Site analysis concentrated on understanding the condition of hillside dwelling as a universal phenomenon, and pinpointing exactly where residents' means and desires differed.

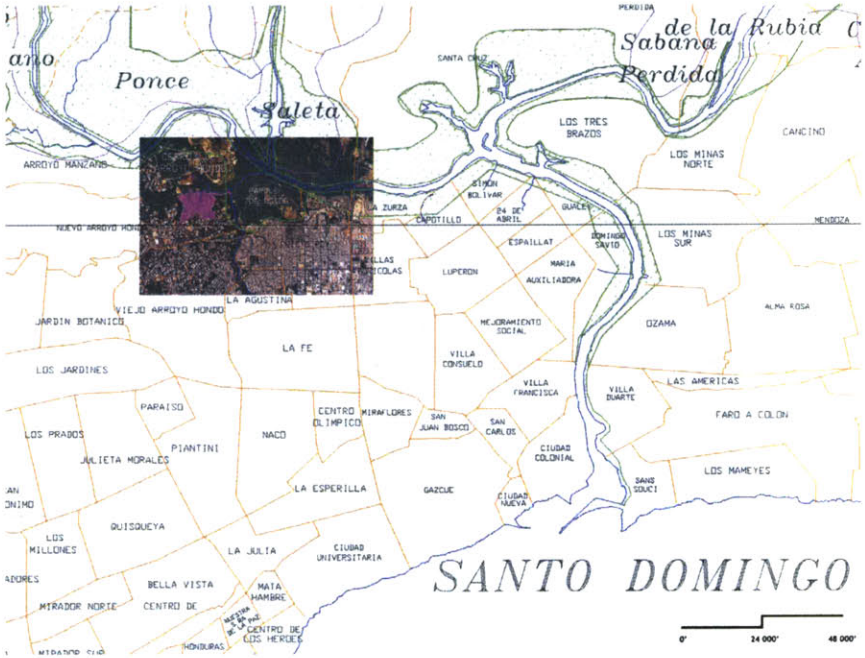


Layout of the roads in the hills of Hollywood near the Reservoir, 1923. (L.A. Public Library, as printed in Rouillard, p.8)

La Puya, Santo Domingo

La Puya is an informal settlement to the north of the central district of Santo Domingo, capital of the Dominican Republic. The land was most likely formerly owned by the government, and settling began in the mid-1970s. First the flatter part of the area near Avenida de los Arroyos was settled, and later housing spilled down the ravines towards the Rio Isabela's tributary at the northern edge. The barrio's neighbors include the National Zoo to the east, the middle class neighborhood of Arroyo Hondo to the south and west, and the new upscale development of Cuesta Hermosa III to the north.[3]

This pattern of settlement has led to a certain affluence at the top of the hill to the south. These houses are longer established and therefore larger, more stable and of more expensive materials. Navigable roads organize the streets, and wastewater runoff is mainly in covered canals at the edge of the streets. Most homes have deep latrine-style toilets, and sewage is contained.



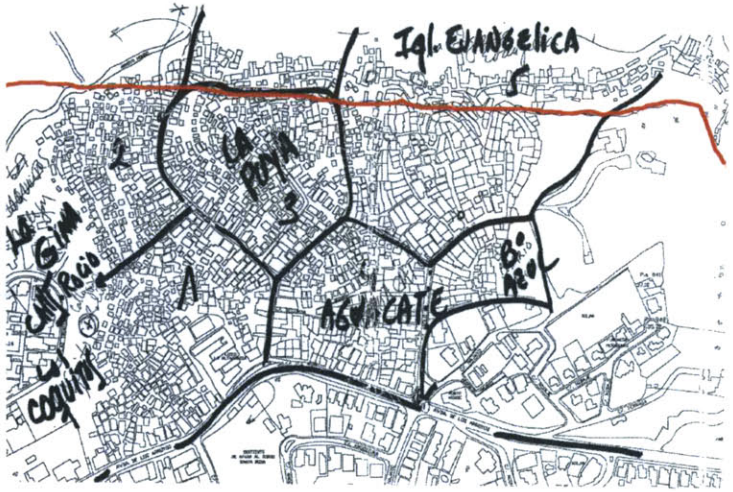
La Puya's location in Santo Domingo. The commercial center ofthe city lies to the southeast of the neighborhood. The hilly areas of the city along the riverbanks are dotted with informal settlements like La Puya. (Oficinas del Plan Director Urbano, ADN)

La Puya and its surroundings. Its density is striking as compared to nearby neighborhoods and public lands (Orthophoto from)

In the middle, there is a wider range of economic levels and construction. The land here slopes quite steeply, and many homes seem to cling to the hillside by a thread. Others, on the other hand, are quite well constructed and stand up to four stories tall. Streets have given way to a system of walkways and public stairs, some as wide as a street and others only just barely navigable on foot. Wastewater and storm runoff run down a system of canals, or cañadas, that follow natural runoff slopes down the middle of streets. Sanitary facilities range from some deep latrines, to shallow latrines and even direct discharge to the cañadas. Frequent hurricanes cause damage ranging from lifting insecurely fastened roofing sheets to mudslides that wipe out entire homes.

A tributary to the Isabela river lies at the bottom of the hill. During the dry season, it is little more than a trickle that does not have enough force to wash away the piles of sewage and trash that collect at the bottom. In the rainy season, however, the tributary floods as often as five times a year. During the past five years or so, this floodplain has been settled much as the rest of La Puya has. These houses are the poorest, partially due to their newness and partially due to the undesirability of the land and the houses' frequent destruction. All the cañadas discharge to this area, creating a breeding ground for malaria, dengue and yellow fevers. When a minor flood occurs, residents simply raise any belongings off the floor and wait uphill for the flood to subside. Structures are weakened over time, and the infected waters breed bacteria inside the homes. Roughly every five years, a larger storm carries away all the homes in the floodplain and these residents must start over.

According to community activist and neighborhood association leader Jesus Maria "Chu Chu" Vinel, the floodplain was never meant to be settled. When asked what should be done to alleviate the problem, Chu Chu said he was expressing the sentiment of the majority of the residents when he declared that nothing can be done for them in La Puya - they should simply be relocated to another outlying part of the city as soon as possible. The Dominican Defensa Civil asked La Puya leaders to draw a red line, *la linea roja*, that would determine which residents were to be relocated, and which could remain in their homes. A rough sketch of that line is below.

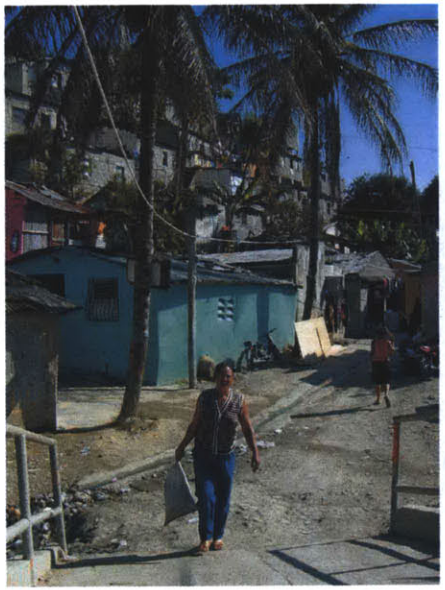


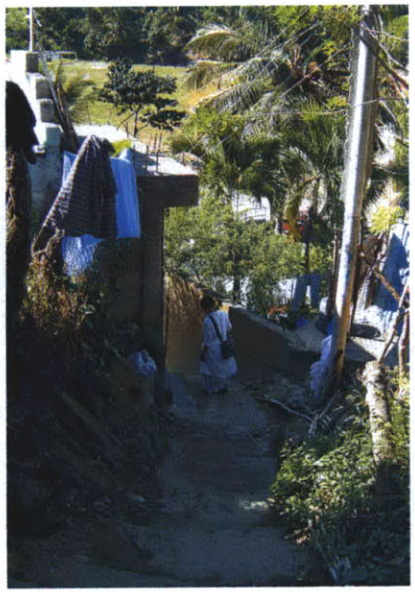
A rough map of La Puya showing *la Linea Roja*

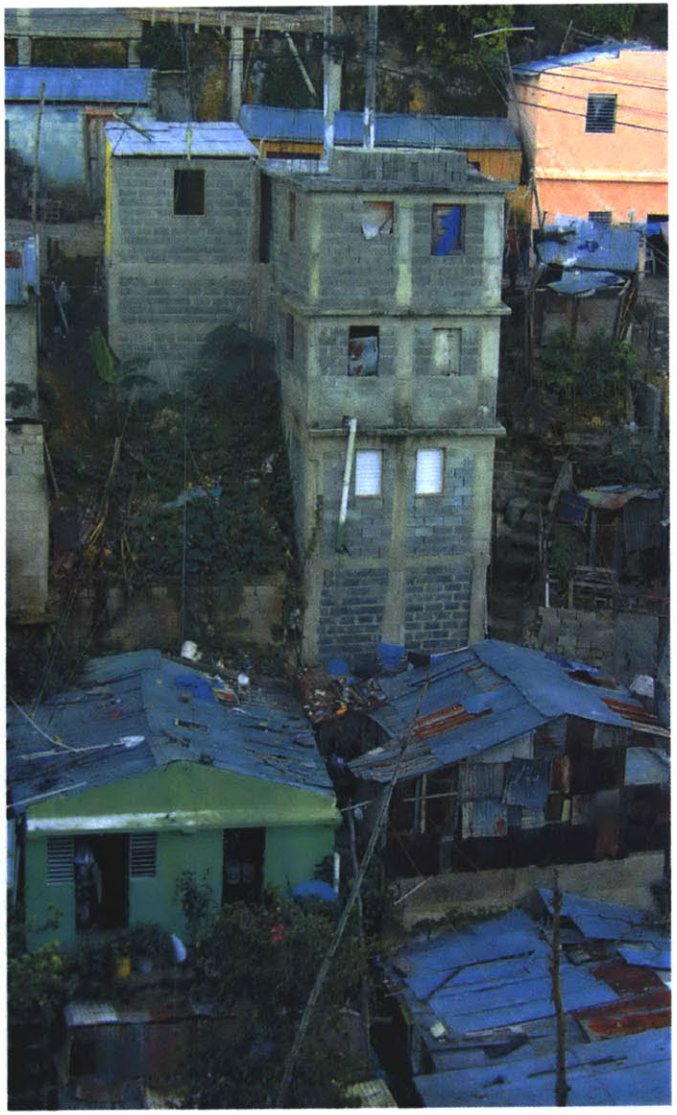
La Puya divided into four sectors: the top to the south, two middle sections and the lowest floodplain area to the north. Black lines delineate neighborhood council sections.

Floodplain residents, however, see distinct advantages to remaining in La Puya. Many residents moved to this part of the city initially because of nearby employment. More have family and friends that form a support system, enabling adults with children to work and go to school and children to grow up with their relatives. A trade network has developed which procures new and used building materials and other necessities. The exchange of labor, goods and favors is essential to the functioning of a life with little resources that is endemic in La Puya.

If more hillside land were made available and a construction method could be offered that would make hillside living safer, floodplain residents could be relocated within La Puya rather than moved to another part of the sprawling city. The money that the government would invest in building new homes for relocated residents could instead be applied to the partial construction of new units, and users could finish the houses with materials salvaged from their current homes.



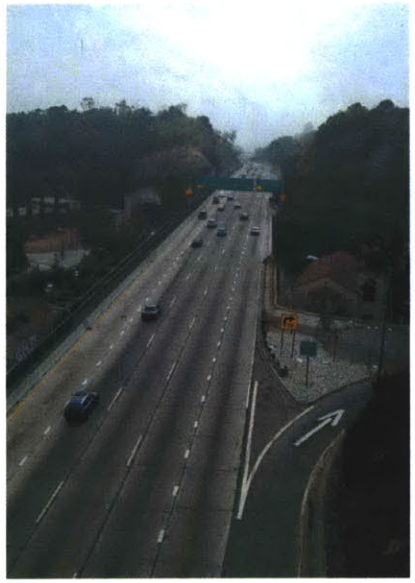


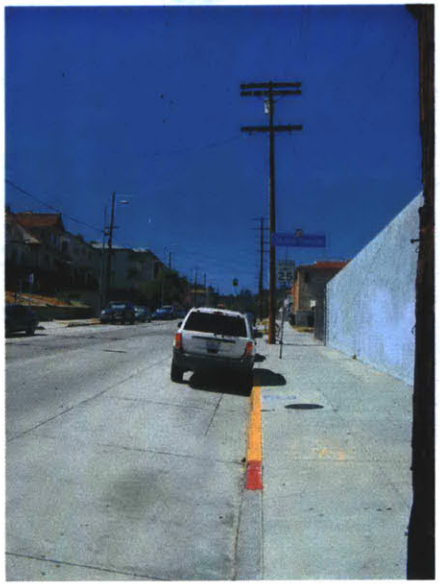


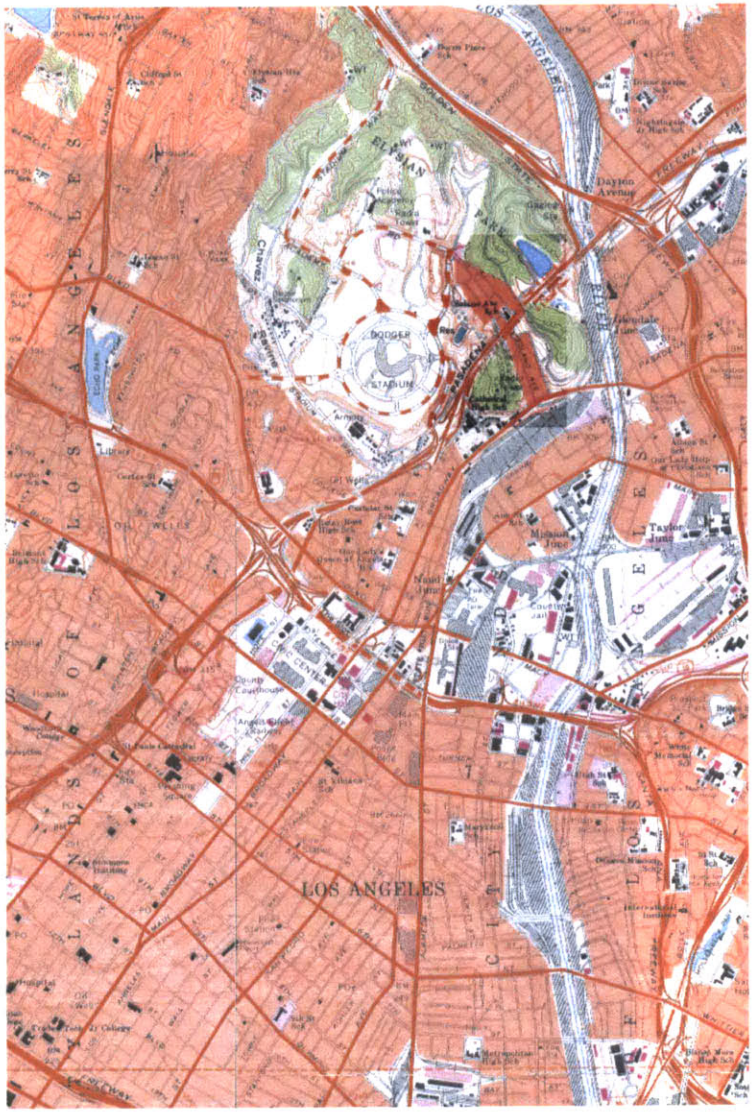
Solano Canyon, Los Angeles

Solano Canyon is one of Los Angeles' oldest neighborhoods. Located just north of Downtown and Chinatown, and surrounded by Elysian Park to the north and east, and Dodger Stadium to the west, the neighborhood retains a secluded, residential character despite its proximity to the center of the city. The canyon is long and linear, running north to south, and is bisected by the Pasadena Freeway. Two winding roads connect the northern section to the southern. About 320[4] residents live in Solano.[5]

Solano Canyon is remarkably diverse in several respects: Its housing stock consists of mainly single-family homes,







Solano Canyon surrounded by Elysian Park and Dodger Stadium, with Downtown Los Angeles to the South. (MIT Humanities Library)

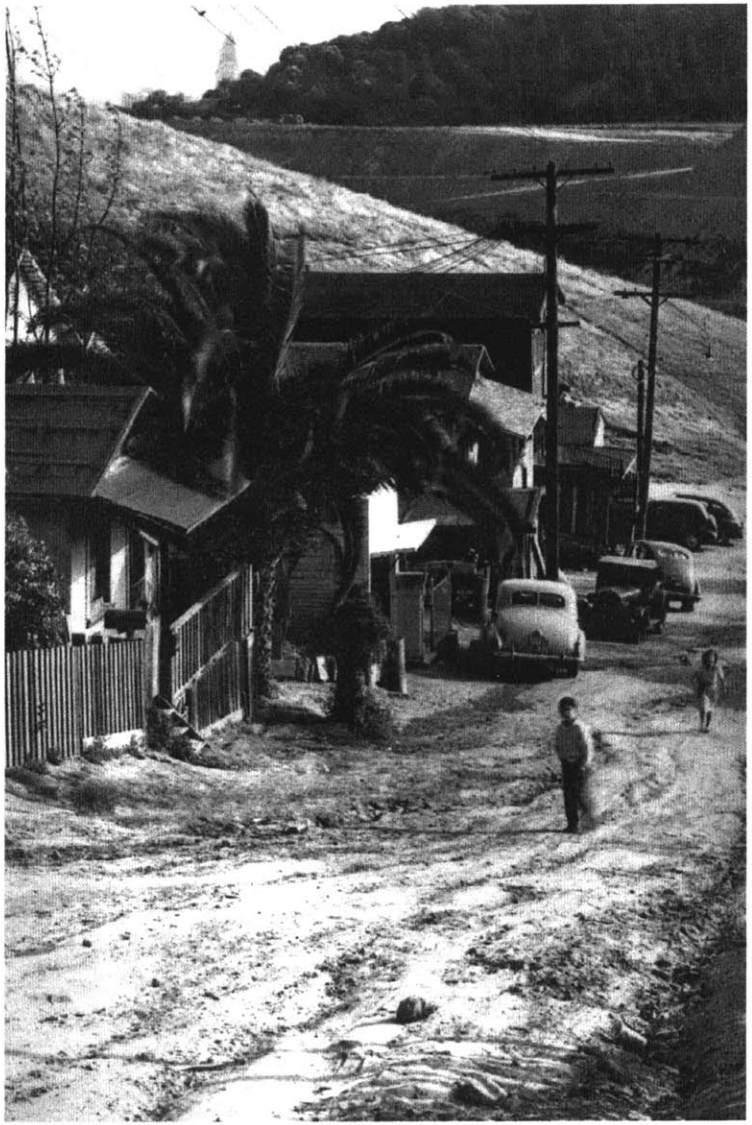
Orthophoto of Downtown LA and surroundings, showing relative densities and effect of topography on grid. (Alexandria Digital Library)

but also contains a number of two-family houses and apartment buildings. Residents are primarily Asian and Latino, and from a wide range of economic backgrounds. The neighborhood's size is conducive to community awareness and activities, as evidenced by the active community garden, involvement with the local elementary school and political activism.

The history of a neighborhood adjacent to Solano Canyon has left quite a mark on the community as it stands today. Under the authority of the 1945 state Community Redevelopment Act, slums in urban areas could be cleared as long as displaced residents were offered "safe, sanitary housing at a price within their means.[6]" Throughout the early 1950s, the entire area referred to as Chavez Ravine was cleared using Eminent Domain for the purpose of constructing 3,360 units of public housing, one third of the total 10,000 units planned for all of Los Angeles at the time. Elysian Park Heights, as the development was to be called, was caught up in a national battle over public housing[7], and the project was stopped in 1953 - after the land had been cleared (but for a few remaining holdouts) but before anything had been built. By 1958, an agreement had been reached to relocate the Brooklyn Dodgers to a new stadium and 40 acres of parkland, to be built on the cleared land.

Solano Canyon consists of two residential sections bisected by the Pasadena Freeway. (Alexandria Digital Library)

A family of six lived in this one-room house on Brooks Street. (Cuff)

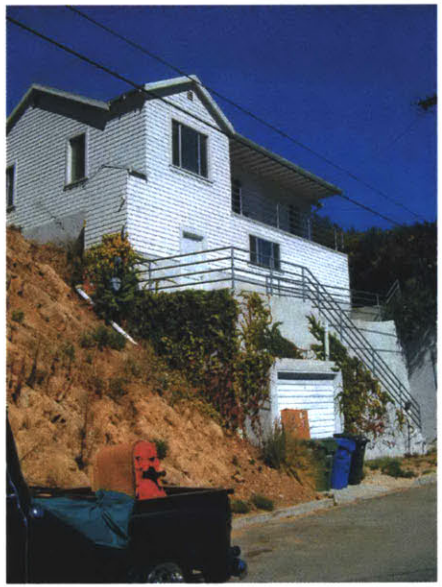


Chavez Ravine in the 1940s (Cuff)

With the memory of the debacle of the 1950's clearly in mind, today's Solano remains fiercely protective of its character, its residents and its land.

