



CRETE house

WATER

MISSION STATEMENT

CRETE house is a model for advanced technology, resiliency, safety and livability. The project is designed as a demonstration of integrated building technology featuring an innovative precast concrete panelized system used in homes, as a compelling alternative to traditional wood light frame construction. Our house addresses self-sufficiency in terms of energy, **water** and food production, providing an attractive outdoor space integrated with varying capacities of the exterior to grow food sustainably.

WATER COLLECTION OVERVIEW

Our method for water collection features a rainwater harvesting system that collects rainwater from the roof and provides irrigation, emergency water storage, and water for other potable uses. The concrete gutters featured in the design are used as a strategic system for this water collection, allowing for the avoidance of chemicals that are often present in potable water.

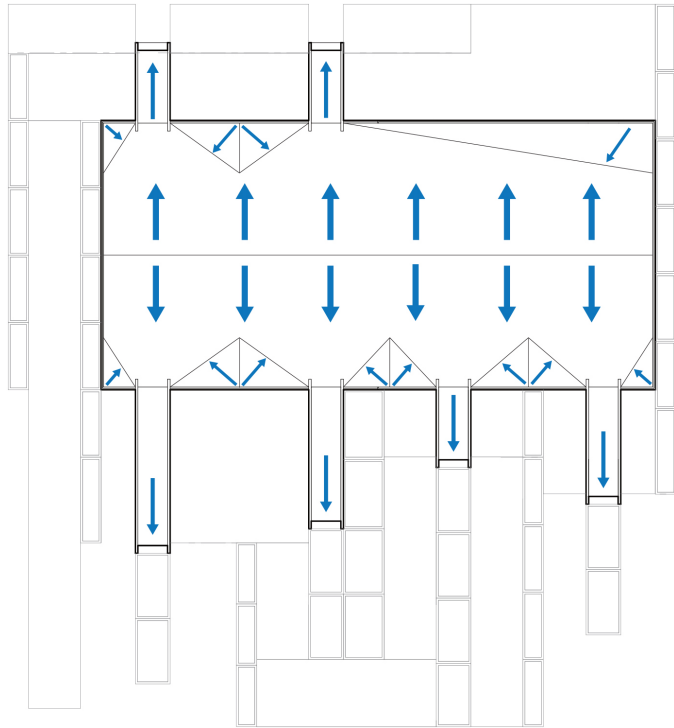


CRETE house consists of a single precast concrete volume treated as an elegant massing which engages its surrounding landscape. It is a 2:1 rectangular volume, with an east-west orientation. The north and south walls are modulated with concrete rainwater gutters flowing into linear greenery. Each of the gutters exists as a displacement of the façade's openings to create a transitional partially covered exterior space.

Rainwater harvesting has a low cost and lessens the need for expensively collected water. In terms of water collection, reclamation, and reuse Team WashU plans to utilize a system of hydroponic gardening with planters integrated with the gutters on the outer edge of the exterior decking. Due to the constant reuse of nutrients and water from hydroponic systems, we will be able to reclaim more water. Also, little to no pesticides need to be used while topsoil erosion is eradicated. We will be planning on using a hydroponic system in order to maximize the usage of the water collected on site.

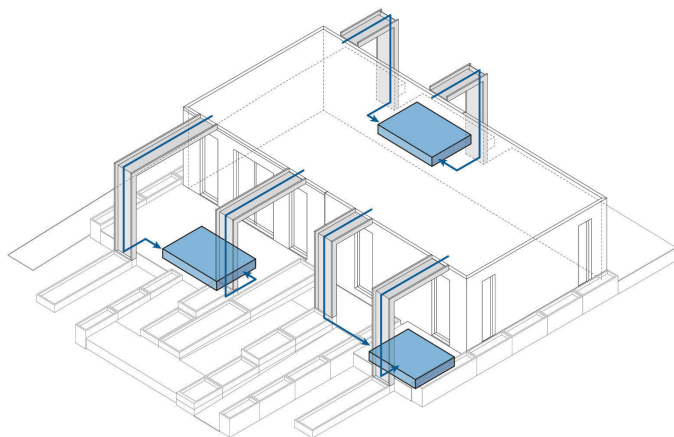
RAINWATER HARVESTING SYSTEM

The house will employ a harvesting system to collect rainwater to add to our water supply for the competition and in the longer term for the residents of the house.