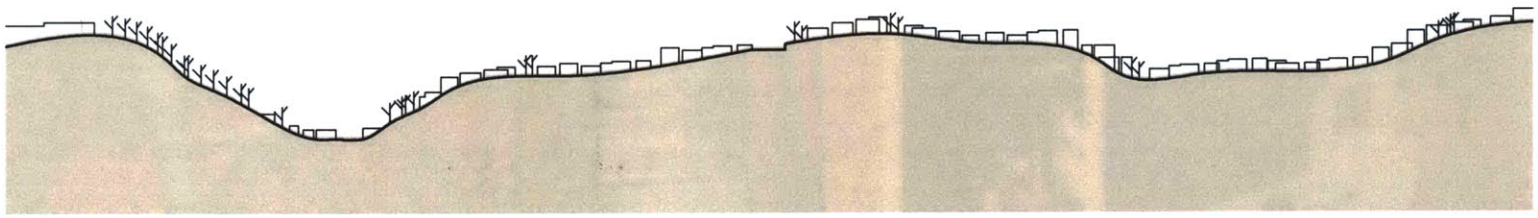
> "Large developers holding land that extends from Aliso Village north to Dodger Stadium advise their consultants to tread quietly through Solano, a working-class Latino neighborhood adjacent to Chavez Ravine that watched as their neighbors' homes were destroyed. Since then, residents have vigorously opposed threats to their own neighborhood to avoid the same fate.[8]"

A community-run website describes the area thus: "It is a secluded area of Los Angeles that not many people know exists. And that's just the way we like it.[9]"

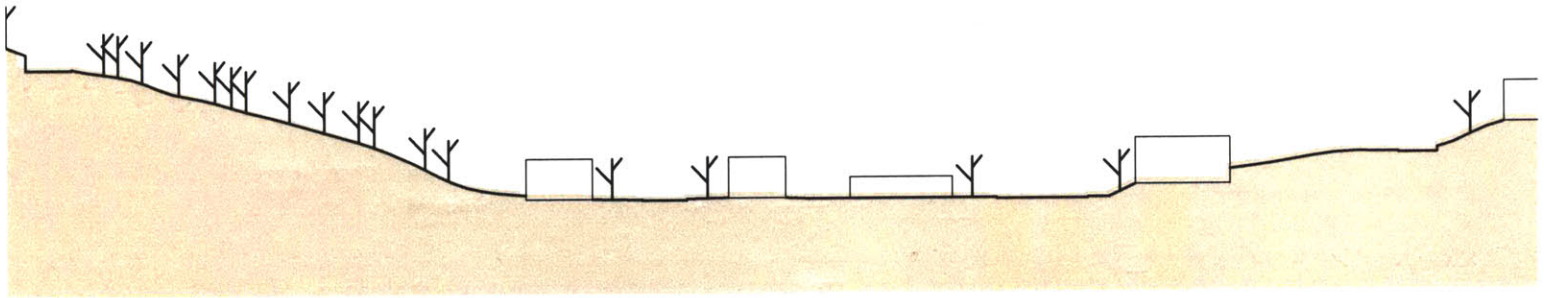


Site Comparison - Physical Characteristics

Slope



Buildings sit on slopes in La Puya up to 50°, however most houses built on steep slopes are unstable due to poor construction practices combined with landslides and high winds. Stairs frequently take the place of streets and most navigation is done on foot.

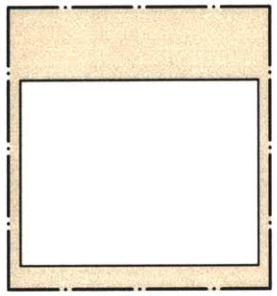


In Los Angeles, hillside land is often the most desirable due to the clean air and views. Many builders choose to grade lots for simplified construction. Grading, however, damages the sensitive balance between water flow and erosion, and extensive cut-and-fill practices destabilize the land and the buildings built on it.

Scale

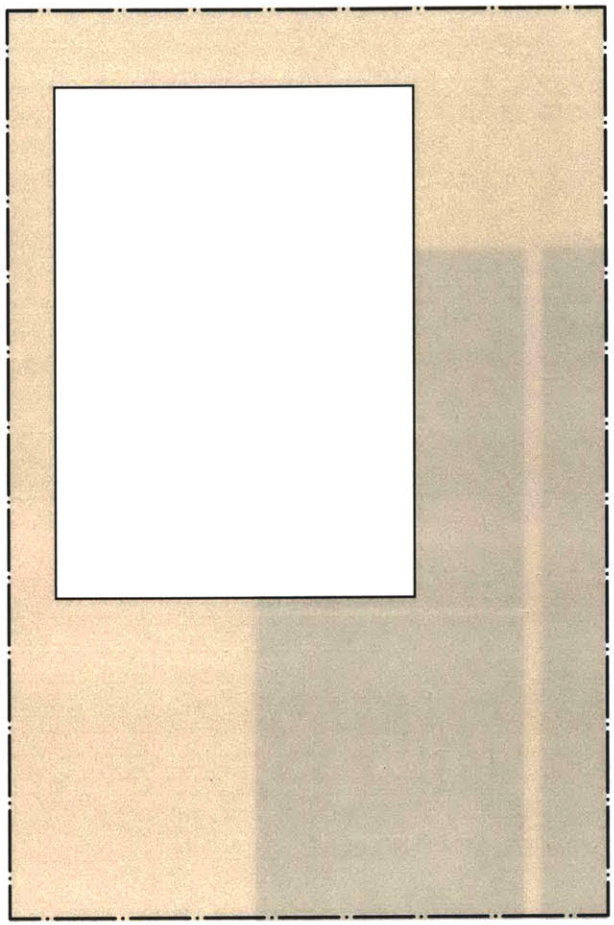
Typical lot La Puya

- 310 ft^2 house
- 520 ft^2 lot
- 60% lot coverage
- Municipal water and electricity
- Lack of sanitary facilities



Average lot size in La Puya is 518 ft^2. While settlement takes place outside of the formal sector, lots are bought and sold, and lot lines are respected. Given the lack of individual open space, the vast majority of groundspace is paved.

Houses in La Puya are quite small, with an average size of 308 ft^2 for two rooms. Bathrooms are not typically integrated into the building. Shallow latrines are built as additions onto houses and are occasionally shared among several homes. Adjacent homes often belong to several members of a single family.



Typical Lot Solano

- 1275 ft^2 house
- 3775 ft^2 lot
- 34% lot coverage
- 2 bedrooms, 1.5 baths

Lot sizes in Solano Canyon are limited. Average lot width is 50 ft, and the average area is 3775 ft^2, 7.3 times the size of a La Puya lot. Many lots are graded, and primarily occupied toward the streetfront, setting up a relationship between a house and its neighbors while maintaining some private outdoor space. Lots and yards are lushly planted.

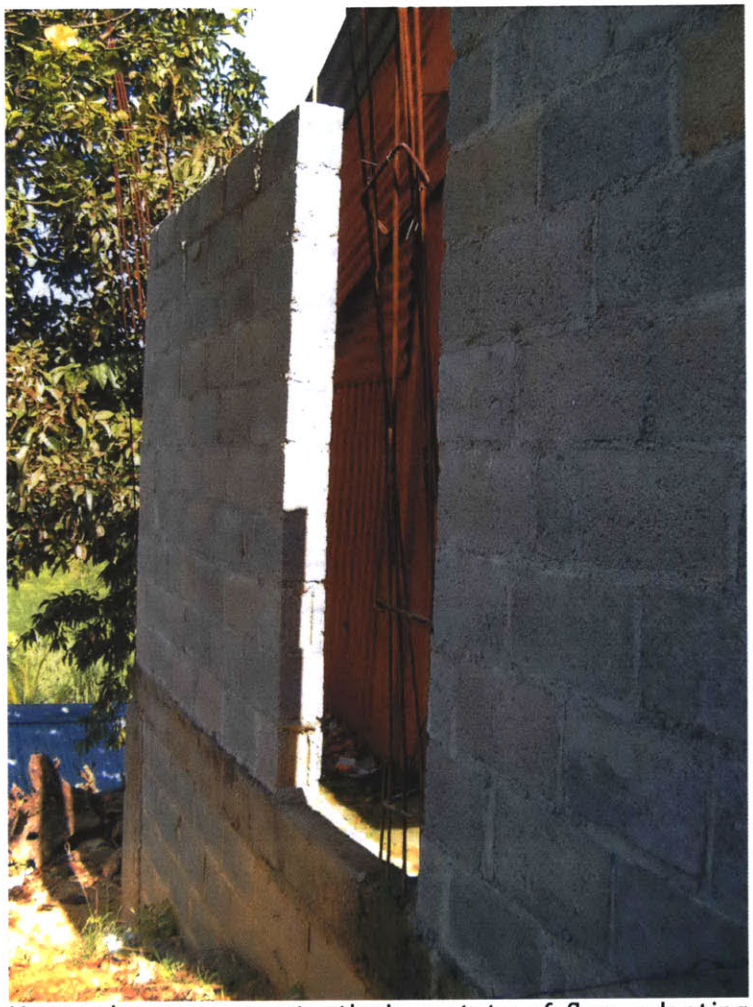
Houses typically have an average of three rooms, 1.5 baths, a kitchen and a garage or carport. Many of the houses in Solano have been there for over thirty years, and have been adapted and renewed frequently. The neighborhood is remarkable in the variety of housing stock available: newer homes, houses in need of repair, large and small single family homes, multifamily homes and a few apartment buildings.

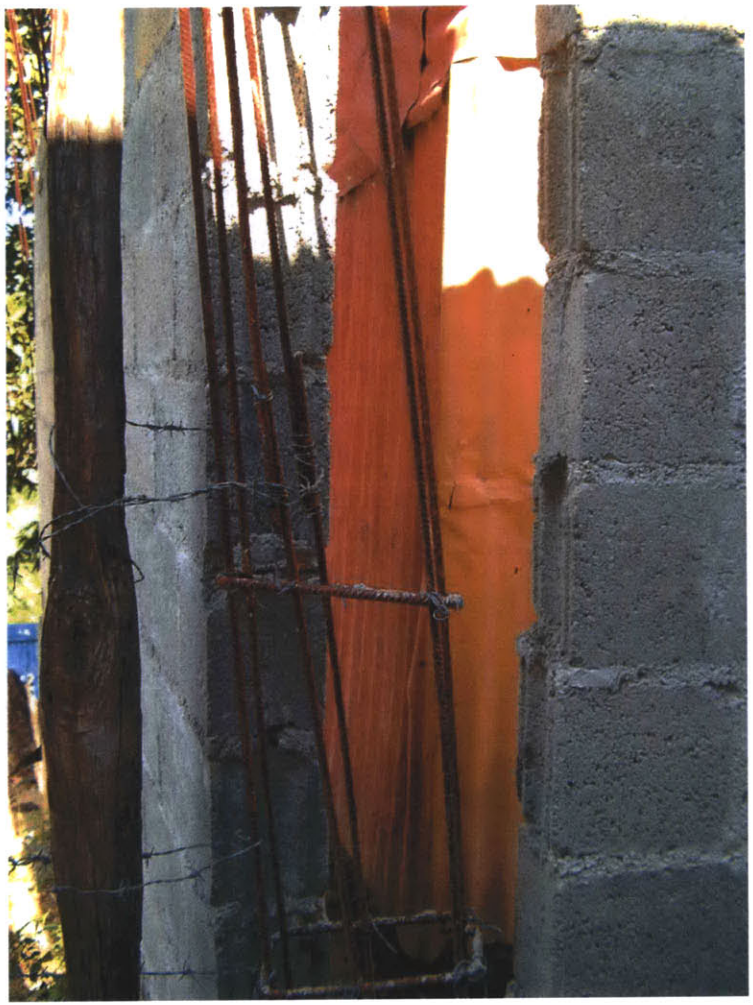
Site Comparison - Common Practices

The starkest difference between La Puya and Solano Canyon lies in the construction methods and materials used.

Although informal, La Puya has a highly developed system in place for residential construction. The most common materials are sold and even produced locally within the neighborhood. Contractors either buy materials from neighborhood shops or trade with neighbors and friends for new or used materials.

Corrugated galvanized steel sheets are the least expensive and the most common building material for both roofs and temporary walls. There is some plywood used in La Puya, but it is relatively expensive and ill suited to the wet climate. The material of choice is locally produced CMU block, which is lightly reinforced with expensive steel rebar.



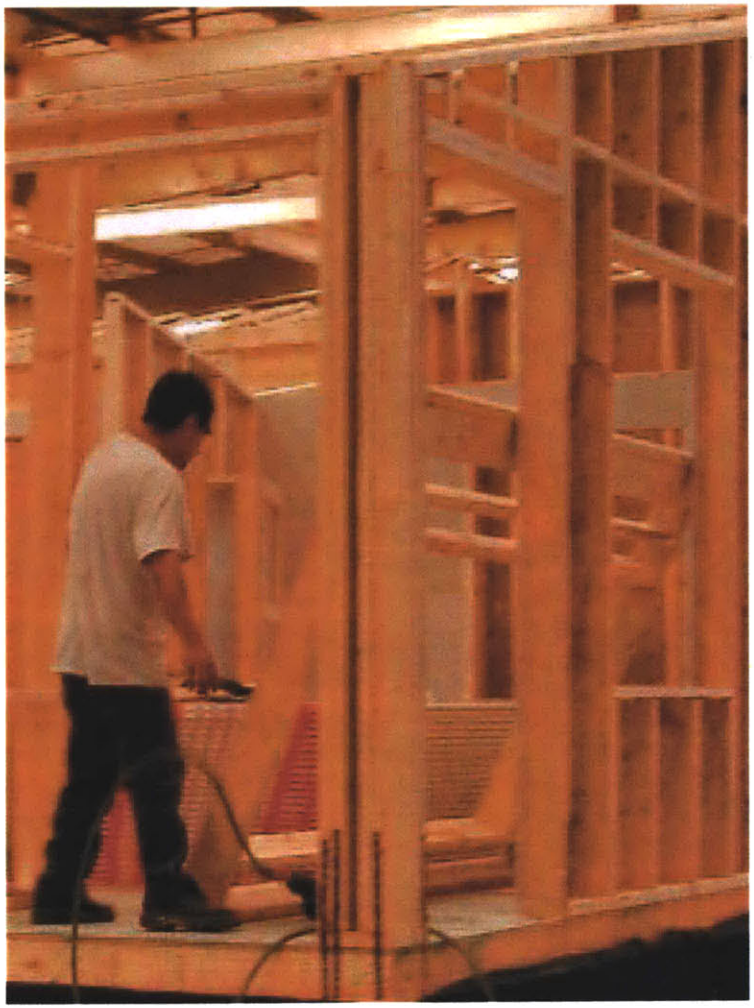


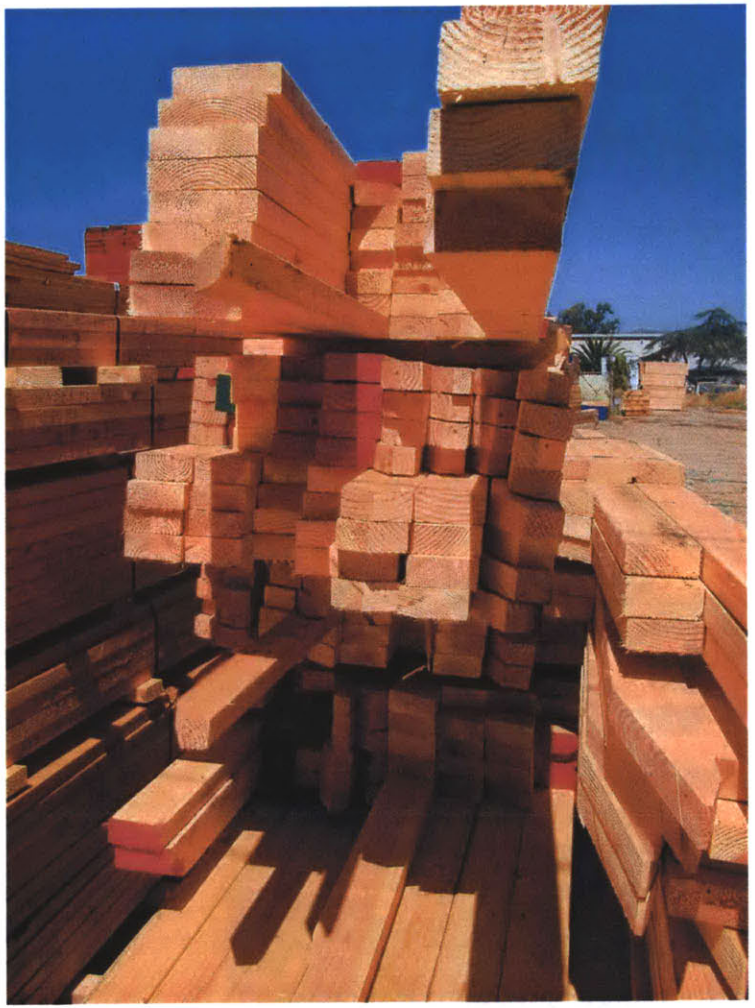
Houses here are constantly in a state of flux, adapting to residents' needs when money and materials are available.

Construction in Solano, like much of the United States, involves the collection of raw materials and prefabricated components from all over the country. With lumber from the Northwest as the primary structural material, and site-poured concrete foundations, everything from pre-hung doors and windows to cabinetry assemblies are hammered and nailed into place. This form of construction requires a certain standardization of methods and sizes, but encourages quick, high quality, safe and functional production.

Individual expression and adaptation normally take place over a long period of time. In areas where one developer builds several houses at once, it may take decades before individual houses in a neighborhood take on the characters of their owners.

Houses in Solano vary from about fifty years old to brand new and the neighborhood simultaneously expresses individuality and cohesion.





A newly developed section of Los Angeles' Westchester shows little variety in housing stock.

One of the older houses in Solano Canyon showing the area's diversity. It has probably gone through some changes over the years.

Notes

[1] Rouillard, p.137
[2] Levin, p. xvii
[3] Information about La Puya and Santo Domingo from direct observation as well as interviews with residents, NGO staff and city officials. Research conducted as a part of the SIGUS January 2003 Workshop in Santo Domingo.
[4] http://caot.lacc.cc.ca.us/112/FinalChavezRavine/CR_community.htm
[5] Information about Solano Canyon gathered from Dana Cuff's *The Provisional City*, the community website, http://caot.lacc.cc.ca.us/112/FinalChavezRavine/index.htm, interviews with local authorities and direct observation. Research conducted as a part of Schlossman Fellowship in August 2003.
[6] As cited in Cuff, p.273
[7] For more information on the battle surrounding public housing in this era, Cuff's *Provisional City* provides good insight.
[8] Cuff, p. 300
[9] http://caot.lacc.cc.ca.us/112/FinalChavezRavine/CR_community.htm

Principles

The Role of the Architect

Much has been written on the role of the architect. The American Institute of Architects considers itself the "voice of the architecture profession" in the United States. Its representation to the public of the role of the architect can be summed up in the "What Can an Architect Do For You" section of its website.

> Architects have the education, training, experience and vision to maximize your construction dollar and ease the entire design and construction process....

In particular, residential architects:

> ... are specially educated to help you define what you want to build, present options you might never have considered, and help you get the most for your valuable investment.... Architects are trained problem solvers.... Your architect represents you, not the contractors.[1]

On the other end of the scale, Le Corbusier defined the architect as such:

> The architect, by his arrangement of forms, realizes an order which is a pure creation of his spirit; by forms and shapes he affects our senses to an acute degree and provokes plastic emotions; by the relationships which he creates he wakes profound echoes in us, he gives us the measure of an order which we feel to be in accordance with that of our world, he determines the various movements of our heart and of our understanding; it is then that we experience the sense of beauty.[2]

As we see in practice today, successful architects approach the profession in ways as varied as the two definitions above. Norman Foster not only produces a very different looking building from one by Zaha Hadid, but also considers different priorities when approaching a project.

In the end, it is really up to the individual with architectural training to define for him- or herself exactly what role he or she wants to fulfill. I consider it a part of my architectural education as well as an integral part of this thesis project to determine for myself what role I will play in the profession. For me, an architect is one who has the skills, training and desire to:

Approach and define complex problems, bring out the poetics and solve for it in a technically minded way.

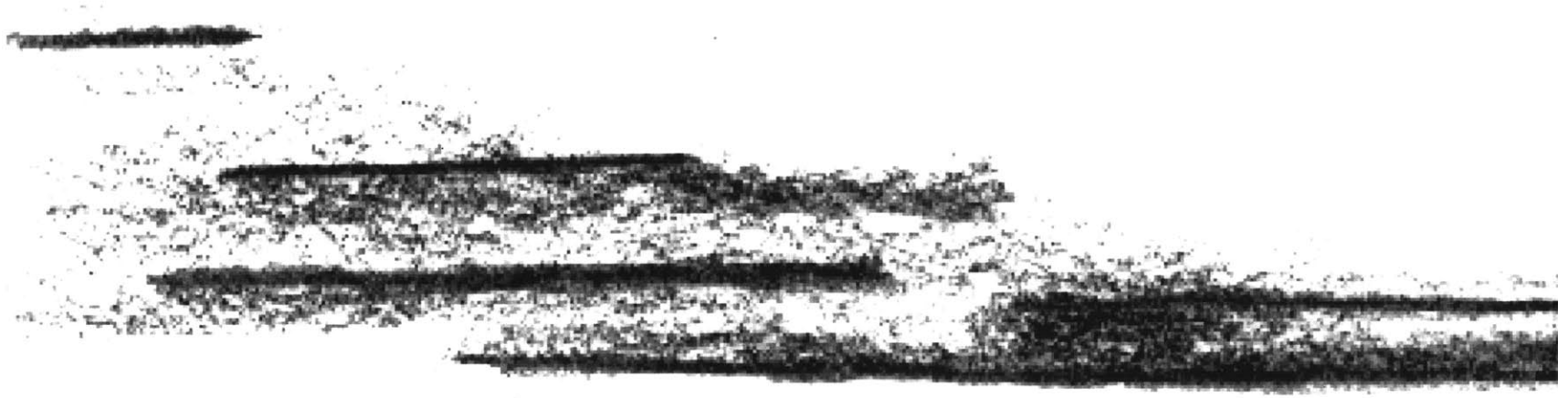
It is with this in mind that I have approached the extraction of the following principles as a poetic basis for the design of the system.

Flow

Humans live on horizontal surfaces; hillsides are not horizontal. Negotiating between slopes and surfaces creates moments of movement and stasis.

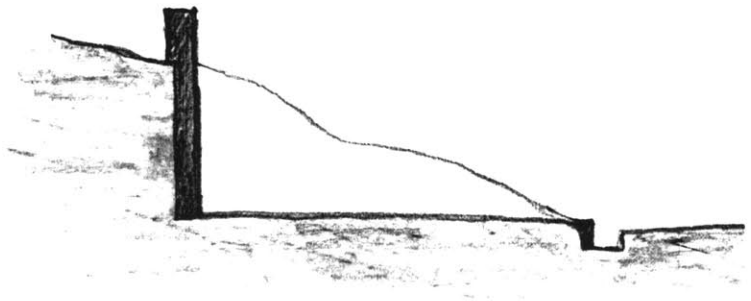
*The condition of living on a hillside is a condition of **flow** through those moments of movement and stasis.*

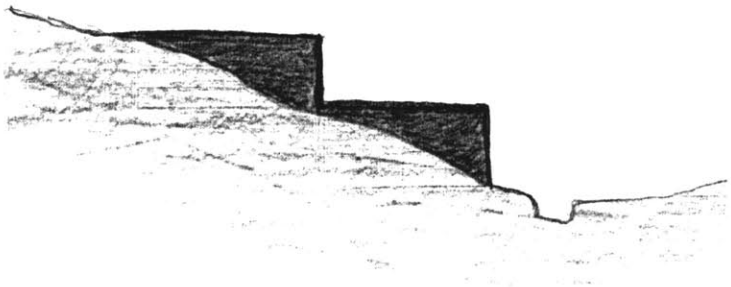
Three types of flow are primary on sloped land: earth, water and human flow.



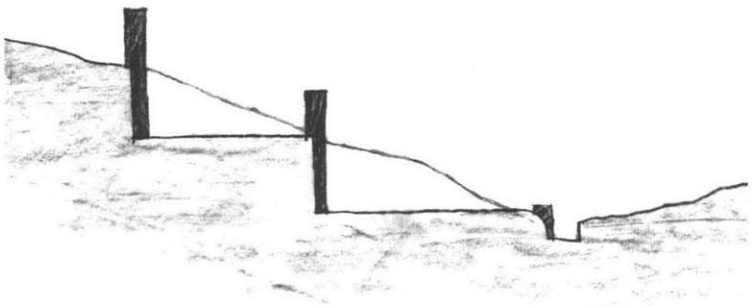
Earth

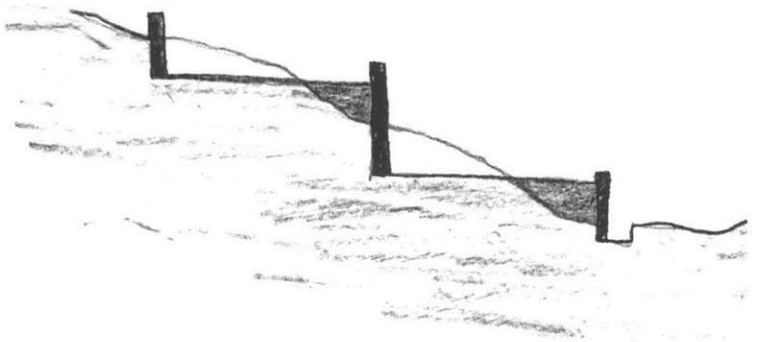
Earth must be held against gravity, stabilized against sliding and retained against erosion. It provides a shelter and a habitat, a base from which to build. Hillside dwelling implies both combating and embracing earth flow.





Choosing the type of connection to the ground is primary to any hillside construction. Some choose to cut the entire space into the hillside, or build completely on manmade fill. These are acts of violence to the slope - a denial of the natural conditions that make dwelling on a hillside what it is. Excavation requires not only a consideration of the tools and methods available on a particular site, but also a sensitivity to how the site is transformed by the act of digging.

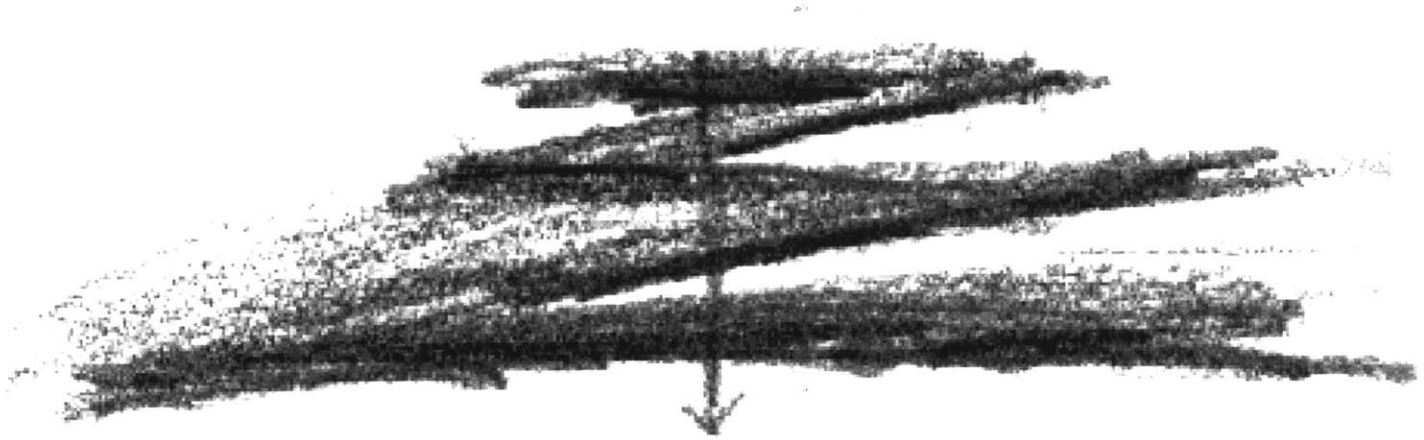


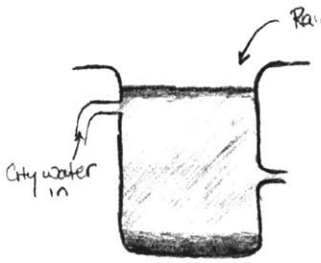


Water

Water flow takes desirous and undesired forms on hillsides. Rainwater must be diverted yet allowed to soak into the earth. Clean water supply feeds the home. Wastewater must be carried away. In between is use. Water is the element that connects the building to the site and the user to the building.

A precious resource at both sites, water management plays a key role in daily life in both La Puya and Solano. While the specifics are different, on the community level water is integrated in the transportation, safety and waste disposal systems in both places. On the individual level, obtaining and storing drinking water, bathing, irrigation and cooking cause each resident to interact with the water system. The system will seek to enhance our daily interaction with water in order to increase understanding of the resource and its management, and to facilitate users' connection with their homes, their neighbors and their communities.

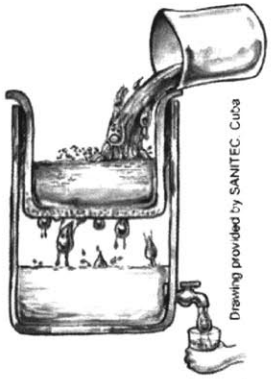




Average residential water use for Americans is 50 gal/day/person. In order to store enough water for three days for a family of four, 80.2ft³ of storage space is needed: a 12'h x 8'w 10"d wall.
On an average day in LA in January, about 8ft³ of rainwater can be collected. A two day record rainfall in Santo Domingo would have yeilded 87.3ft³ of rainwater.

Rainwater collection cannot realistically provide enough water for a family of four consistently at either site. However, rainwater can be combined with city water supply, ready for filtering or direct use for laundry, etc.

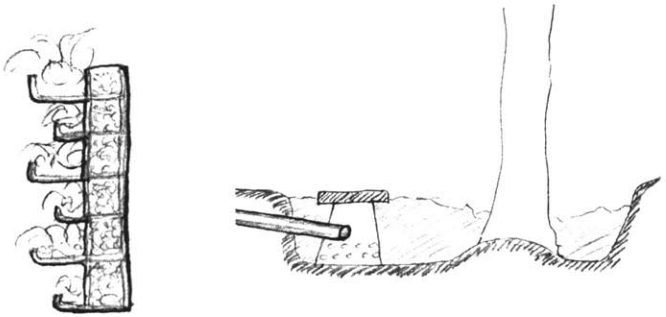
Storage/Rainwater Collection



For simply drinking purposes, a filter basin of .67 ft³ will filter enough water without letting filtered water sit. If hygiene, kitchen, laundry and housekeeping use is included, a 4.14 ft³ will be needed.

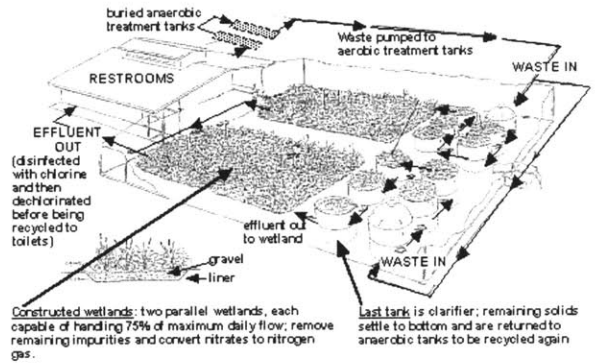
Only water for direct ingestion needs to be filtered to drinking quality. Filters such as this ceramic one must be cleaned once a month and replaced once a year. Filters can be locally produced of indigenous materials.

Filtration



Water from laundry and bathroom sinks and tubs can be directly released to soil either in a gravel and mulch pit, or vertically into a porous growing wall. Graywater reuse helps with soil retention and its nutrients promote plant growth.

Graywater Irrigation



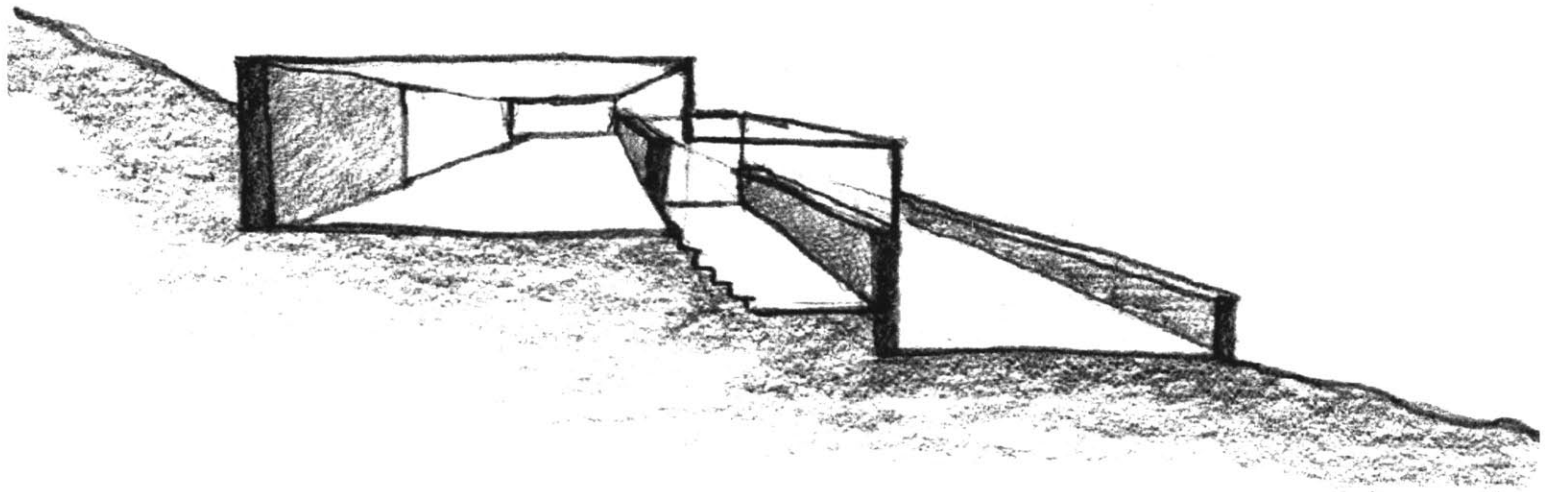
La Puya has a desperate need for sewage treatment. And while Los Angeles has water treatment facilities, they are not well maintained and are very costly. LA could benefit from a lesser load on the system, Solano Canyon could benefit from green communal space, and individals could benefit from localized treatment.

Sewage Conveyance/Treatment

Human

Dwelling, as a basic condition, requires flat surfaces for rest, and allows movement over sloped terrain. These spaces occur within the home as well as throughout a community, and their orchestration amounts to choreographing human interaction and retreat.

Opportunity abounds in building on a slope - each part of the lot has its own spatial condition. Movement up the slope changes the character of a space as much as the architecture does. A large part of the individuality of a home lies in how its design addresses issues of interaction and retreat, how it relates to the street and the neighborhood.



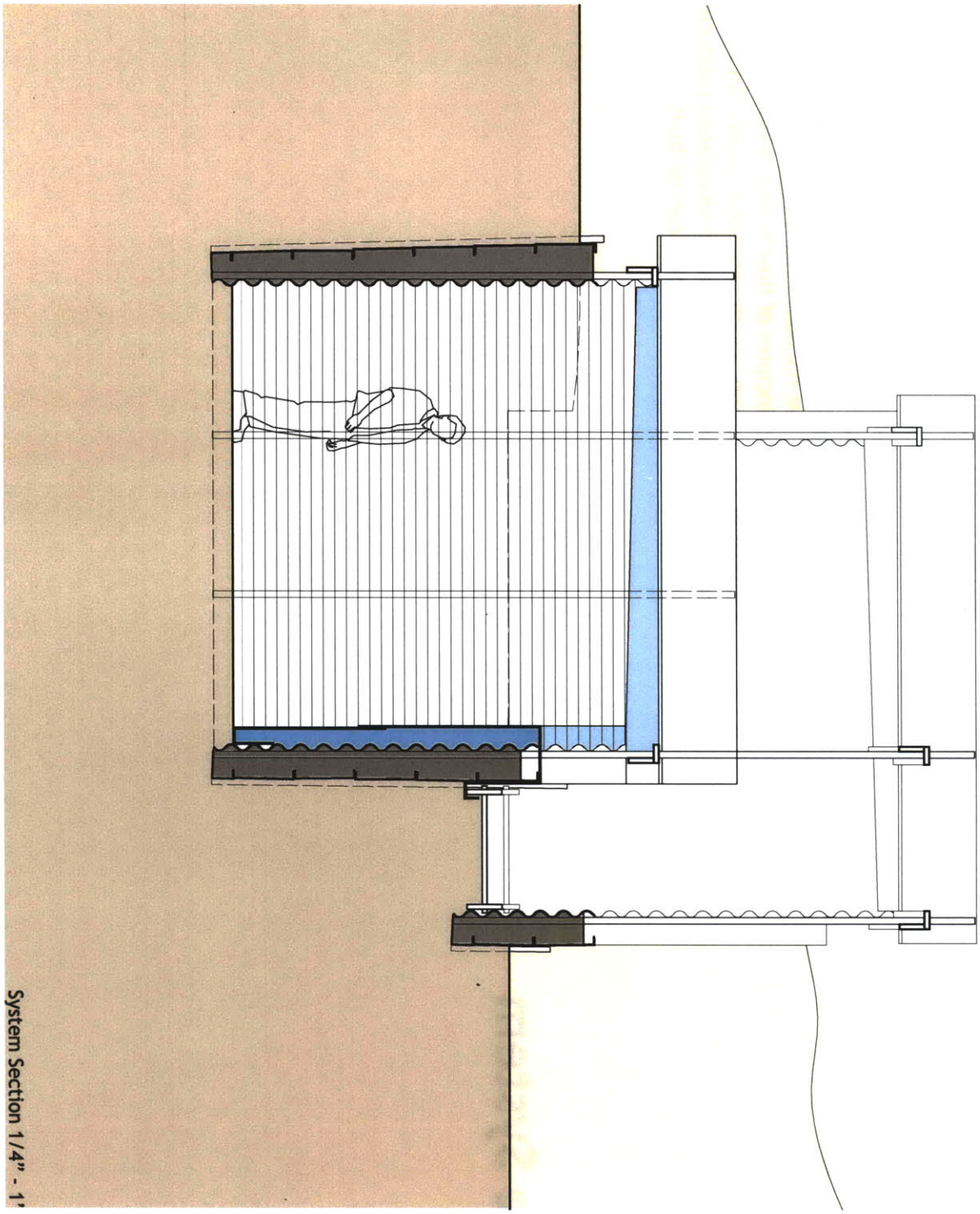
Notes

[1] http://www.aia.org/consumer/overview.asp
[2] Le Corbusier, p. 1

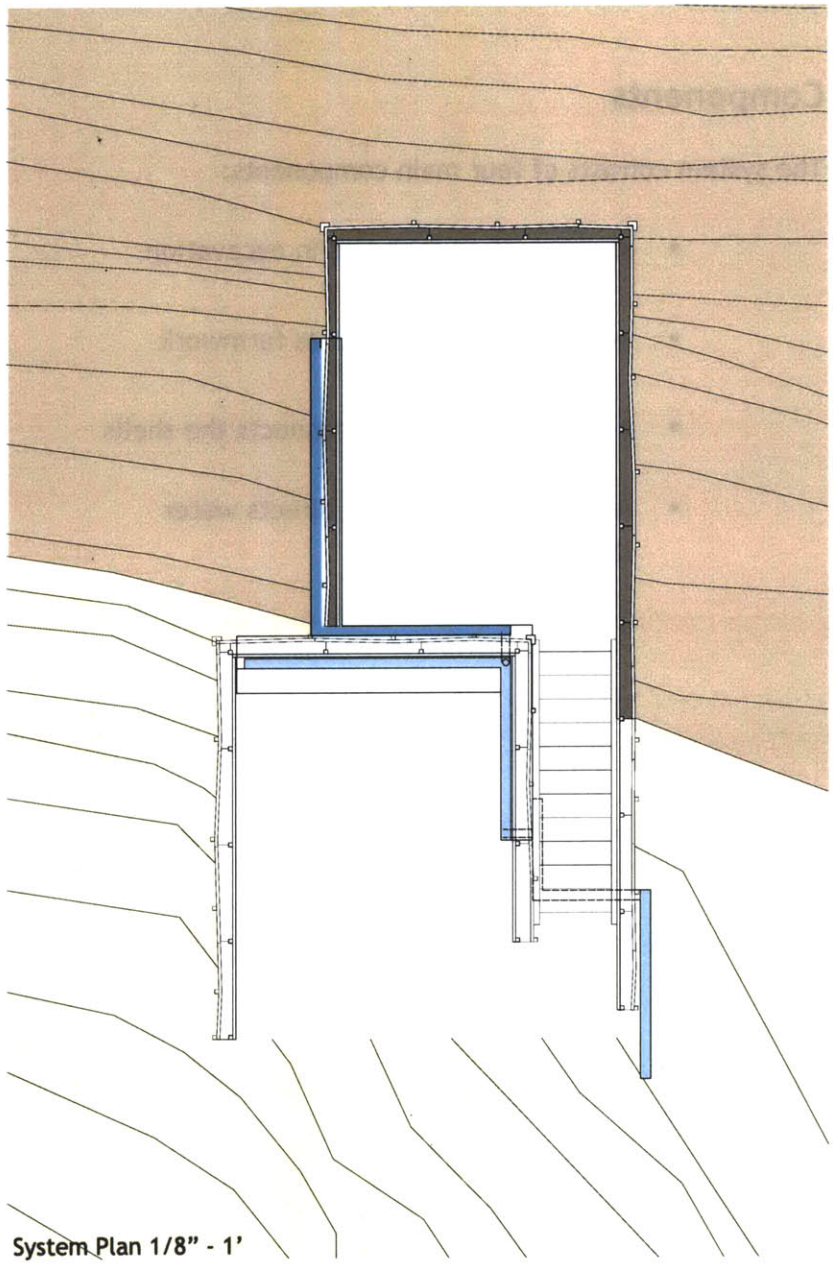
The System

Integrating Functions

Rather than arrive as a finished unit, the system is comprised of four main components. The components are an integral part of the excavation and construction process, enabling the prefabricated assembly to engage with the flow of the hillside. The components respond to the identified principles of flow in four ways: through addressing excavation, earth retention, water flow and circulation. Together, they form an integrated platform upon which individual intervention can be built.