ROOF PLAN SHOWING WATER DIRECTION

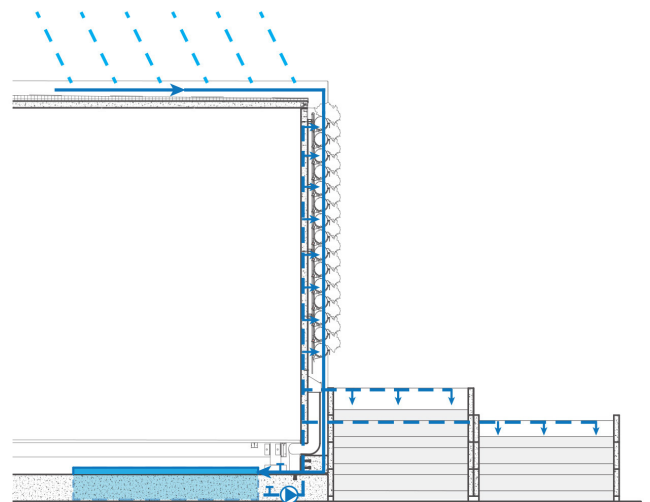
The system begins at the roof with six gutters that minimally slopes to the South and North edge of the roof (see roof plan above).



WATER COLLECTION STRATEGY

Rainwater is directed, by means of tapered insulation along a gentle 1/8" per foot slope, toward vertical gutters on the south and north sides of the building. The rainwater then cascades down behind the vertical planting system that runs the height of the vertical gutters.

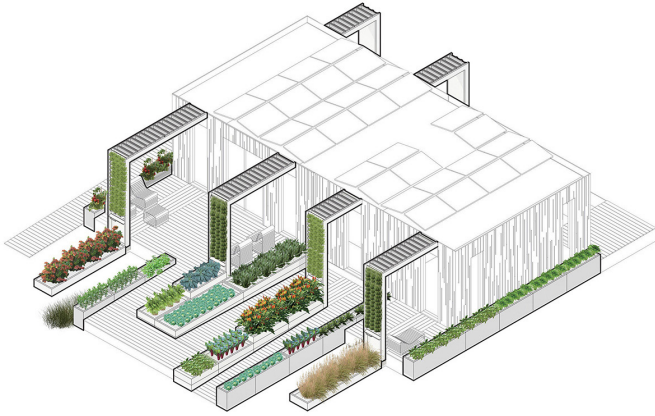
These vertical gutters contain a water collector, which drains water through a leaf eater drain; preventing mosquitoes and larger dirt particles and leaves from flowing before entering to the larger water storage tanks. The system incorporates water pumps through a separated piping system to irrigate the vertical and horizontal planters. In an effort to reclaim as much water as possible within each planter tray, excess water from plants' roots will be collected and drained into a separate system of pipes to be filtered and fed back into the water tanks. The diagram below explains conceptually how the water flows.



IRRIGATION DIAGRAM

LANDSCAPING

CRETE house will demonstrate a true community collaborative food supply through a home garden system. As part of a sustainable lifestyle, the house will provide nearly year-round vegetables, fruits and spices cared and harvested by the residents.