System Section 1/4" - 1'

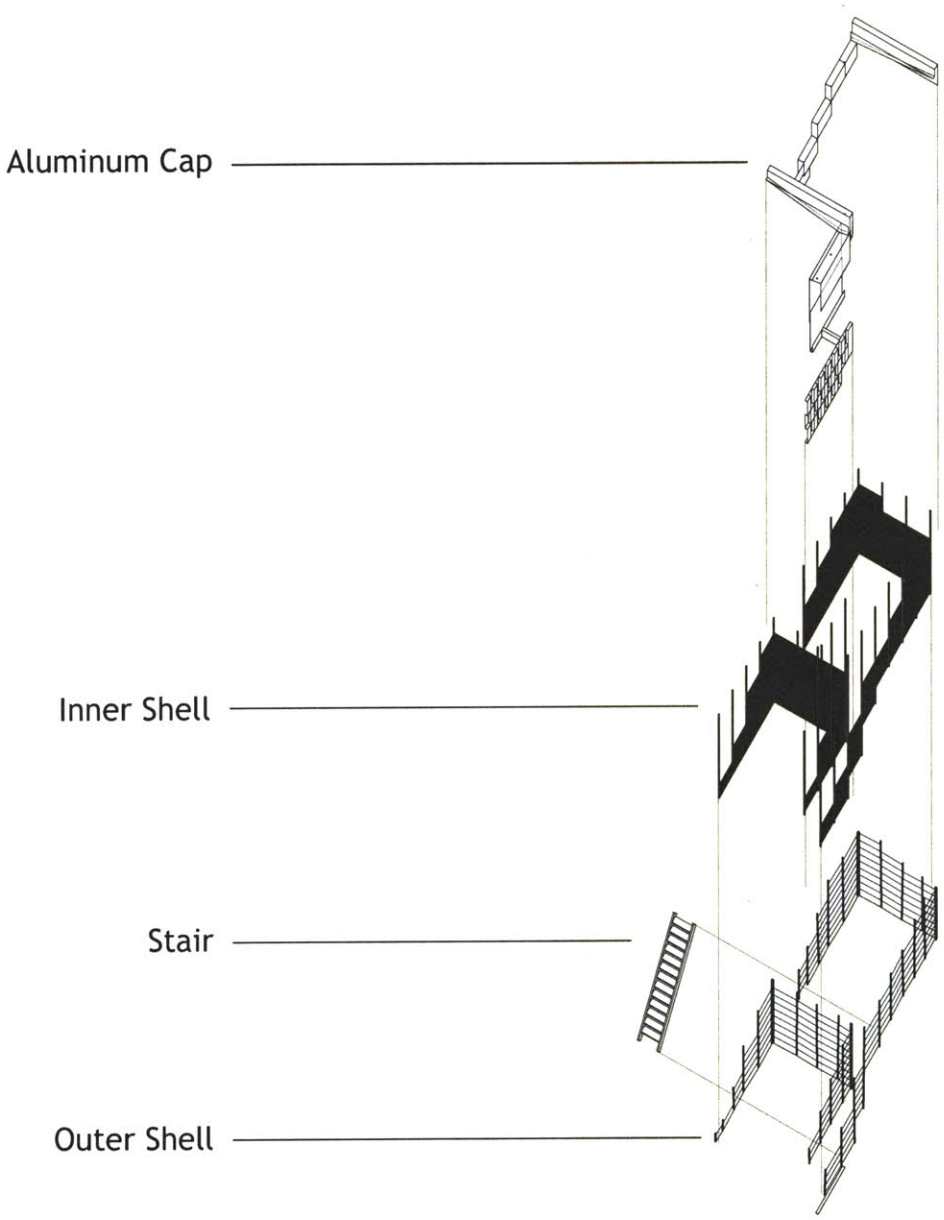


System Plan 1/8" - 1'

Components

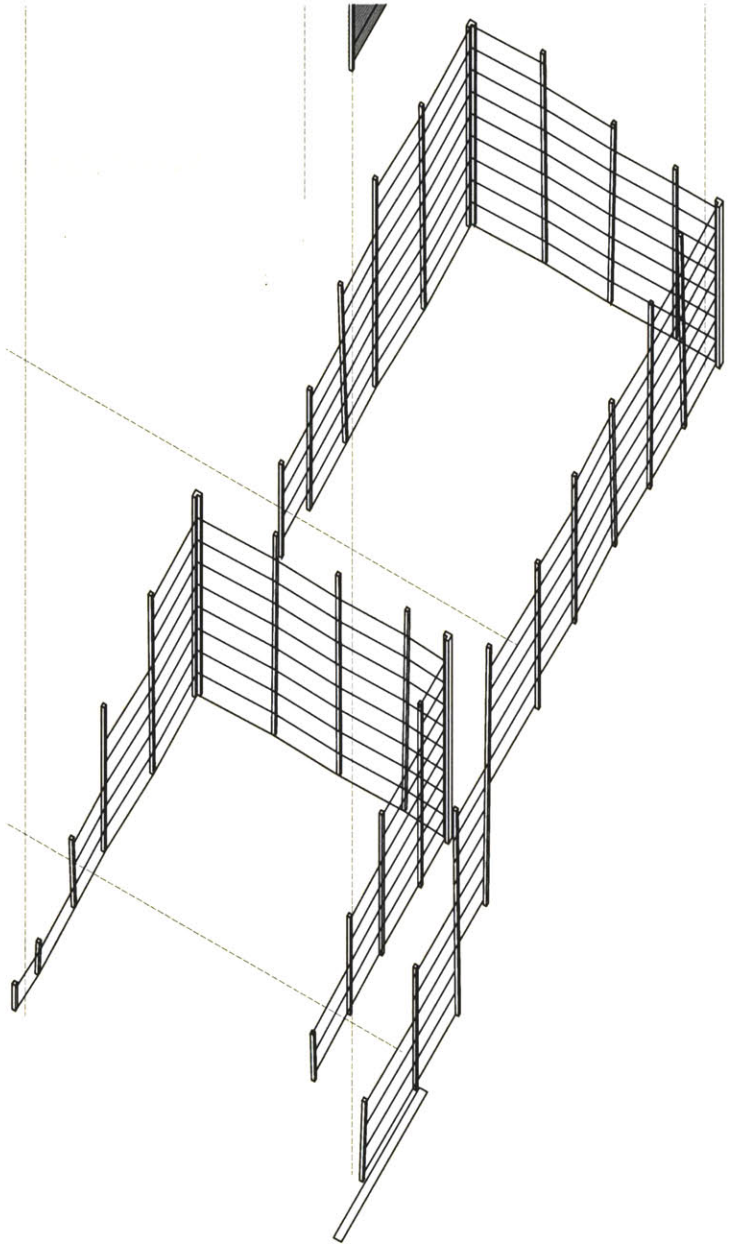
The system consists of four main components:

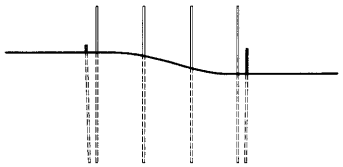
- An outer shell that aids in excavation
- An inner shell that acts as formwork
- A stair assembly that connects the shells
- An aluminum cap that directs water through the house

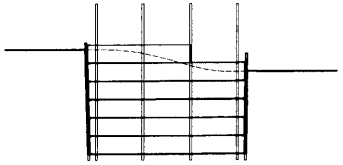

Aluminum Cap
Inner Shell
Stair
Outer Shell

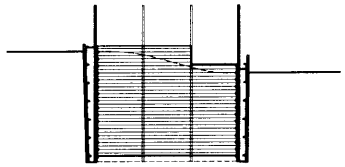
Excavation

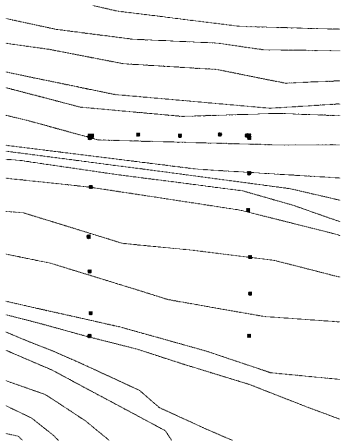
The outer shell of the retaining wall formwork is flexible to allow for variations in site conditions. It consists of stakes that are driven into the ground and planks that are nailed to the stakes as excavation takes place, similar to the soldier beams and lagging that are used on larger excavations. The planks are made of flexible plastic, strong enough to temporarily hold the pressure of the earth and flexible enough to conform to uneven excavation and rocky ground.



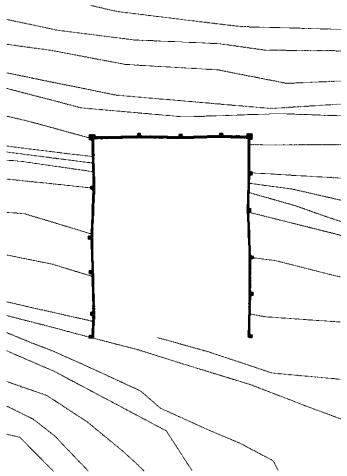




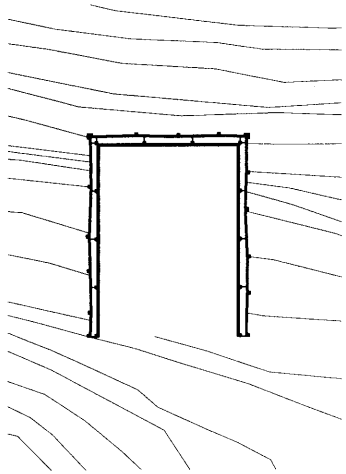




Phase 1



Phase 2

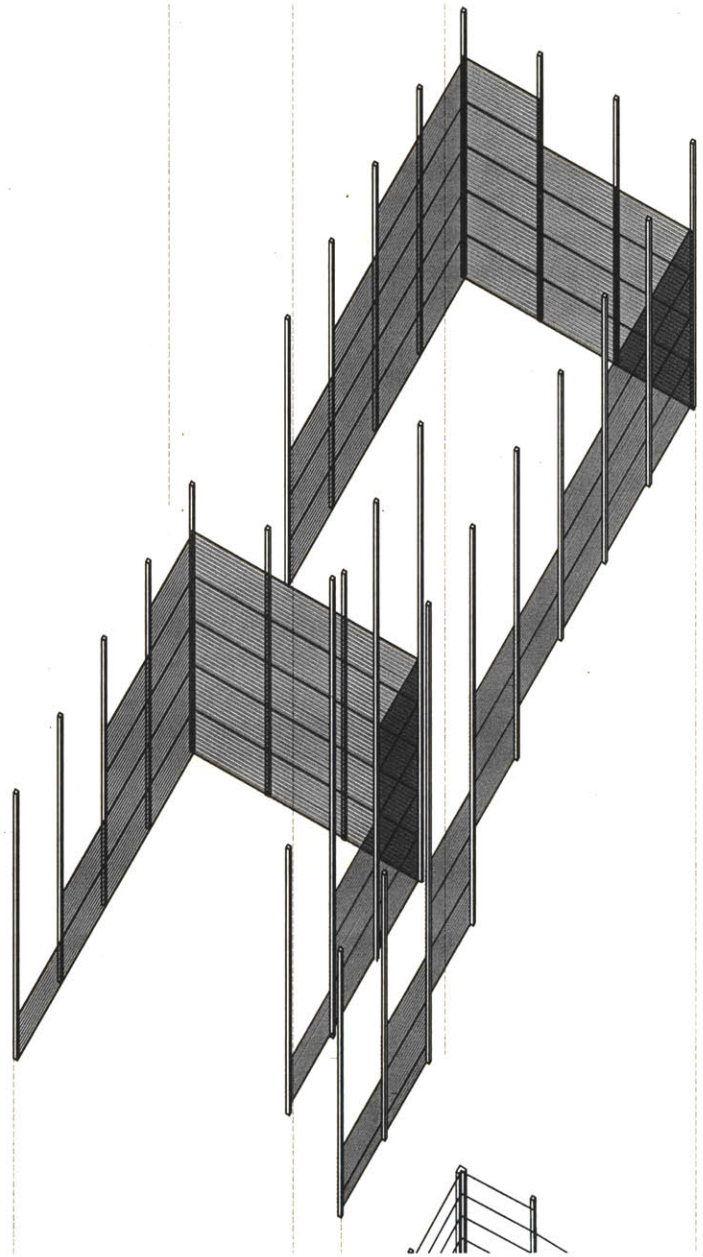


Phase 3

Retention

The inner shell arrives as a kit of standardized parts, and acts as a more rational interface to the interior. Steel tubes are driven one foot below the bottom of the excavation at four foot intervals, and are later used as a framework to support additional wall material and the roof. Commonly available zinc-galvanized corrugated steel sheets are preformed to slot into the steel tubes. The two-foot height of the panels can correspond to the slope of the hill so that the wall need not be taller than necessary to retain the earth at the back and the sides of the excavation.

The space between the shells is then filled with concrete, which acts as the permanent retaining wall. Expensive reinforcing bar is unnecessary because the corrugated steel acts as reinforcing for the wall. The zinc coating prevents the metal from corroding when exposed to damp inside the house. The wall can be as thin as three or four inches, even at the back where it is tallest. No footing is necessary, because the U-shaped form of the wall provides resistance from overturning.



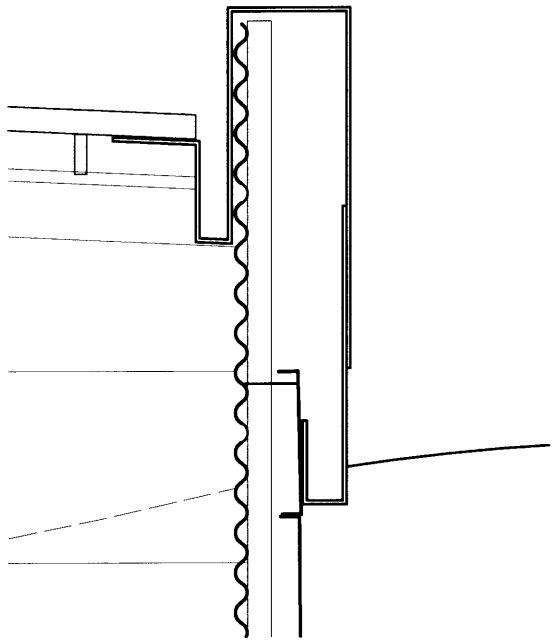
Water Flow

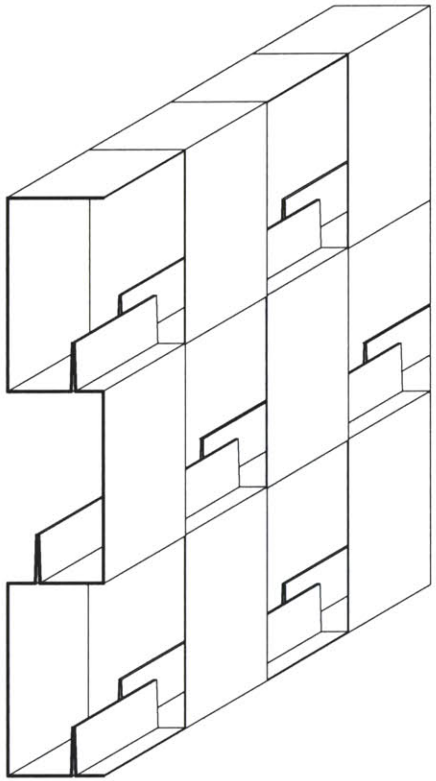
The aluminum cap integrates the water functions with the structure of the house, protecting the back wall, directing rainwater through the system as well as providing a cavity for plumbing and the interface to appliances and wet spaces within the house.

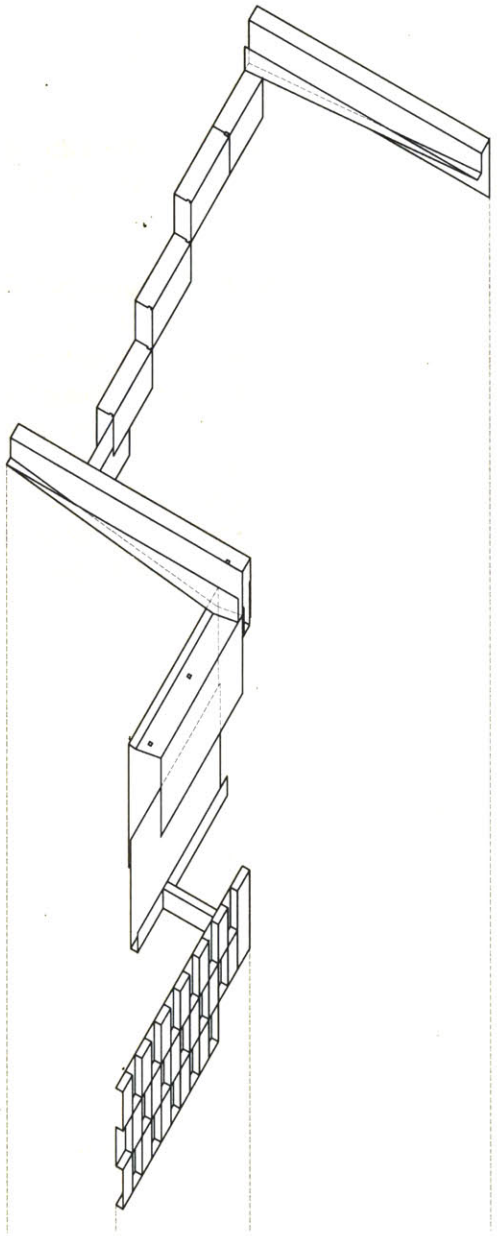
Folded sheets of aluminum form a modular cavity wall that hooks over the poured concrete between the shells. The gutter at the back wall acts as flashing for the user-built roof, collecting rainwater to periodically flush the drainage system.

The gutter and downspout are the only pieces of plumbing directly supplied with the system. Plumbing expectations not only vary greatly between California and the Dominican Republic, but inspection requirements in the United States greatly complicate the selection of plumbing equipment. Instead, the flexible cavity wall indicates the path that water flow takes through the house without limiting functionality or restricting future change. Wet spaces are located in conjunction with circulation, setting up a consistent relationship between places of rest, movement from one shell to another, and service spaces.

The aluminum system also provides a means for the disposal of graywater that helps to remove toxins and reintroduces the water to the ground. The simplest form of graywater treatment is simply a drip line to a gravel pit that irrigates a tree. This requires some open space downhill of the water use that can be used as a patio. However, in La Puya such open space is a rare commodity. Swedish ecologist Folke Günther developed a vertical system for the natural treatment of graywater that has proven itself in Gabarone, Botswana.[1] Wastewater is directed through the chambers in the living wall, each planted with plants that absorb the polluting nutrients in the wastewater. Water emerges ready for reintroduction to the ecosystem after percolating through the wall. The folded aluminum integrates a living wall into the flow of water into, through and out of the house.



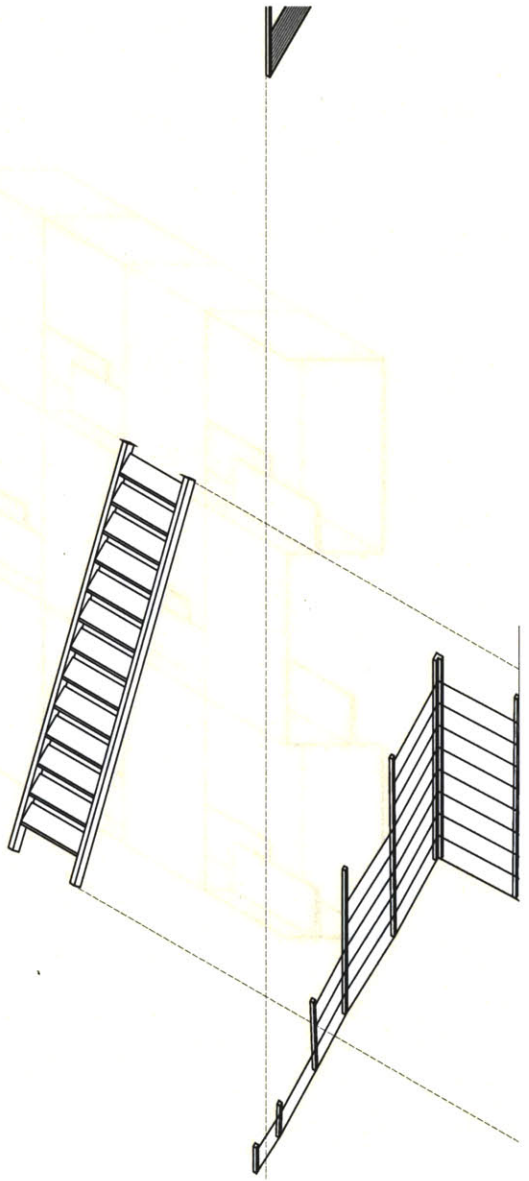


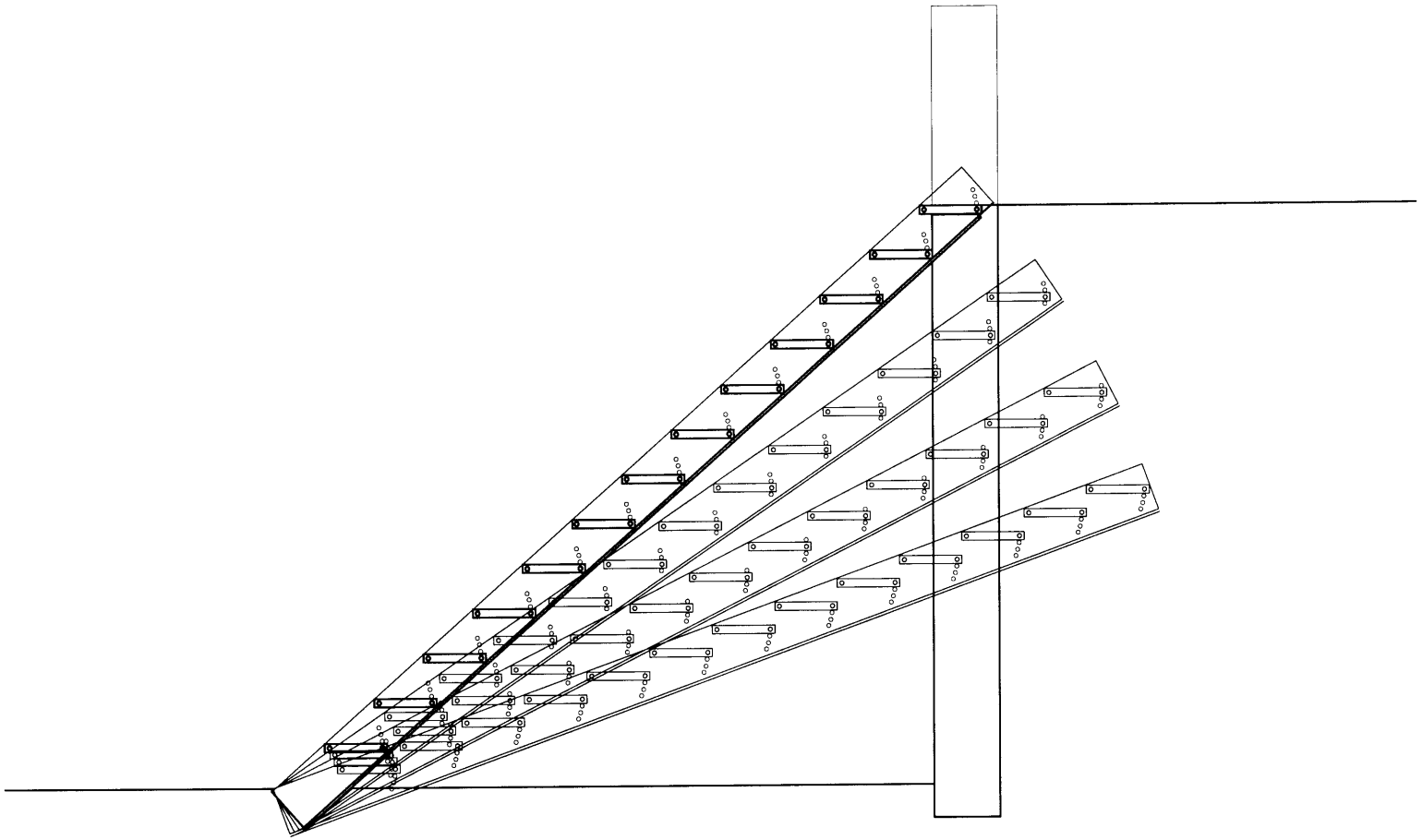


Circulation

The adjustable stair attaches to the cap assembly and connects the shells spatially, navigating between levels of earth.

The stair treads adjust to four angles between the extremes of an 6 ½ : 9 stair and 2 ½ : 11 ¼. Its length then stipulates that the floor-to-floor height be 4'1", 5'5", 6'9", or 8'. This limitation must be taken into account in the planning and excavation stages, but also lends a consistency and standardization to the process. The stair's dependency on being between two retaining walls sets up the link from one shell to another, and helps to determine the relationships between spaces.





Delivery

The components are all made of materials readily available in both the Dominican Republic and California. They are designed to be easily fabricated in small-scale factories, so that jobs that are created stay close to the community the product is intended to serve, and shipping distances are minimized.

The components are lightweight for delivery and installation in difficult conditions. The proximity of the fabrication shop also allows for the product to be adjusted as time and actual implementation tests the system.

Perhaps the largest obstacle to the realization of a new system for housing is financing. In La Puya, where the government already has plans to build housing blocks for displaced residents of the floodplain, it is conceivable that the same agency might subsidize the prefabricated component system. It would then be up to the individual to use the materials salvaged from the disassembly of his or her floodplain home, or new materials, to complete the new house. The system would most likely be less expensive for the government than a full-fledged relocation program, and residents would have the opportunity to remain in their community.

In Southern California, housing is extremely expensive. A system that allows for easy upgrading over time helps to offset that cost and opens up opportunity for some that might not otherwise have it. The prefabricated component system would be privately purchased, and the owner would expand and complete it as the means become available. The following images describe how that upgrading process might take place.

Notes

[1] http://www.holon.se/folke/projects/openliw/openlev_en.shtml

The System Applied

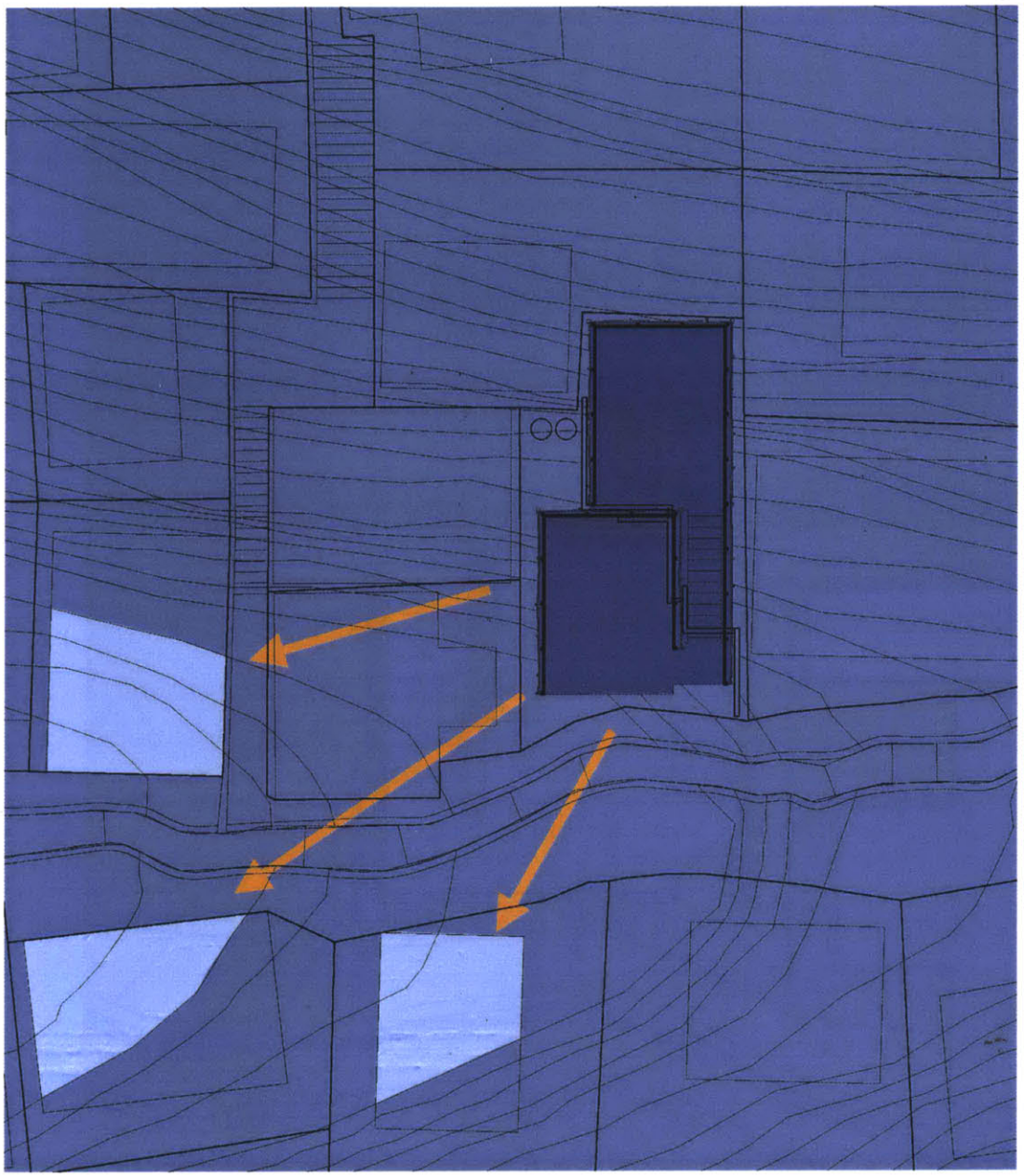
Two Houses

The system was developed based on a set of abstract principles derived from looking at specific site conditions. Once these principles were abstracted, and very real concerns of construction, materials and durability were looked at, the system was developed. The system was only a product of the sites in the most basic sense, and so it needed to be tested on specific lots on the two sites.

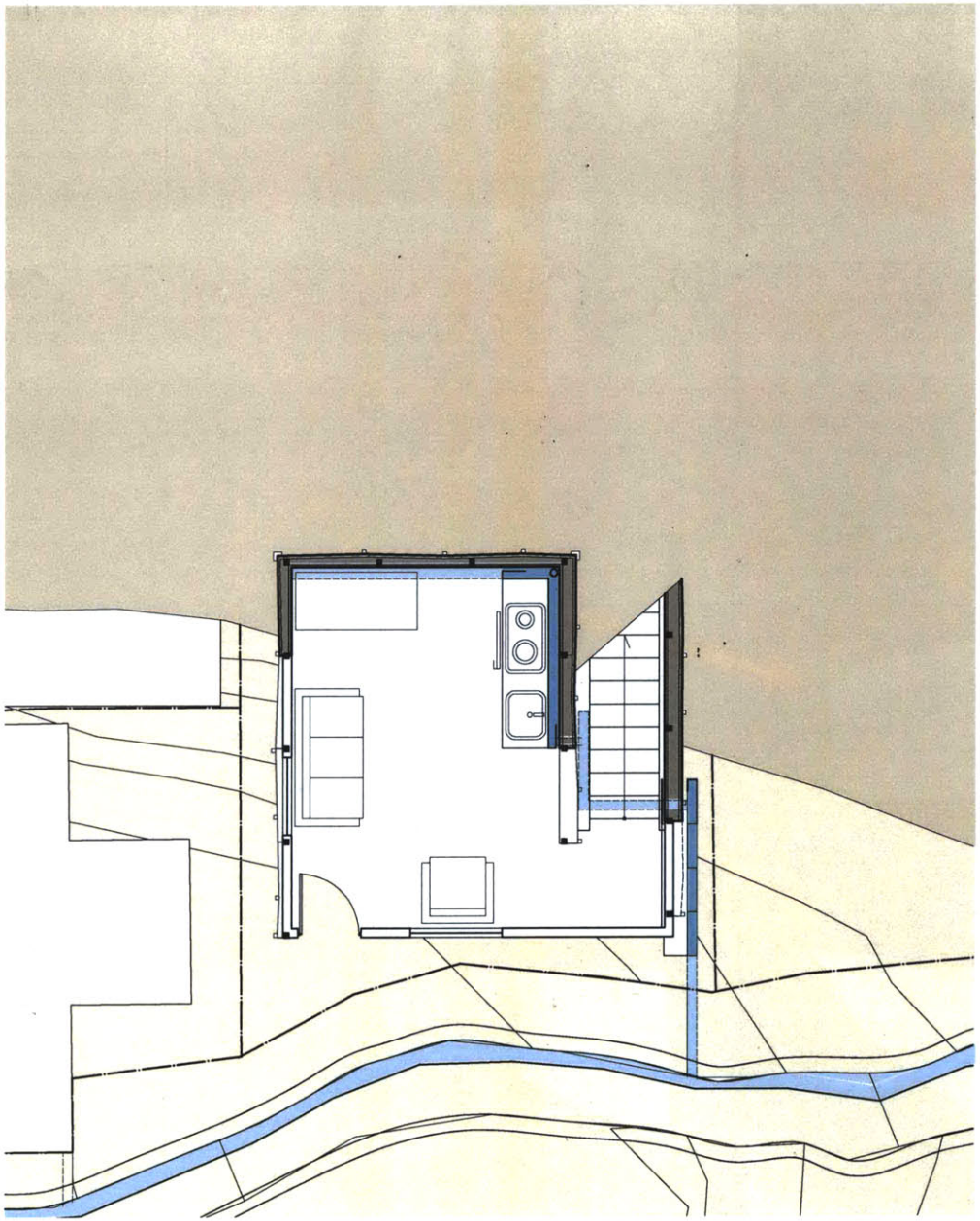
Two houses were designed using the system. Each was meant for a family of three, expandable in the future. Since the foundation is the most costly and difficult part of hillside construction, it is assumed that most future expansion would be vertical.

Residence in La Puya

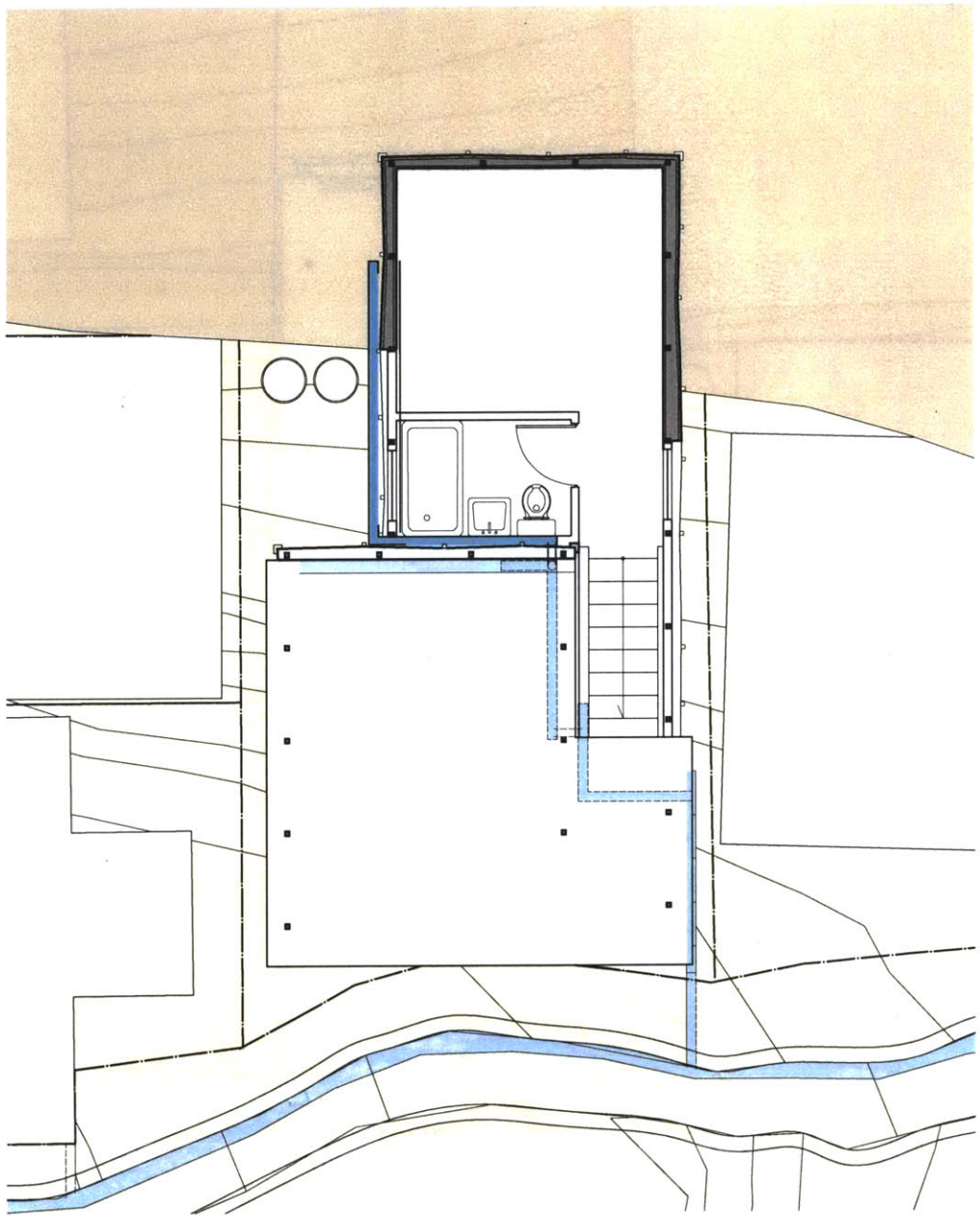
Lot Plan 1/16” - 1’



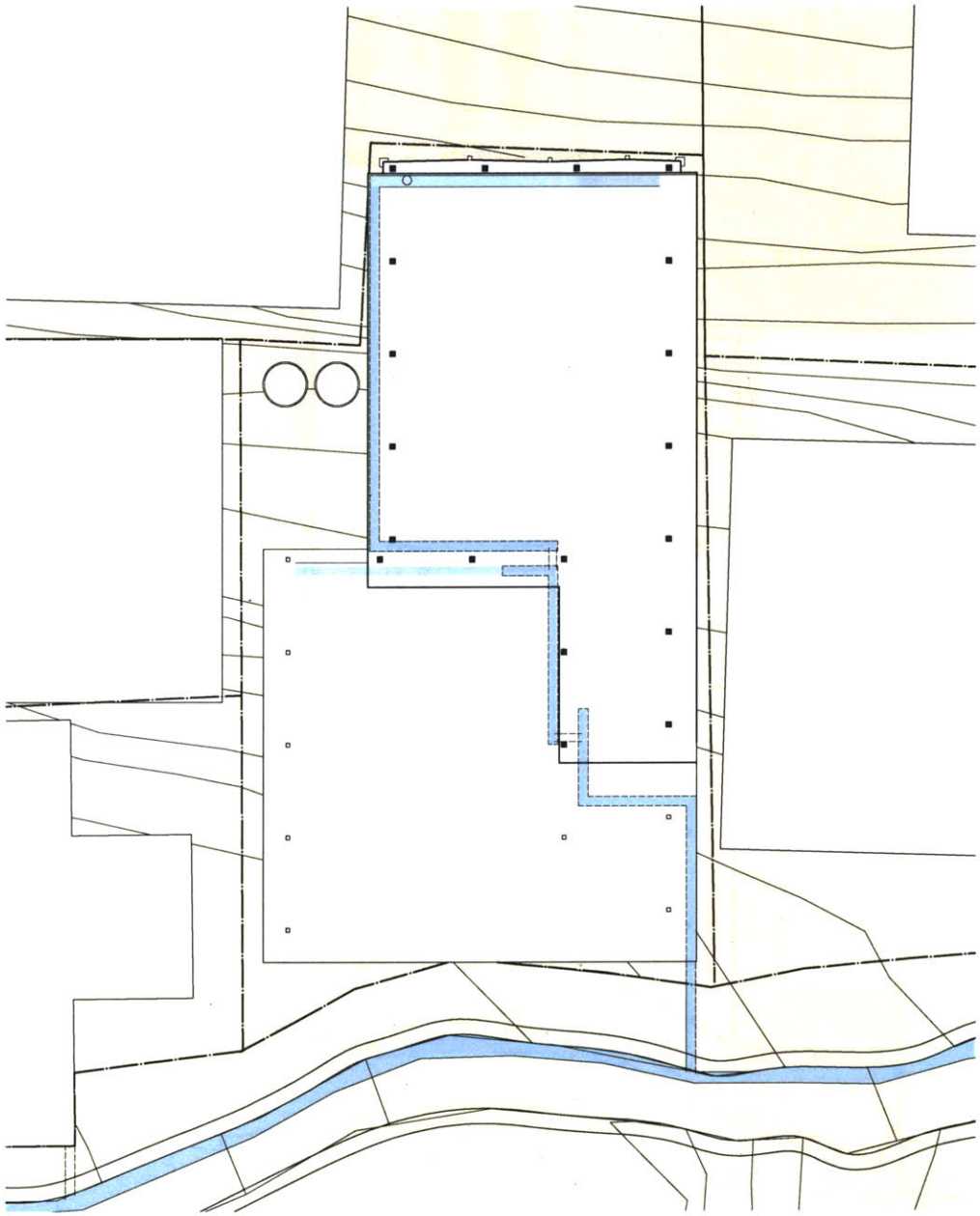
As earth is removed for excavation, it is used to level out nearby lots and raise houses above the flood plain.



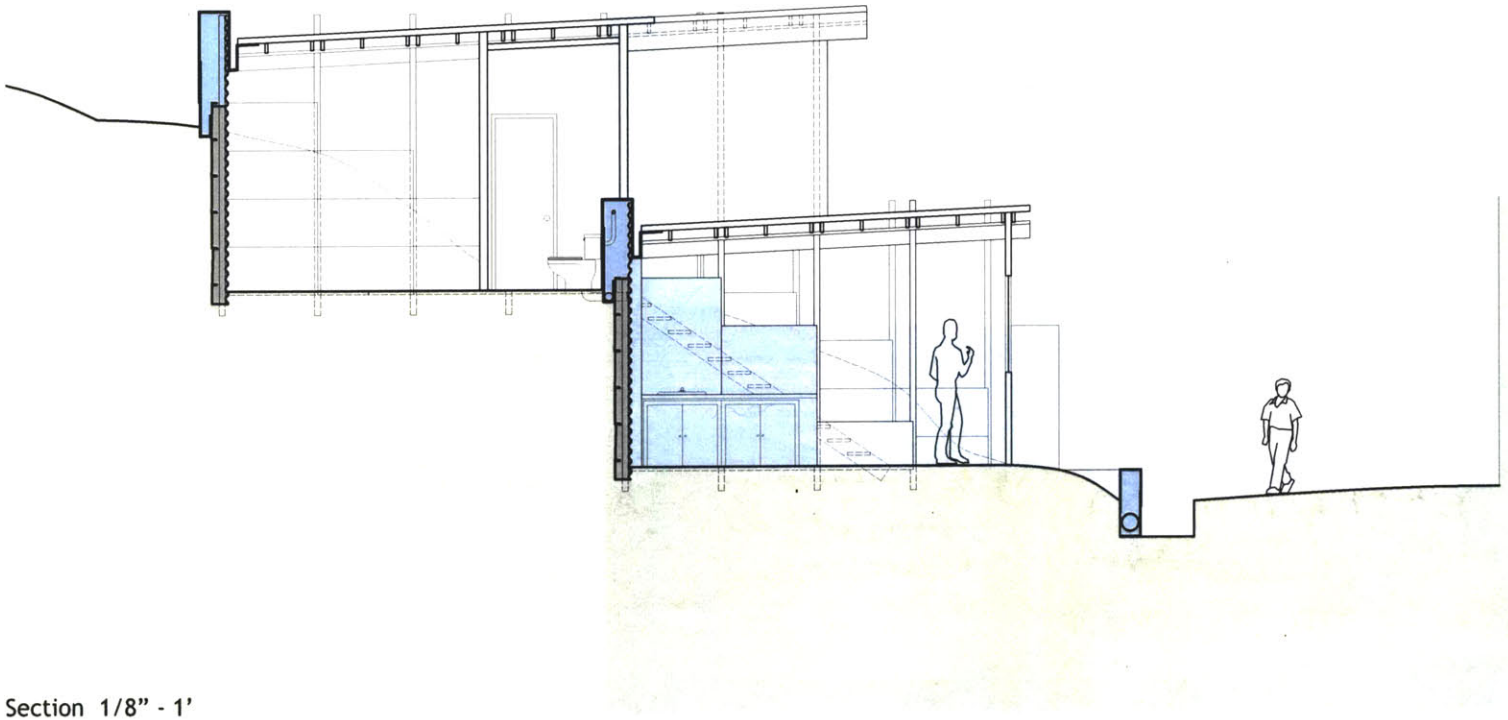
Plan Level 1 1/8" - 1'