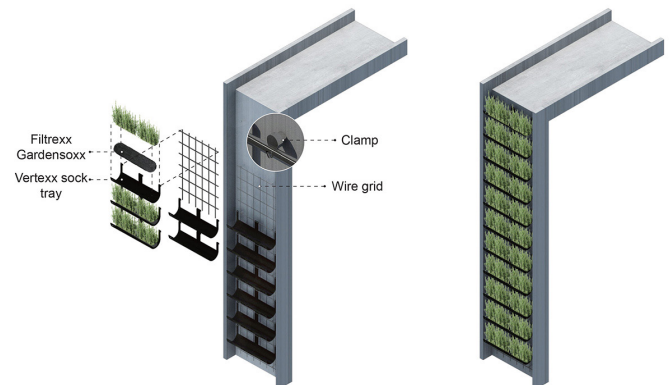
LANDSCAPING STRATEGY

If CRETE house were to be integrated into neighborhoods within St. Louis, a sustainable edible garden could be a place of community, collaboration and self-sufficiency for food deserts (areas that do not have quick access to produce and grocery stores). Implementation and influence of CRETE house within St. Louis neighborhoods is a long-term goal by nature of its prefabrication and modular capabilities. However, the permanent location of CRETE house, after the competition, will be at Tyson Research Center right outside the city of St. Louis. [See section on Tyson Research Center]. At Tyson, the house will accommodate researchers living and working at the ecological center. The landscaping and edible gardening will respond to the local St. Louis climate conditions and the needs of the residents. For example, the plants may alter to species the researchers are examining or trying to preserve.

The design concept of the house is a concrete box permeated by green gutters that, among other functions, serve as a growing platform for harvesting food. Team WashU designed a hydroponic growing system for food production with vegetated modular vertical and ground planters watered with tube drip lines. The irrigation tubes are integrated into the vertical pieces and connect to the water storage tanks beneath the decking. As previously noted, a rainwater harvesting system is implemented to collect rainwater into the water storage tanks to be pumped to the plants and the rest of the house when needed.

VERTICAL PLANTERS

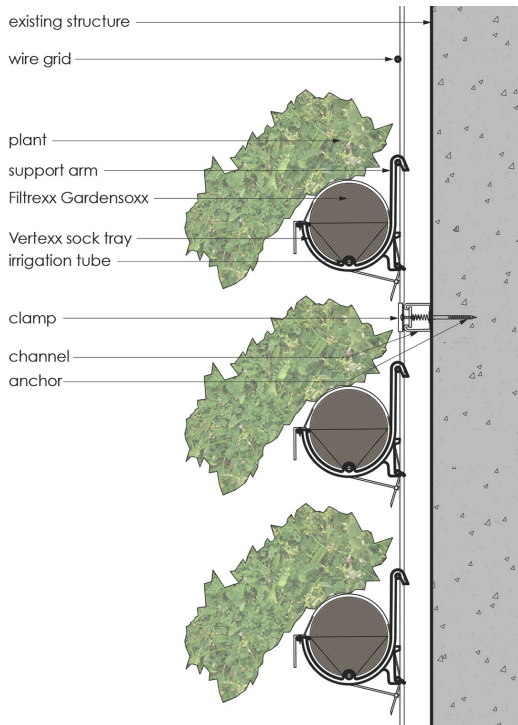
These vertical planters (see images below) fit into the modular and flexible design theme of the project. The resident can remove the individual Gardensoxx when the plants are ready to be harvested and place new ones as growing seasons change. Mostly spices, herbs and smaller flowering plants will be grown in the vertical system.



FILTREXX VERTICAL PLANTING SYSTEM

The vertical gardening system will be implemented with Filtrexx products; individual plants will be grown in their Gardensoxx in their larger system of trays.

The array of Gardensoxx in their trays clip on to a wire grid, which is attached to channels that are secured into the structure of concrete gutters. This method allows us to easily disassemble and transport the plants individually to maintain greater care in the proces of moving to Denver, then reattach the wire grid and simply clip the trays back into place.



FILTREXX SYSTEM DETAIL

The Filtrexx system allows for the drip line along each row to be controlled, therefore minimizing the amount of water released along the bottom rows because water will drip down from the upper rows. Excess water will be collected and recycled.

PLANT SELECTION

Since this project will be situated both in Denver and then St. Louis, we selected native plant species for both areas. Denver and St. Louis are in different Plant Hardiness Zones, therefore we tended to select more Missouri native plants that were frost-resistant to ensure growth during the competition in Denver's October weather.