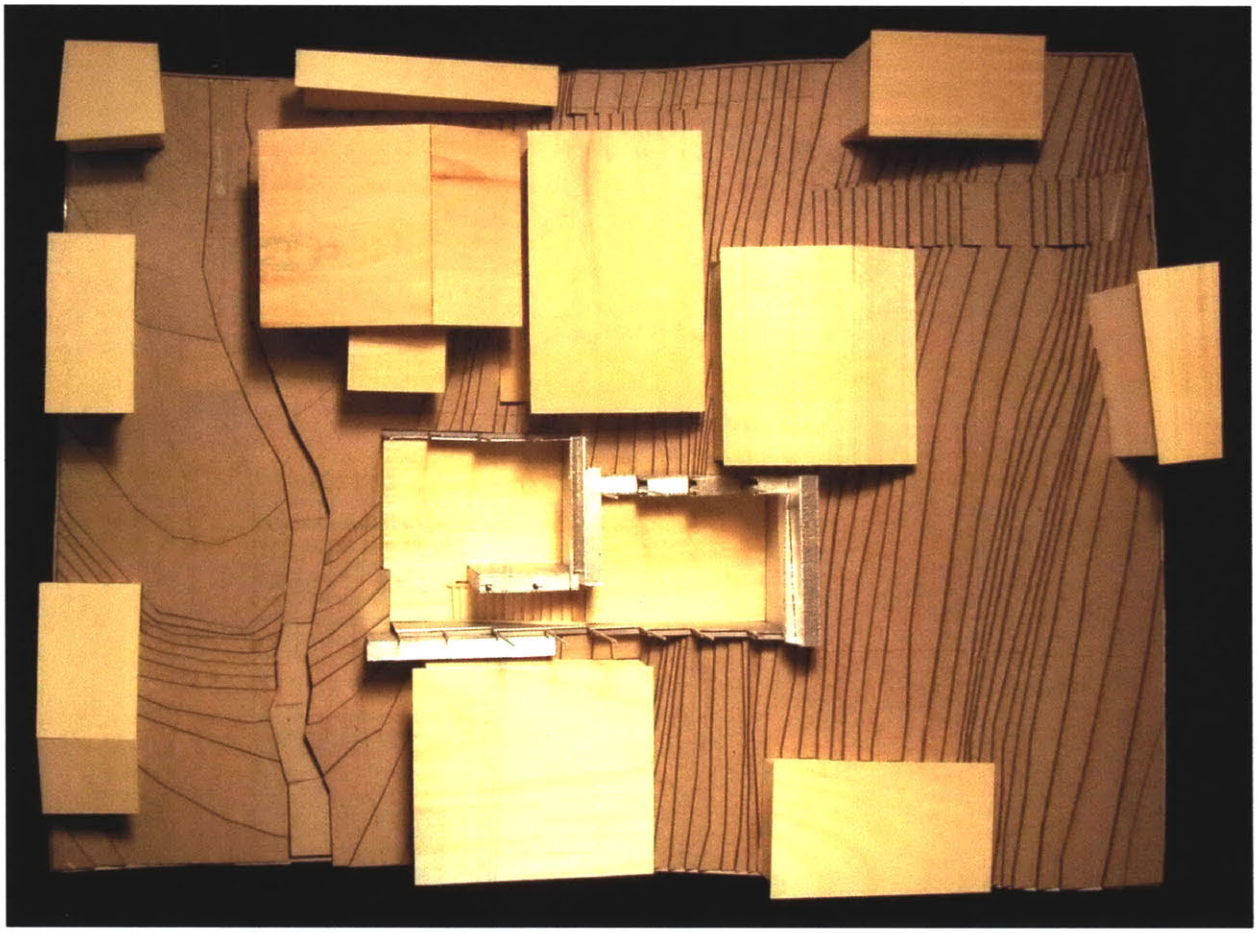
Plan Level 2 1/8" - 1'

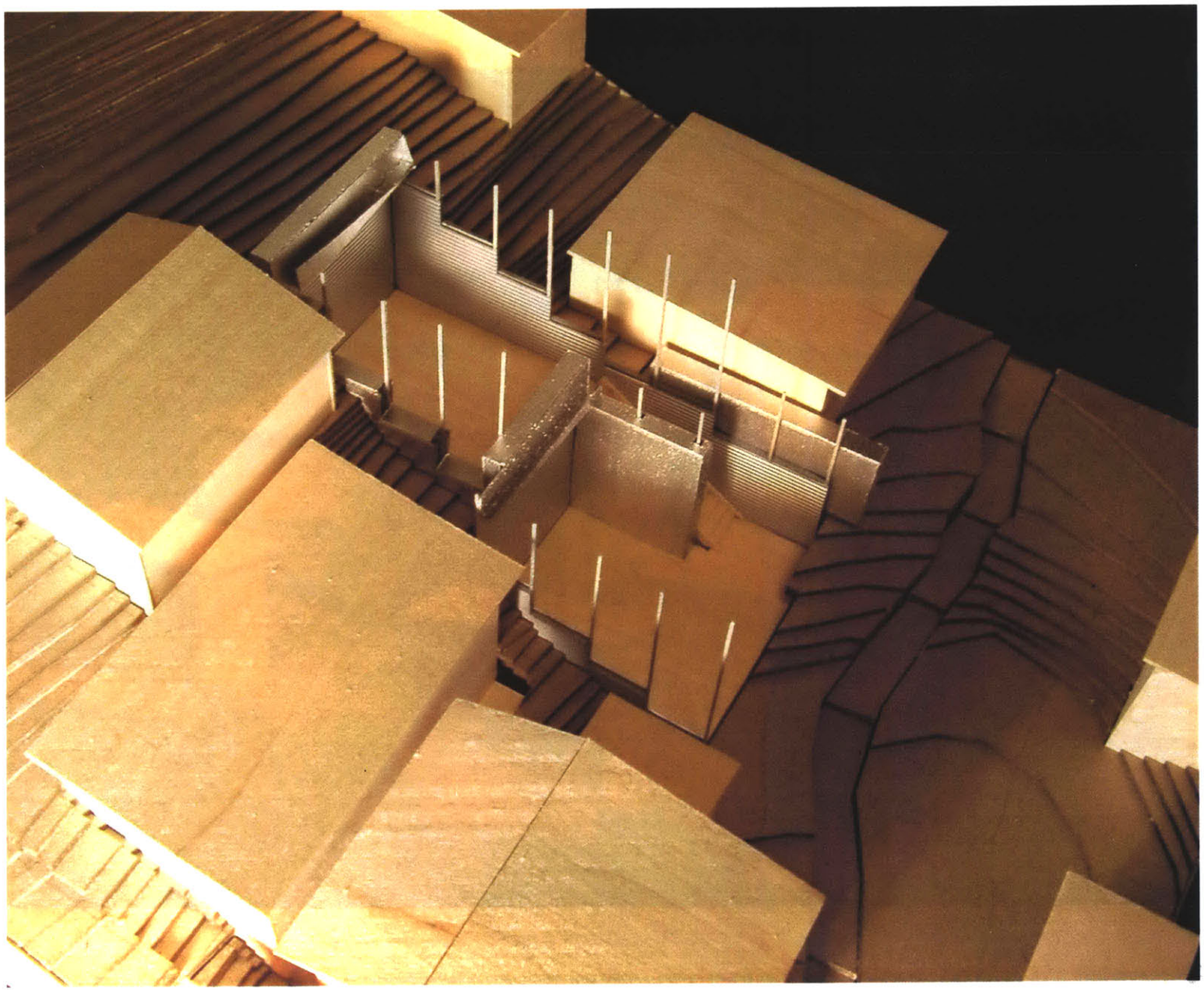


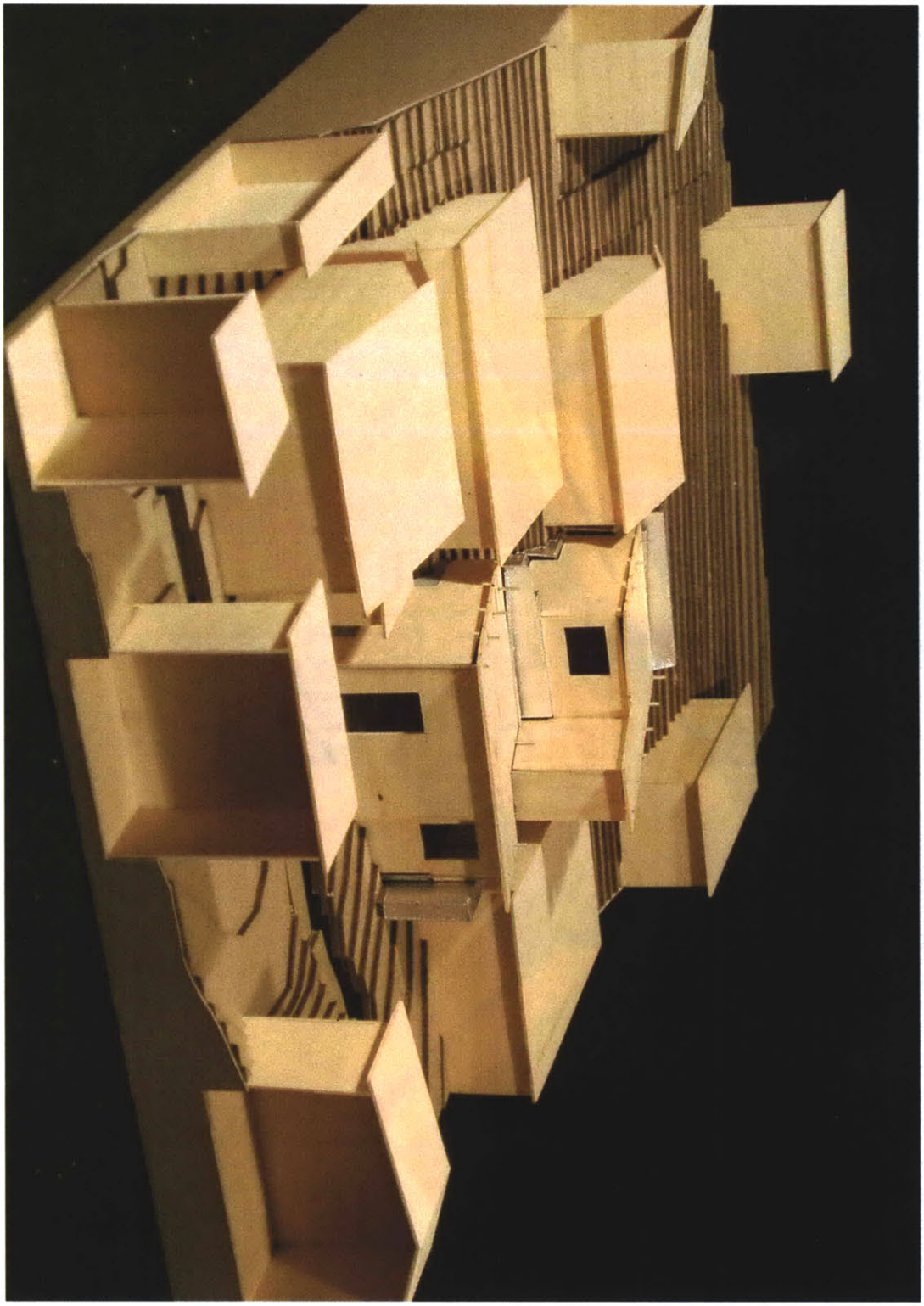
Roof Plan 1/8" - 1'

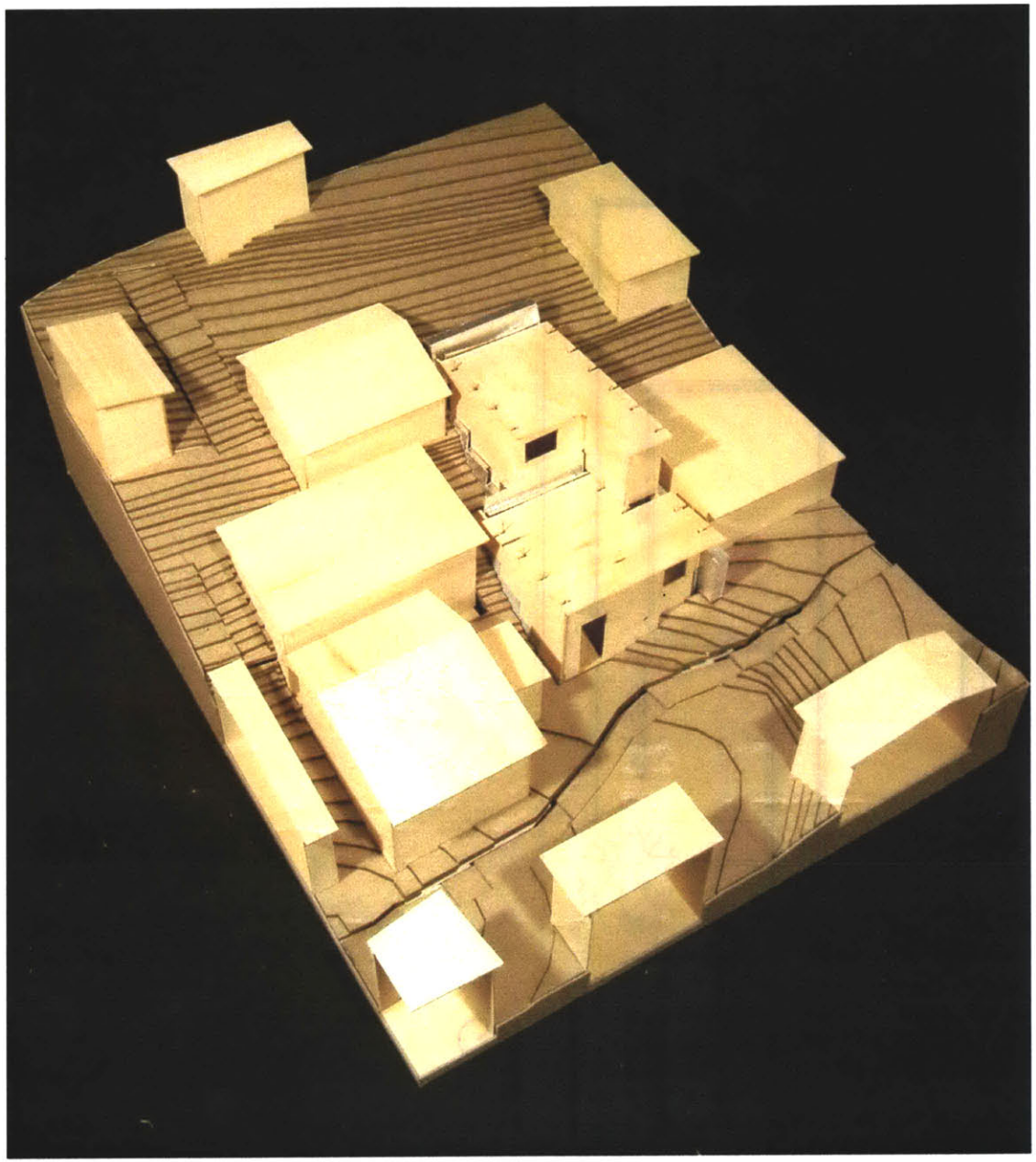


Section 1/8" - 1'

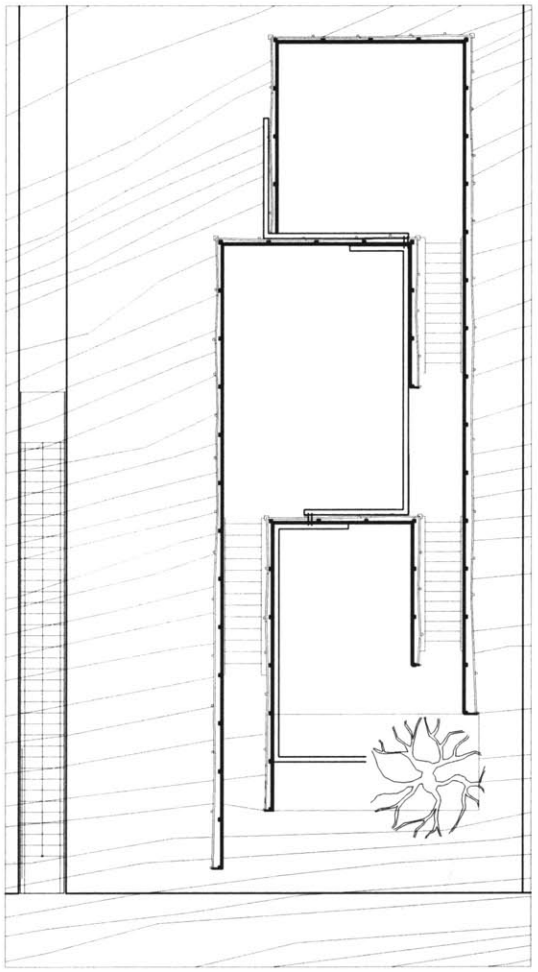




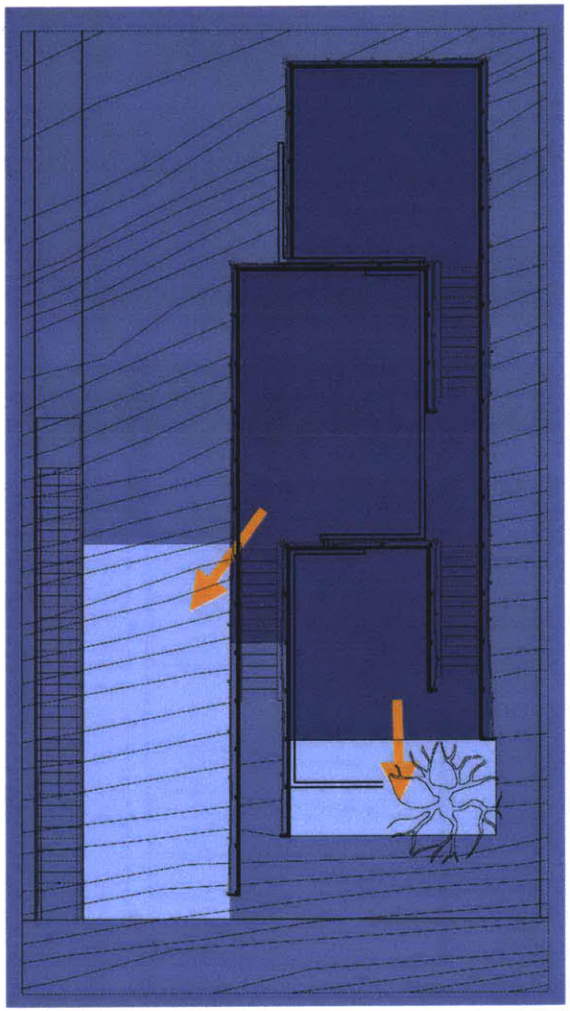




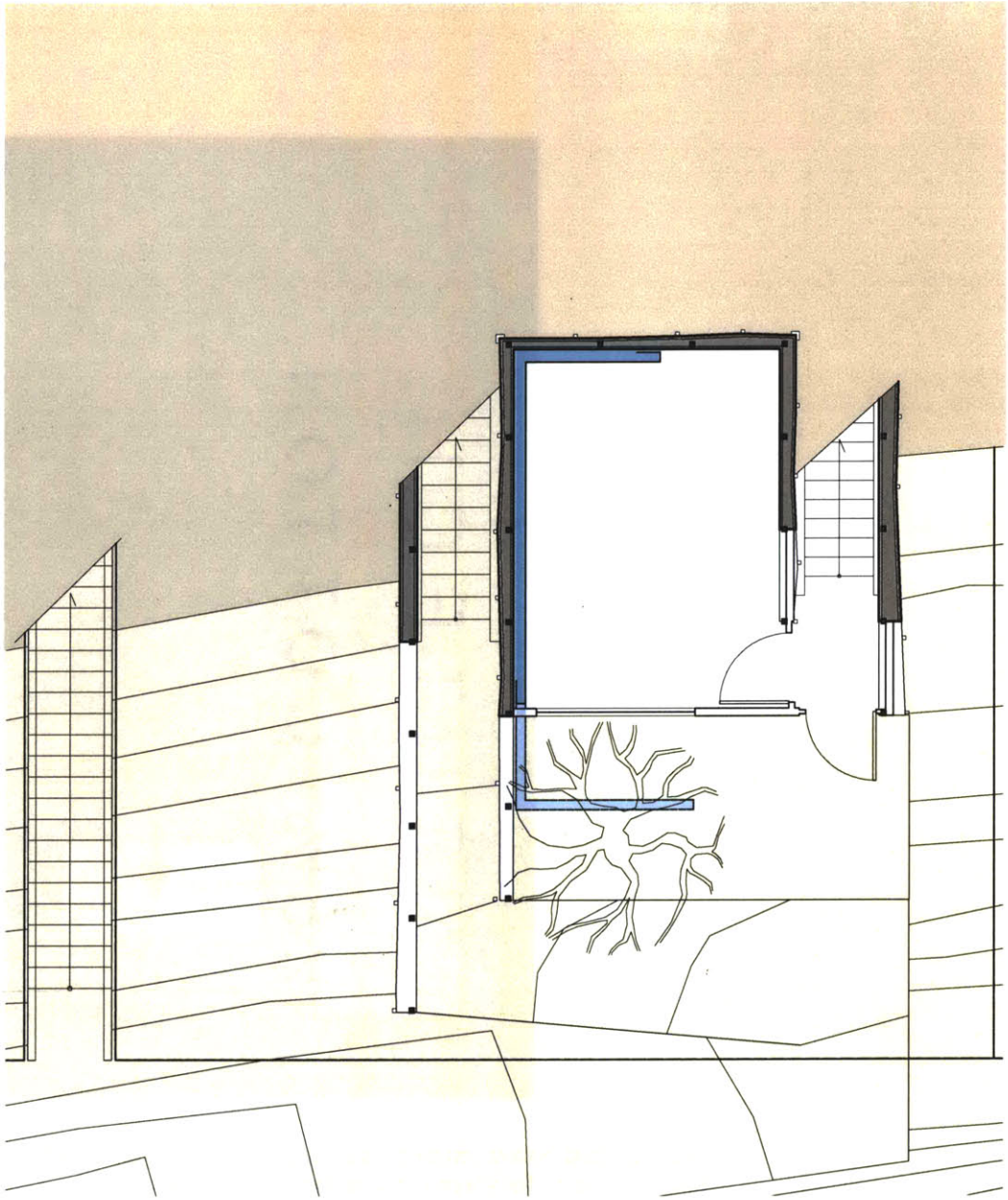
Residence in Solano



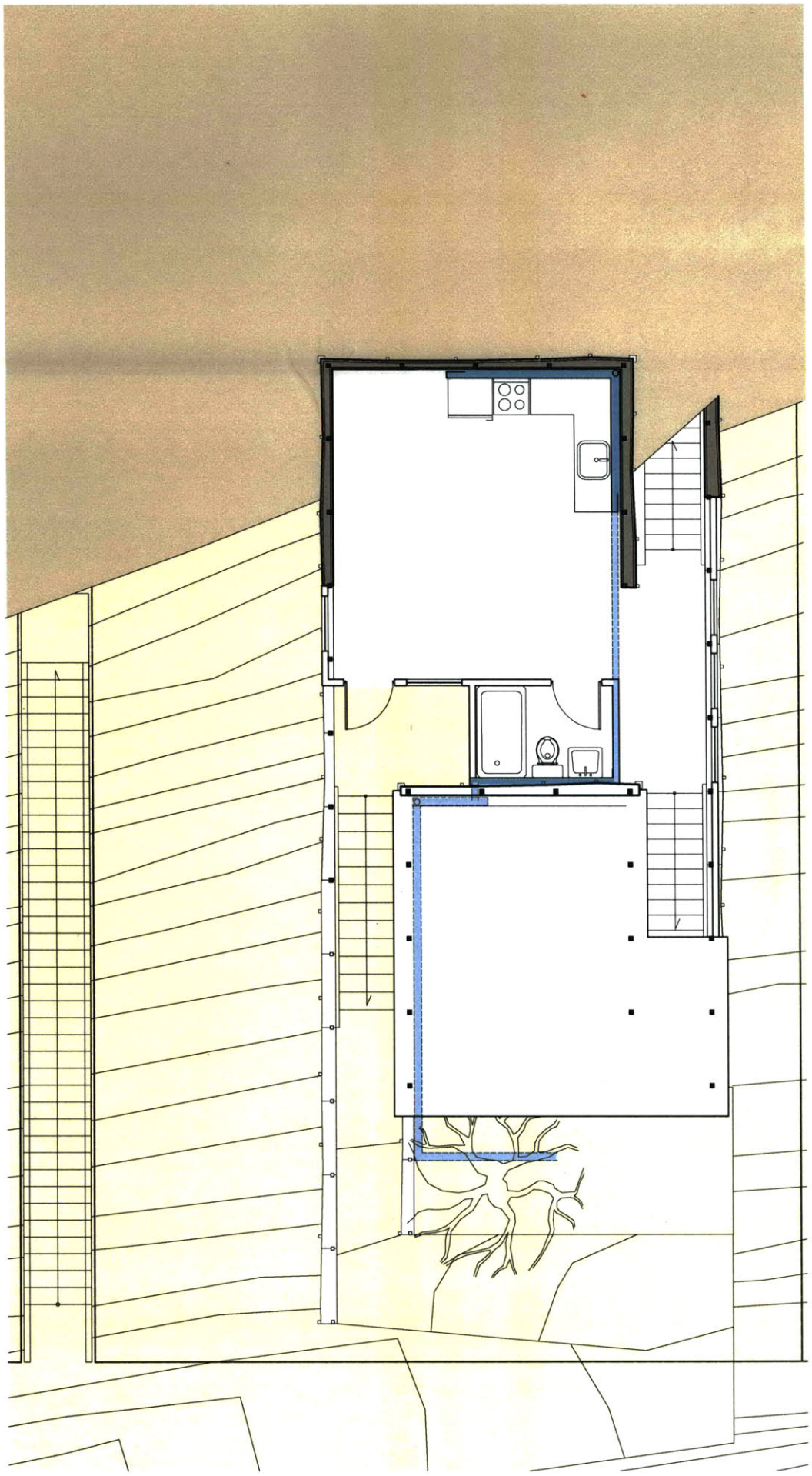
Lot Plan 1/16" - 1'