Abv.	Plant name	Location around house	Quantity
Br	Broccoli	South	2
Ka	Kale	South	2
Ar	Arugula	South	2
Sp	Spinach	South	4
Cr	Carrots	South	7
Ra	Radish	South	4
Pe	Green Peas	South	7
Po	Potato	South	9
Ca	Cabbage	South	4
On	Onion	South	12
Ch	Chives	South Channels	30
Mn	Mint	North Channels	60
Ba	Basil	South Channels	30
Cl	Cilantro	South Channels	30
Ro	Rosemary	North Channels	60
Ps	Parsley	North Channels	60
Sa	Sage	South Channels	30
Ty	Thyme	North Channels	60
Rm	Rosemallow	South and East	9
Qp	Queen of the Prairie	South	6
Cf	Cardinal Flower	South and East	15
Sg	Switchgrass	West	20
Sa	Sedum Album	Roof	76

Total 539

PLANT SELECTION LIST

Our first priority in selecting plants were those that grew in the later summer and fall months in order to have blooming and healthy plants during the 10 day competition. We consulted several experts including Missouri Botanical Gardens and Jost Greenhouses for plant selection and advice. See Reference Image and Plant Schedule below.

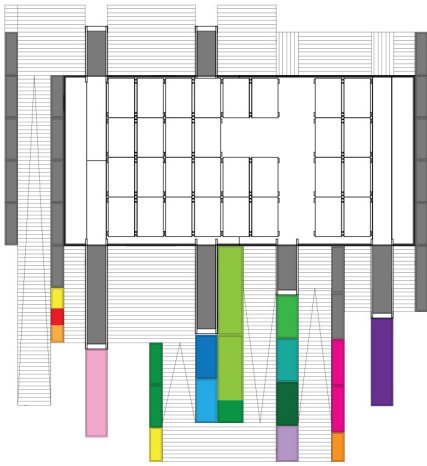
SELF SUFFICIENT STRATEGY

As part of our self-sustaining goal CRETE house provides nearly year-round vegetables, fruits and spices cared and harvested by the residents.

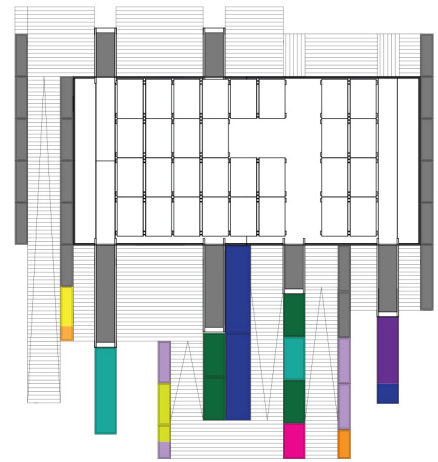
The chart below shows the weekly vegetable requirements for various types of residents.

	age	dark green vegetable	red and orange vegetable	beans and peas	starchy vegetable	Other vegetable
children	2-3 yrs old	1/2 cup	2 1/2 cups	1/2 cup	2 cups	1 1/2 cups
	4-8 yrs old	1 cup	3 cups	1/2 cup	3 1/2 cups	2 1/2 cups
girls	9-13 yrs old	1 1/2 cups	4 cups	1 cup	4 cups	3 1/2 cups
	14-18 yrs old	1 1/2 cups	5 1/2 cups	1 1/2 cups	5 cups	4 cups
boys	9-13 yrs old	1 1/2 cups	5 1/2 cups	1 1/2 cup	5 cups	4 cups
	14-18 yrs old	2 cups	6 cups	2 cups	6 cups	5 cups
women	19-30 yrs old	1 1/2 cups	5 1/2 cups	1 1/2 cup	5 cups	4 cups
	31-50 yrs old	1 1/2 cups	4 cups	1 cups	5 cups	4 cups
	50+ yrs old	1 1/2 cups	4 cups	1 cups	4 cups	3 1/2 cups
men	19-30 yrs old	2 cups	6 cups	2 cup	6 cups	5 cups
	31-50 yrs old	2 cups	6 cups	2 cups	6 cups	5 cups
	50+ yrs old	1 1/2 cups	5 1/2 cups	1 1/2 cups	5 cups	4 cups
sum/week		3 1/2 cups	10 cups	3 cups	11 cups	9 cups
sum/half year (autumn)		91 cups	260 cups	78cups	251 cups	299cups
		22.75 lb	65 lb	19.5 lb	87.75 lb	74.75 lb