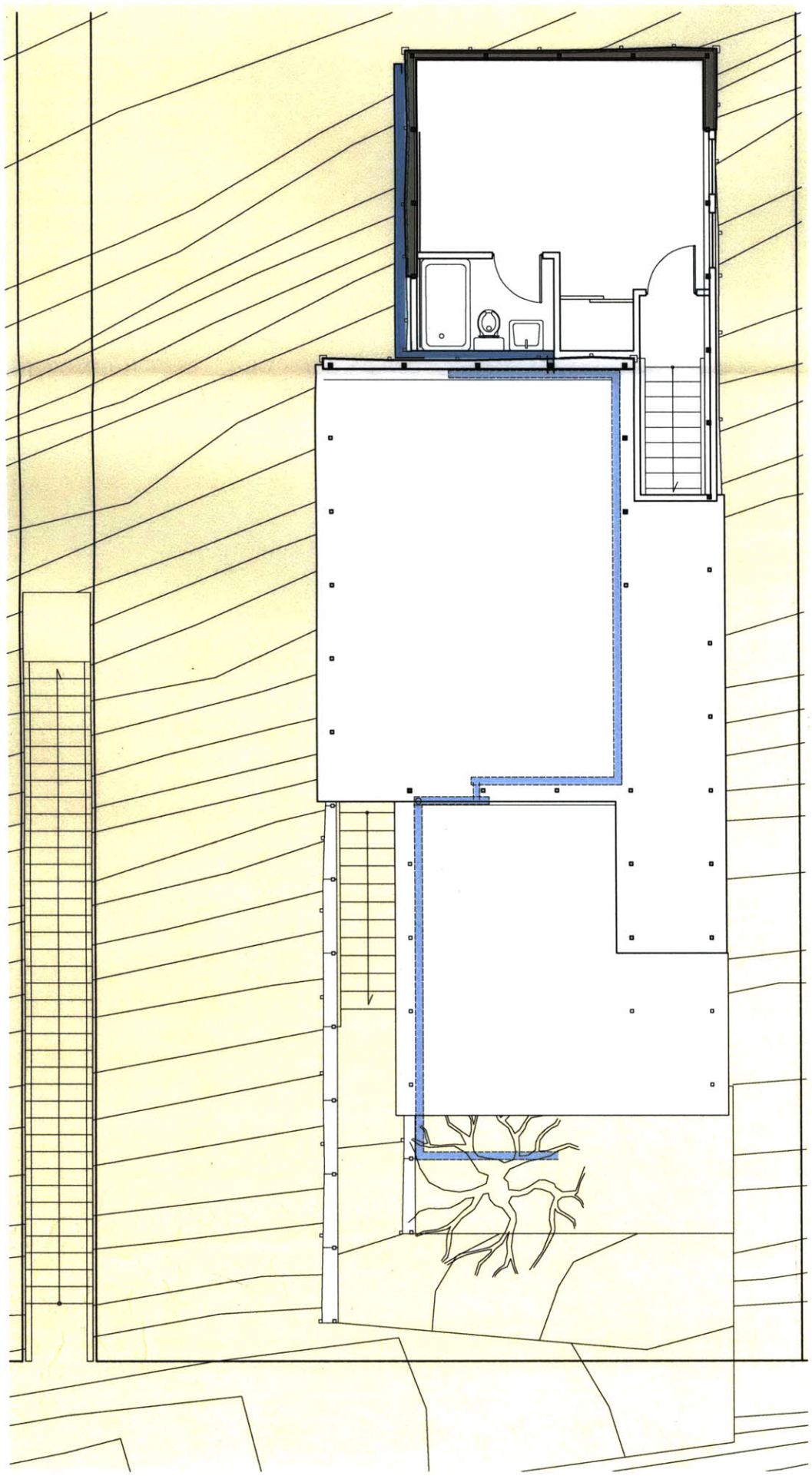
The displaced excavation earth is used on the owner's lot to provide flat open spaces for graywater treatment and a patio.



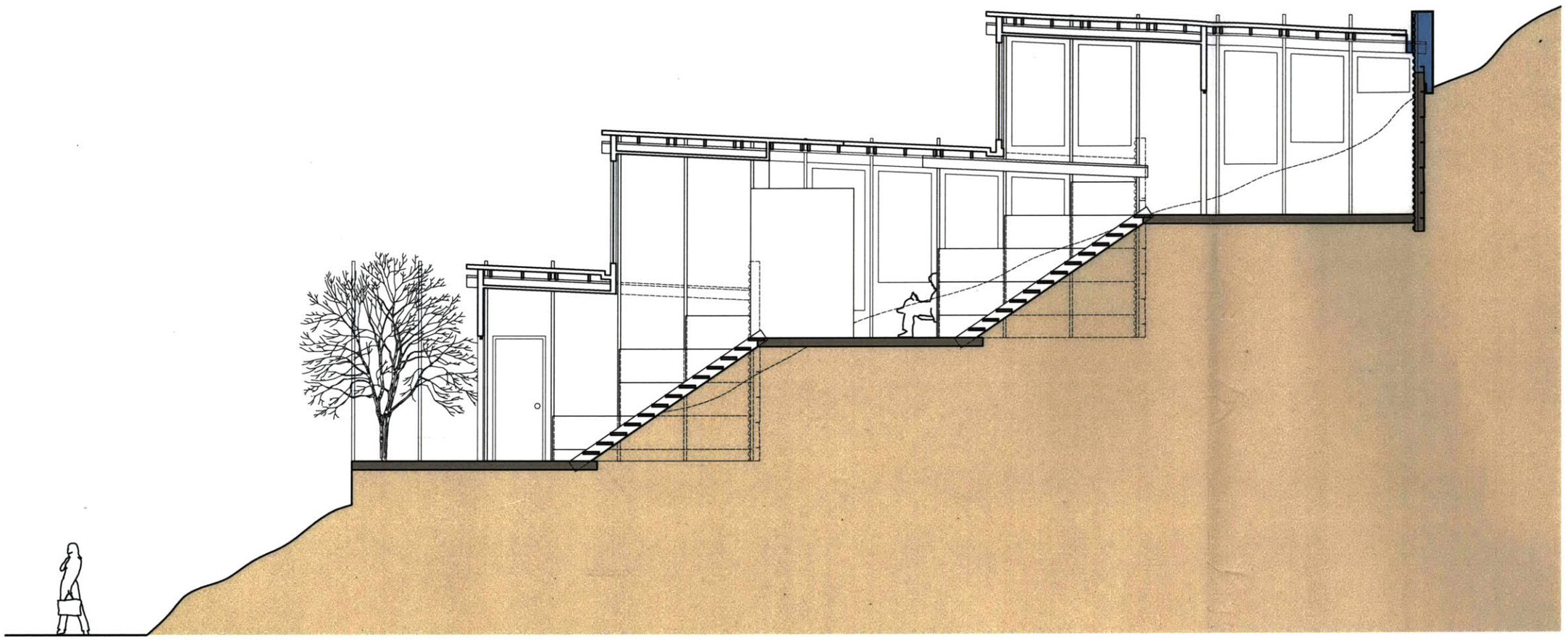
Plan Level 1 1/8" - 1'

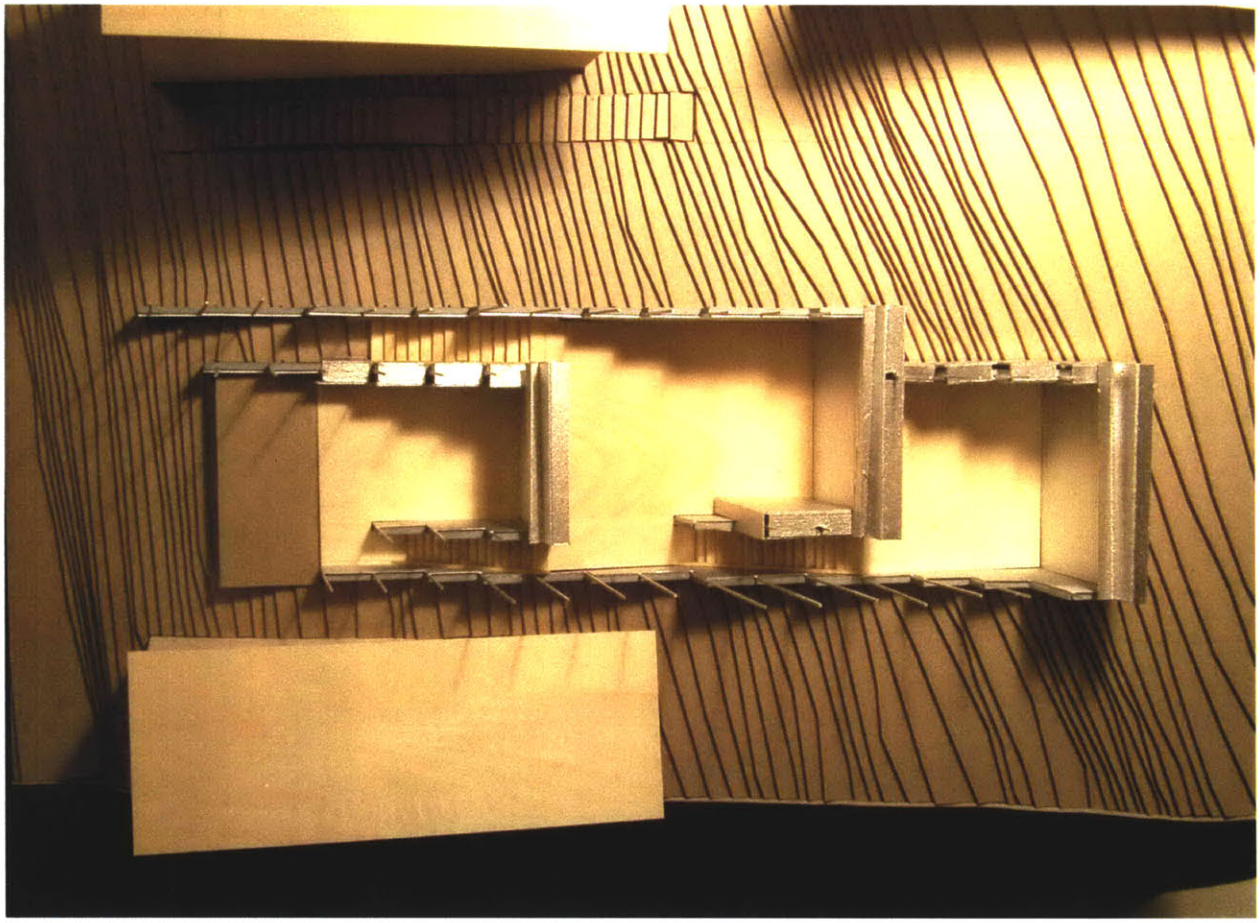


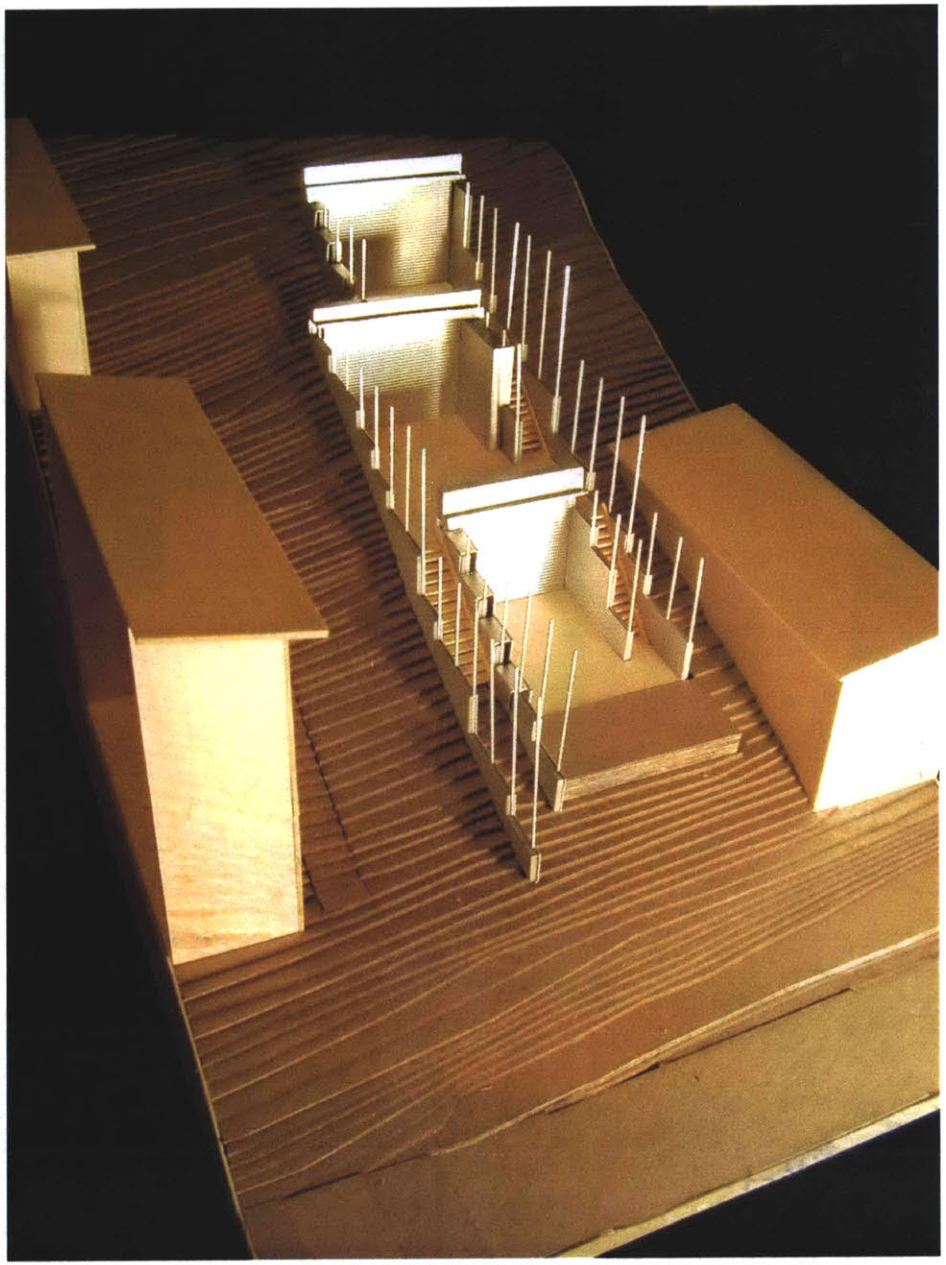
Plan Level 2 1/8" - 1'

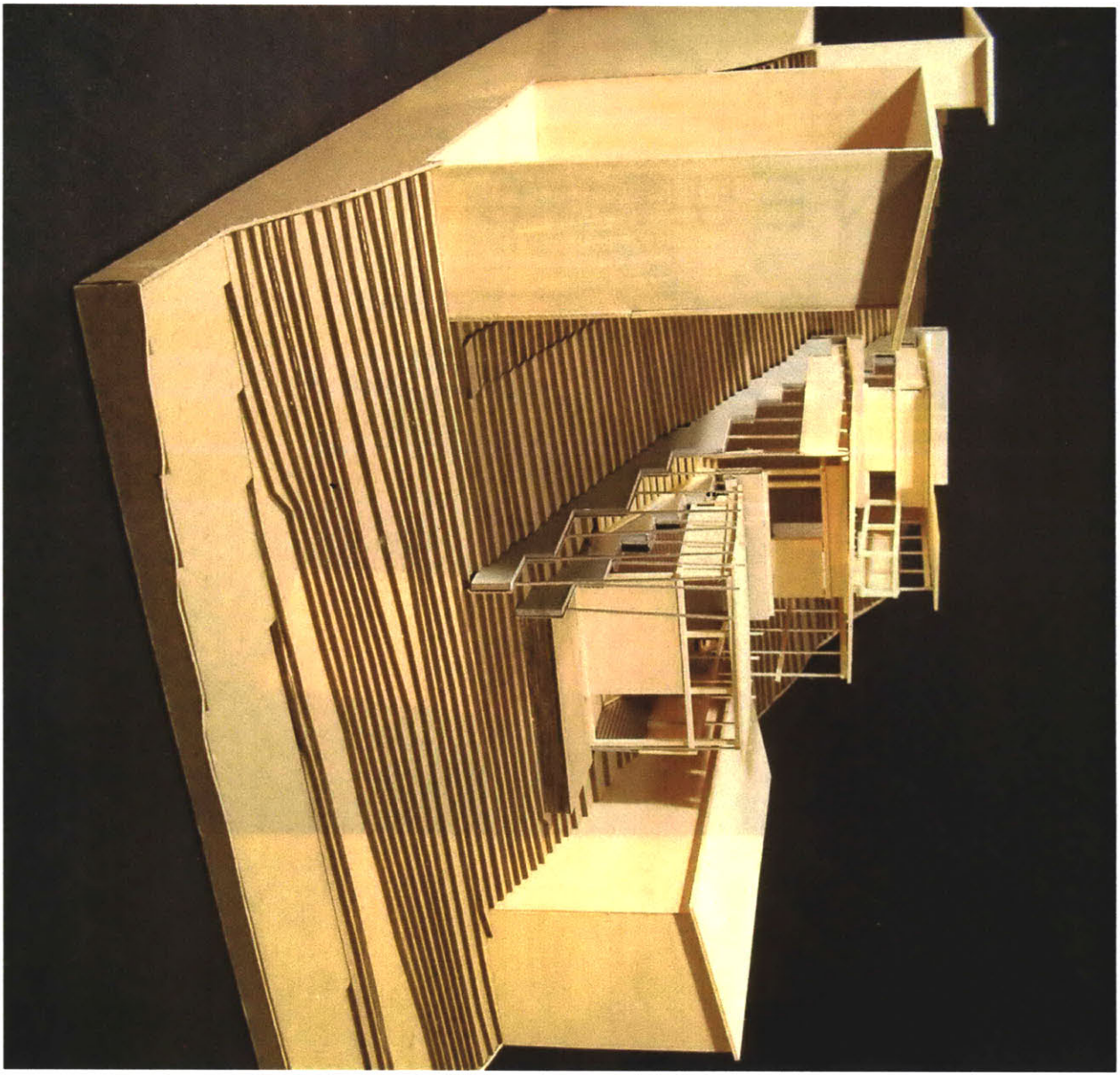


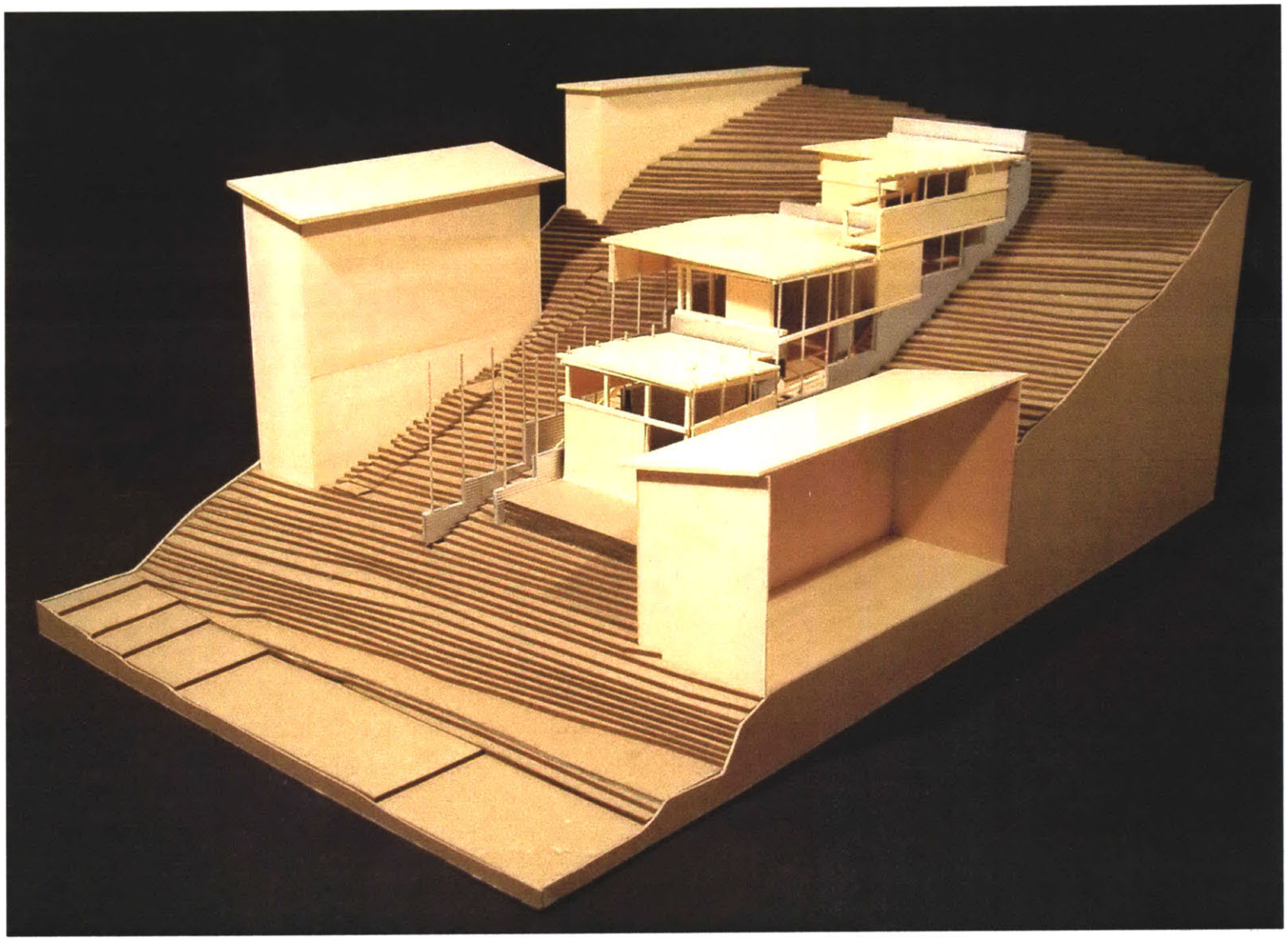
Plan Level 3 1/8" - 1'











Site Interventions

Approach to Large-Scale Interventions

Affecting change on a large scale is a complex issue with regional repercussions. While it is a goal of this thesis to instigate change at the regional level, the approach is incremental rather than sweeping. Similar to the overall approach to housing change, the idea is to introduce the new system in scattered locations throughout the neighborhood. As the new buildings are fleshed out by users and their systems are integrated with neighborhood and city systems (sewerage, water, electricity and gas supply), the changes in the way the house's system functions will begin to have an effect on the neighborhood functioning.