VEGETABLE NEED TABLE BY GENDER & AGE



SPRING SEASON









































FALL SEASON

category	vegetable	calories per 10oz.	water need per week (in)	date to plant	number of days to bloom	min. row space(in)	expected units	expected sf	expected yield (lbs/100sf)	sum calories	sum food(lb)	sum water(g)
dark green vegetable	broccoli	117	1.25	7/25 ~ 8/5	70-80	24	2	10.4	26-39	4,274	24.2	17.3
	kale	140	1.25	7/20 ~ 8/5	50-65	18	2	5.0	135-202			
	arugula	86	1.25	9/15~10/15	30-40	12	2	5.1	135-202			
	spinach	70	1.25	8/1 ~ 8/20	40-50	12	4	5.0	50-100			
red and orange vegetable	carrot	115	1.0	7/25 ~ 7/30	70-85	18	7	46.9	100-150	10,162	73.5	16.7
	radish	63	1.25	8/1 ~ 8/15	25-35	14	4	7.6	100-200			
beans and peas	green peas	240	1.0	7/4	65-75	24	7	28.4	30-72	7,872	20.5	17.7
starchy vegetable	potato	364	1.5	3/20 ~ 4/10	100-120	30	9	46.9	100-200	54,629	93.8	39.0
other vegetable	cabbage	82	1.25	6/19 ~ 7/17	70-80	24	4	20.8	96-191	13,964	85.3	30.3
	onion	120	1.0	7/27	100-120	14	12	22.8	100-200			
native plants	rosemallow	--	1.0	4/15 ~ 5/20	60-80	24	9	--	--	--	--	100.4
	queen of the prairie	--	1.25	3/25 ~ 5/5	50-65	30	6	--	--			
	cardinal flower	--	.75	4/15 ~ 5/20	40-60	12	15	--	--			
	switch grass	--	1.25	5/15 ~ 6/15	70-85	18	20	--	--			
	sedum	--	.5	3/20 ~ 4/10	36-50	12	76	--	--			

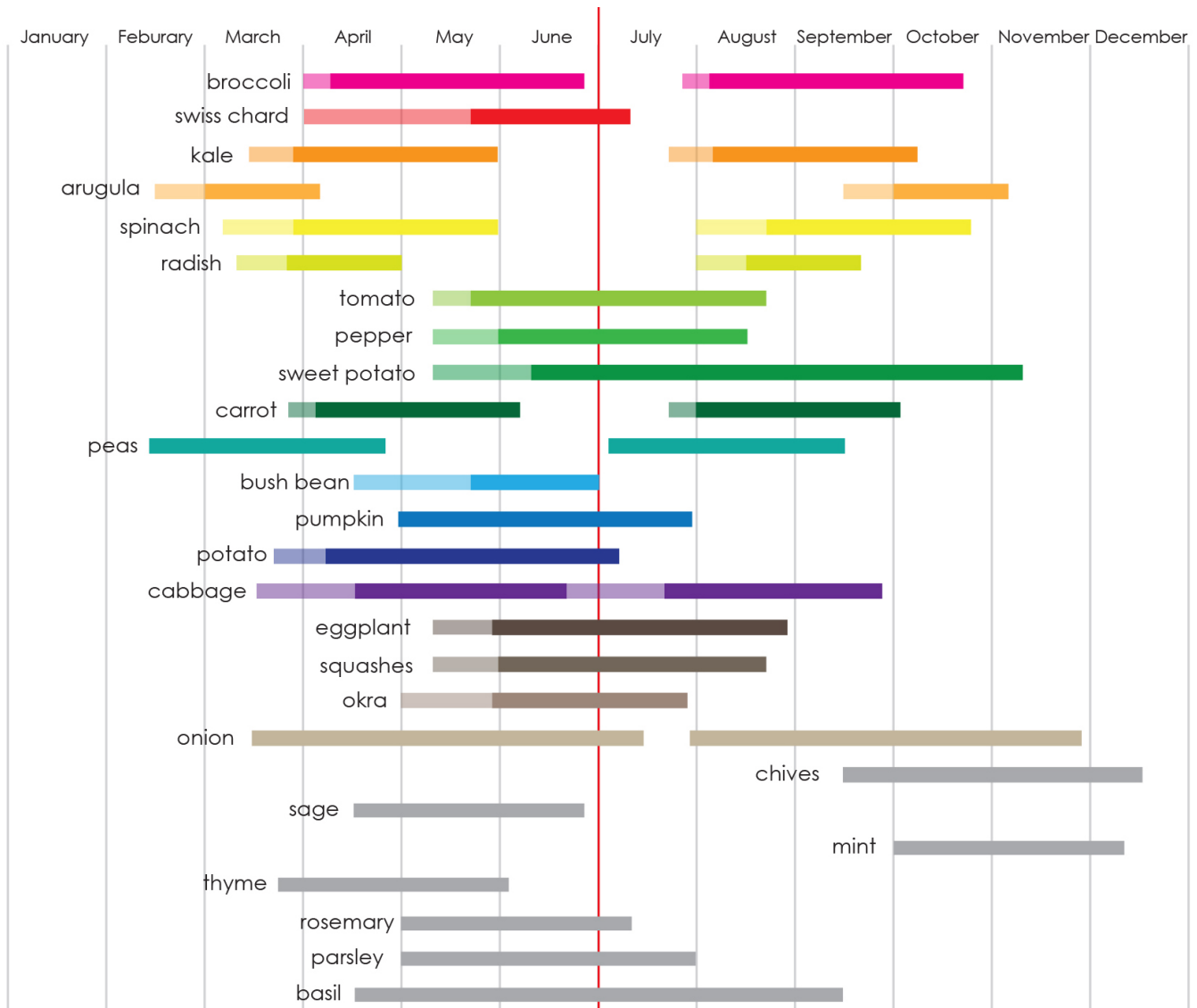
Total **90,901** **297.3** **221.4**
 calories **lbs** **gallons**

PLANT SCHEDULE FOR FALL SEASON

category		vegetable	calories per 10oz.	water need per week (in)	date to plant	number of days to harvest	min. row space	expected units	expected sf	expected yield (lb/100sf)	sum calories	sum food (lbs)	sum water (g)
dark green vegetable		swiss chard	55	1.25	4/1 ~ 5/20	55-65	18	 2	10.4	10	3,894	22.6	18.4
		arugula	86	1.25	2/15	30-40	12	 2	5.1	5			
		kale	140	1.25	3/18 ~ 4/1	50-65	24	 2	5.0	5			
		spinach	70	1.25	3/5 ~ 3/25	40-50	18	 2	5.0	7			
red and orange vegetable		tomato	51	2.5	5/10 ~ 5/20	75-90	48	 4	50	50	23,790	115.7	38.9
		pepper	57	1.25	5/10 ~ 5/30	70-80	30	 3	13.1	5			
		sweet potato	243	2.5	5/10 ~ 6/10	150	30	 1	23.0	70			
		carrot	115	1.0	3/25 ~ 5/5	70-85	18	 3	23.5	9			
beans and peas		bush bean	840	1.25	4/15 ~ 5/20	50-60	24	 2	4.2	72	3,301	21.2	17.6
starchy vegetable		pumpkin	284	2.5	4/29	90-100	24	 2	38.7	144	18,667	39.2	30.5
		green peas	240	1.0	2/18	65-75	24	 2	13.9	15			
other vegetable		eggplant	69	2.5	5/10 ~ 5/25	80-90	24	 3	12.3	3	19,042	109.4	41.7
		squashes	103	1.25	5/10 ~ 5/30	75-90	48	 4	11.4	48			
		okra	94	1.25	5/1 ~ 5/25	55-60	30	 2	14.2	4			
		cabbage	82	1.25	3/20 ~ 4/20	70-80	24	 1	10.4	23			
native plants		rosemallow	--	1.0	4/15 ~ 5/20	60-80	24	 9	--	--	--	--	100.4
		queen of the prairie	--	1.25	3/25 ~ 5/5	50-65	30	 6	--	--			
		cardinal flower	--	.75	4/15 ~ 5/20	40-60	12	 15	--	--			
		switch grass	--	1.25	5/15 ~ 6/15	70-85	18	 20	--	--			
		sedum	--	.5	3/20 ~ 4/10	36-50	12	 76	--	--			