For example, the system supplies a graywater treatment element. This encourages the user to install plumbing that separates graywater from blackwater. The rainwater collected from the roof can either be used to flush out the blackwater system during periods of heavy rain, or can be collected and reused. As the user becomes more educated on the water system within the house, incremental changes outside of the house begin to take place. The same approach that was used for the plumbing wall of providing a flexible, accessible and modular covering system can be used to enhance existing local water treatment and conveyance systems.

In a place like La Puya, where the local sewage system is unacceptably dangerous, new sewage lines can be attached to the existing cañada system and lead down the hill to treatment. The separation of graywater and blackwater will aid in the development of a new sewage system by supporting plant growth within the community that will help anchor soil and absorb rainwater that leads to flooding. The reduction in overall wastewater lowers the capacity necessary for any treatment facility that would need to be installed.

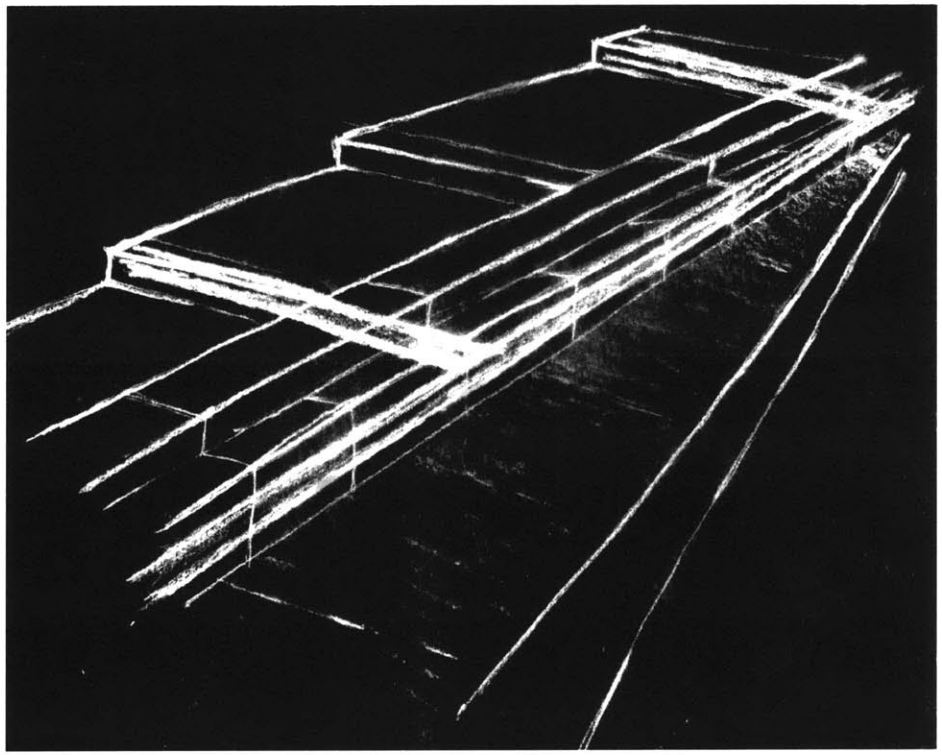
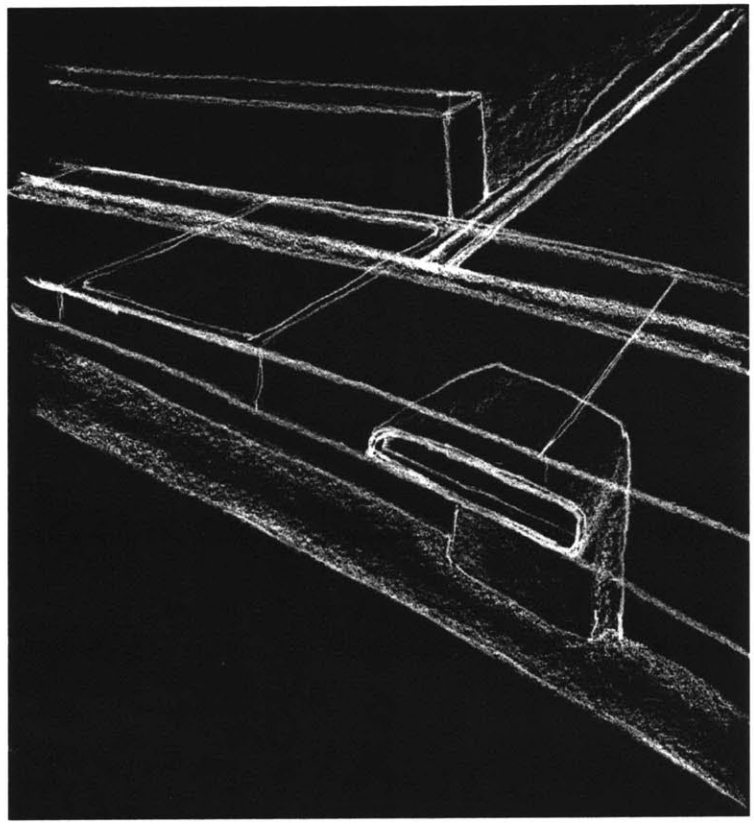


Diagram showing how wastewater lines join with existing ravine and are continued down the slope along the side of the trench. The sewage lines can be covered with a system similar to the aluminum cap within the house. The drainage pipes coming from the houses can be embedded in a shallow stair system that would aid in navigation of the steeper streets.

In Los Angeles, there is a sewage treatment network that has very high capacity already. However, the process of chemically treating wastewater in this way is highly detrimental to the environment. Not only that, but Los Angeles has had several highly publicized sewage leaks over the past decade.[1] A reduction in the amount of wastewater that reaches these plants might eventually lead to the closing of the worst offenders, and a reduced amount of money invested in the system as well. If graywater is treated locally, erosion and fire danger can also be reduced.



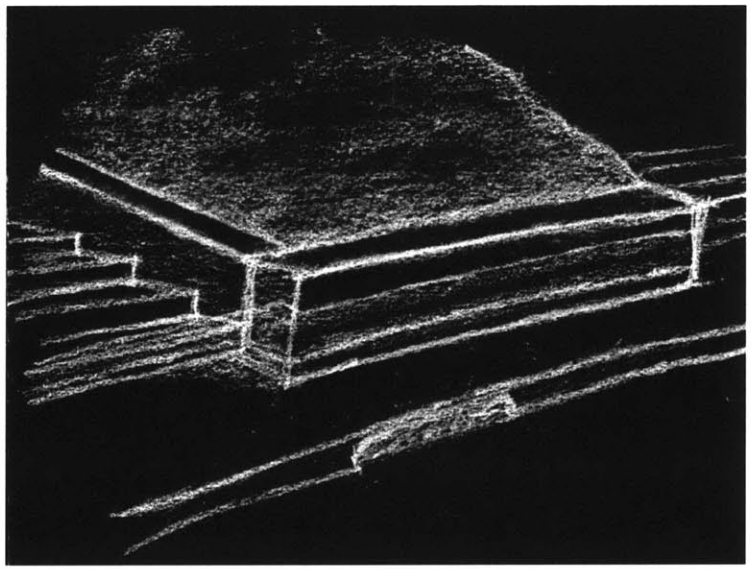
Sewer lines kept simple and accessible under sidewalks and paths, so that community residents can upgrade their exisitng systems easily.

Living Machines

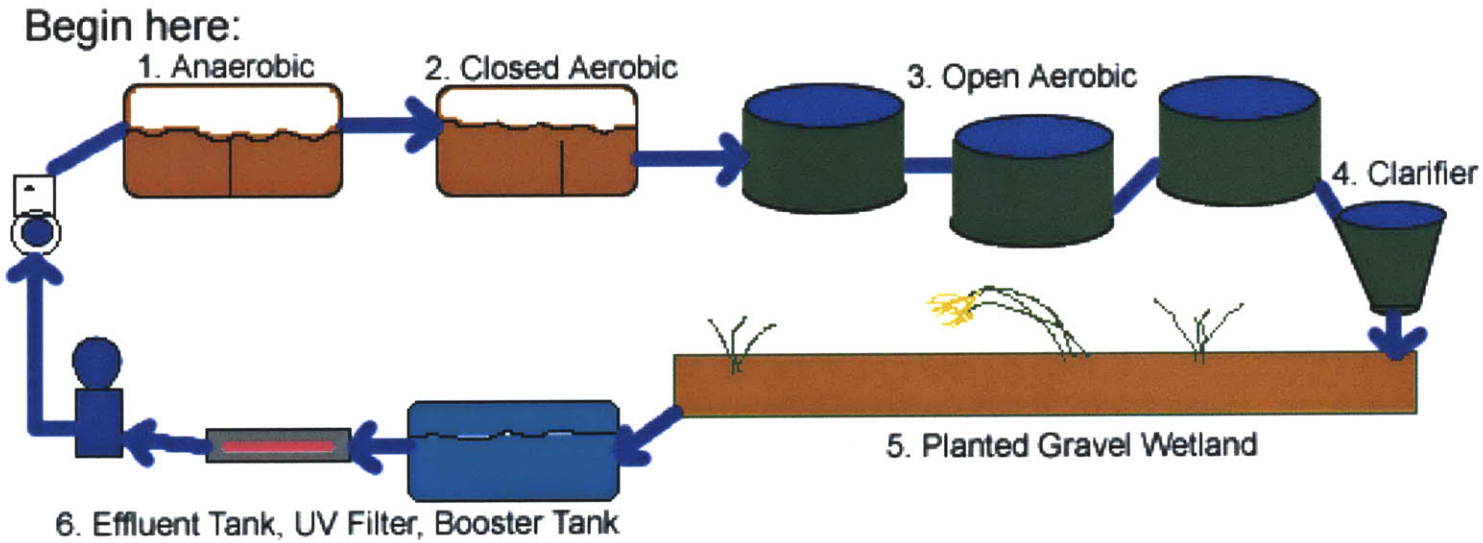
La Puya lacks water treatment altogether. Should graywater be separated from blackwater, only half of the problem would be addressed. Connecting La Puya to the municipal water treatment is impractical, due to issues ranging from red tape to expense. A localized, sustainable and practical solution would be the installation of a Living Machine.

Living Machines were developed and patented by Living Machines, Inc. and are currently in use in a variety of environments from institutions and research facilities to prototypes in developing countries. Penn State's Center for Sustainability describes their Living Machine:

> A Living Machine... is a series of tanks teeming with live plants, trees, grasses and algae, koi and goldfish, tiny freshwater shrimp, snails, and a diversity of microorganisms and bacteria. Each tank is a different mini-ecosystem designed to eat or break down waste. The process takes about four days to turn mucky water crystal clear. It is chemical-free, odor-free... and, compared to conventional waste treatment, it costs less financially and ecologically.[2]



Sewerage diverted to Livng Machines via plumbing laid in garden walls and steps



A diagram of a Living Machine installed at Oberlin University. In this case, the cleaned effluent is used to flush toilets.
http://www.oberlin.edu/envs/ajlc/Systems/Water/Tour/TourHome.htm

The major disadvantages to Living Machines are their labor intensiveness and the land they occupy. However, the open aerobic tanks at the end of the process have been used as public gardens in several installations, an amenity that La Puya is in dire need of. Also, the labor intensiveness could lead to job creation and a heightened awareness of water use and treatment. The Living Machines could be located by the river in the floodplain, newly cleared of squatters by the new houses built uphill.

Opposite: Siteplan reflecting intervention points and connecting infrastructure, as well as locations of Living Machines

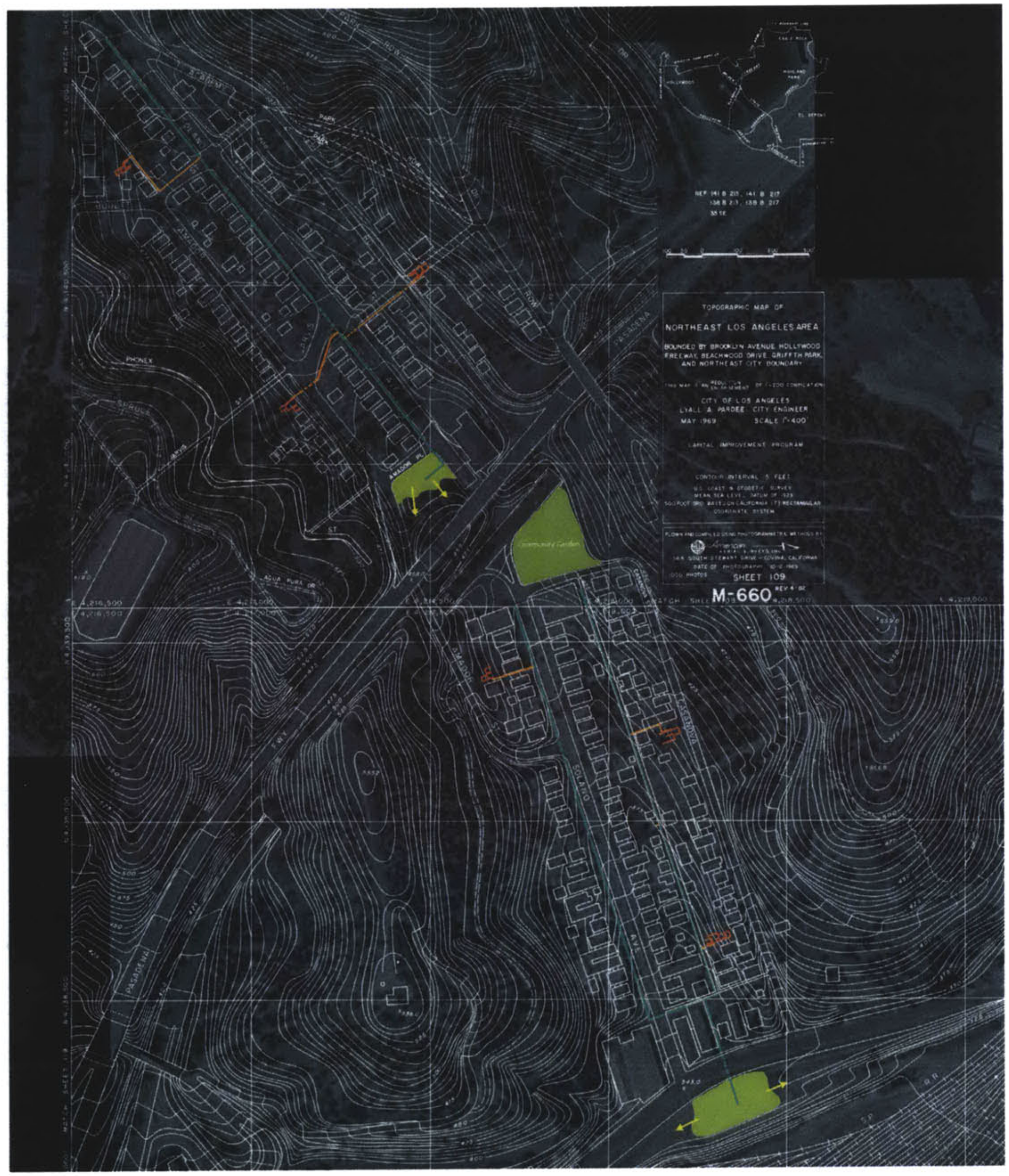

Arroyo
Hondo
25
25

Opposite: Siteplan enlarged


Arroyo
AVDA. DE LOS ARROYOS
INSTITUTO
DE ATUDA AL SERDIO
SANTA ROSA

Solano does not share La Puya's sanitation problems, but a Living Machine could help the community become a model for other neighborhoods in the Los Angeles area, and could contribute to a healthier city and region. The Living Machines proposed in Solano could act as public open space and a learning laboratory for students of the local elementary school. Two sites have been identified that would contribute to that goal: one across the street from the school, the other on an empty lot on the south side of Broadway, the most public face of the neighborhood. The amount of community involvement and interest from both within and without makes Solano a prime candidate for such a pilot project.

Opposite: Siteplan reflecting intervention points and connecting infrastructure, as well as locations of Living Machines
Following pages: Siteplans enlarged to show northern and southern sectors of Solano


TOPOGRAPHIC MAP OF
NORTHEAST LOS ANGELES AREA
BOUNDED BY BROOKLYN AVENUE HOLLYWOOD FREEWAY BEACHWOOD DRIVE GRIFFITH PARK AND NORTHEAST CITY BOUNDARY
CITY OF LOS ANGELES
LYALL A. PARDEE CITY ENGINEER
MAY 1969
SCALE 1"=400'
CONTOUR INTERVAL 5 FEET
SHEET 109
M-660
PASADENA
Community Garden


PARK
ROW
ACADEMY
SOLANO
ST
BOUETT
AMADOR
PHONEX
SPRUCE
JARVIS
AVE
PASADENA
AMADOR PL
Community Garden
AQUA PURA DR
CASANOVA
REF: 141 B 213, 141 B 217
138 B 213, 138 B 217
35 SE
TOPOGRAPHIC MAP OF
NORTHEAST LOS ANGELES AREA
BOUNDED BY BROOKLYN AVENUE HOLLYWOOD FREEWAY, BEACHWOOD DRIVE, GRIFFITH PARK, AND NORTHEAST CITY BOUNDARY
THIS MAP IS AN REDUCTION ENLARGEMENT OF 1"=200' COMPILATION
CITY OF LOS ANGELES
LYALL A. PARDEE CITY ENGINEER
MAY 1969 SCALE 1"=400'
CAPITAL IMPROVEMENT PROGRAM
CONTOUR INTERVAL 5 FEET
U.S. COAST & GEODETIC SURVEY
MEAN SEA LEVEL DATUM OF 1929
500 FOOT GRID BASED ON CALIFORNIA (7) RECTANGULAR COORDINATE SYSTEM
FLOWN AND COMPILED USING PHOTOGRAMMETRIC METHODS BY
American AERIAL SURVEYS, INC.
564 SOUTH STEWART DRIVE – COVINA, CALIFORNIA
DATE OF PHOTOGRAPHY 10-12-1969
1000' PHOTOS
SHEET 109
M-660
REV. 4-82
HOLLYWOOD
EAGLE ROCK
HIGHLAND PARK
EL SERENO
100' 50 0 100 200' 300'


FLOWN AND COMPILED USING PHOTOGRAMMETRIC METHODS BY
American AERIAL SURVEYS, INC.
564 SOUTH STEWART DRIVE – COVINA, CALIFORNIA
DATE OF PHOTOGRAPHY 10-12-1969
1000' PHOTOS
SHEET 109
M-660
REV: 4-82
MATCH SHEET 109
Community Garden
AQUA PURA DR.
AMADOR ST.
SOLANO AVE.
CASANOVA
FWY
PASADENA
E 4,217,000
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N 8,800
4,218,500
4580
552
536.0
343.0

In both cases, government funding could provide partial subsidization for the Living Machines and their upkeep. There is, however, also sufficient interest in both communities for some local support. The combined effort model is not only practical, it responds to some of the same issues on which the project as a whole is based.

Involving people on the individual, community and regional level while lending them some outside support may result in more effective, lasting and targeted change.

Notes

[1]http://yosemite.epa.gov/opa/admpress.nsf/0/9da9ba17a7d5b62485256d9d0073a6de?OpenDocument, http://www.usdoj.gov/opa/pr/2003/April/03_enrd_252.htm

[2] http://www.rps.psu.edu/0009/machine.html

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<http://zimas.lacity.org/map.asp?Cmd=zoomToPIN&PIN=139-5A217%20129&ToolTips=true>

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