Total **68,694** **308.1** **247.5gal-**
calories **lbs** **lons**

PLANT SCHEDULE FOR SPRING



GROWING SEASON CHART

IRRIGATION

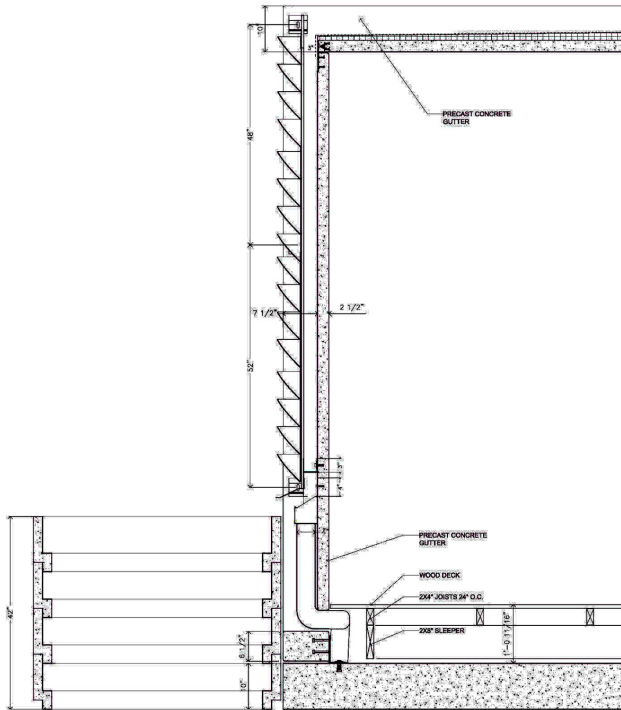
Irrigation for plants will be supplied from a rainwater harvesting system. The rainwater collected from the roof through six gutters, two on the North side and four on the South side, will be funneled into three rainwater tanks.

These bladders will hold any rainwater collected during the competition as well as the 50 gallons for irrigation we are given on water delivery day. A single pump for each of the bladders will recirculate the water to the plants through drip irrigation methods.

Rainwater tanks are located below the deck, two in the south and one on the north side, next to the strip footings of the gutter and each can hold 200 to 300 gallons.

The drip irrigation system will run a series of driplines from the bladders up over the lip of the planters and along the North-South grain of planters. Each drip emitter will have the capacity to drip 2lph or 0.5 gallons per hour. Few of the plants may require watering daily, but most of them will only require watering every other day for a short period of time. For one week, the maximum time the dripline would run would be 5 hours, assuming no rain.

Any remaining water in the planters would be drained through the plant roots and channeled into another recycling water pipe attached to the plant liners. These reclamation water pipes would travel through the bottom of the planters to the tanks to be saved for later use.



IRRIGATION SYSTEM DETAIL

WATER BUDGET FOR VEGETATION

Below is a list of edible plants, their quantity and water needs. As we only get 50 gallons for irrigation during the competition, we will use filtered greywater to fulfill the remaining amount of water needed plus any rainwater we are able to collect.

VERTICAL PLANTERS

Plant name	Water (in)	Quantity	Total Gallons per watering event
Chives	.5	30	2.3
Mint	.5	60	4.7
Basil	.5	30	2.3
Cilantro	.5	30	2.3
Rosemary	.5	60	4.7
Parsley	.5	60	4.7
Sage	.5	30	2.3
Thyme	.5	60	4.7

Total 28.0

GROUND PLANTERS

Plant name	Water (in)	Quantity	Total Gallons per watering event
Broccoli	1.25	2	8.1
Kale	1.25	2	3.3
Arugula	1.25	2	2.0
Spinach	1.25	4	3.9
Carrots	1.0	7	10.8
Radish	1.25	4	5.9
Green Peas	1.0	7	17.7
Potato	1.5	9	39.0
Cabbage	1.25	4	16.2
Onion	1.0	12	14.1
Rosemallow	1.0	9	14.1
Queen of the Prairie	1.25	6	17.7
Cardinal Flower	.75	15	10.6
Switchgrass	1.25	20	29.4
Sedum Album	.5	76	28.6

Total 220.8

The planters on the ground will only need watering once a week, therefore the total amount of water they need remains 220.8 gallons of water. However, the plants along the vertical planters will need watering about 3x a week. The total amount of water needed for the vertical planters is 84 gallons of water throughout the week. This brings the total amount of water needed for the plantings throughout a week to 304.8 gallons.

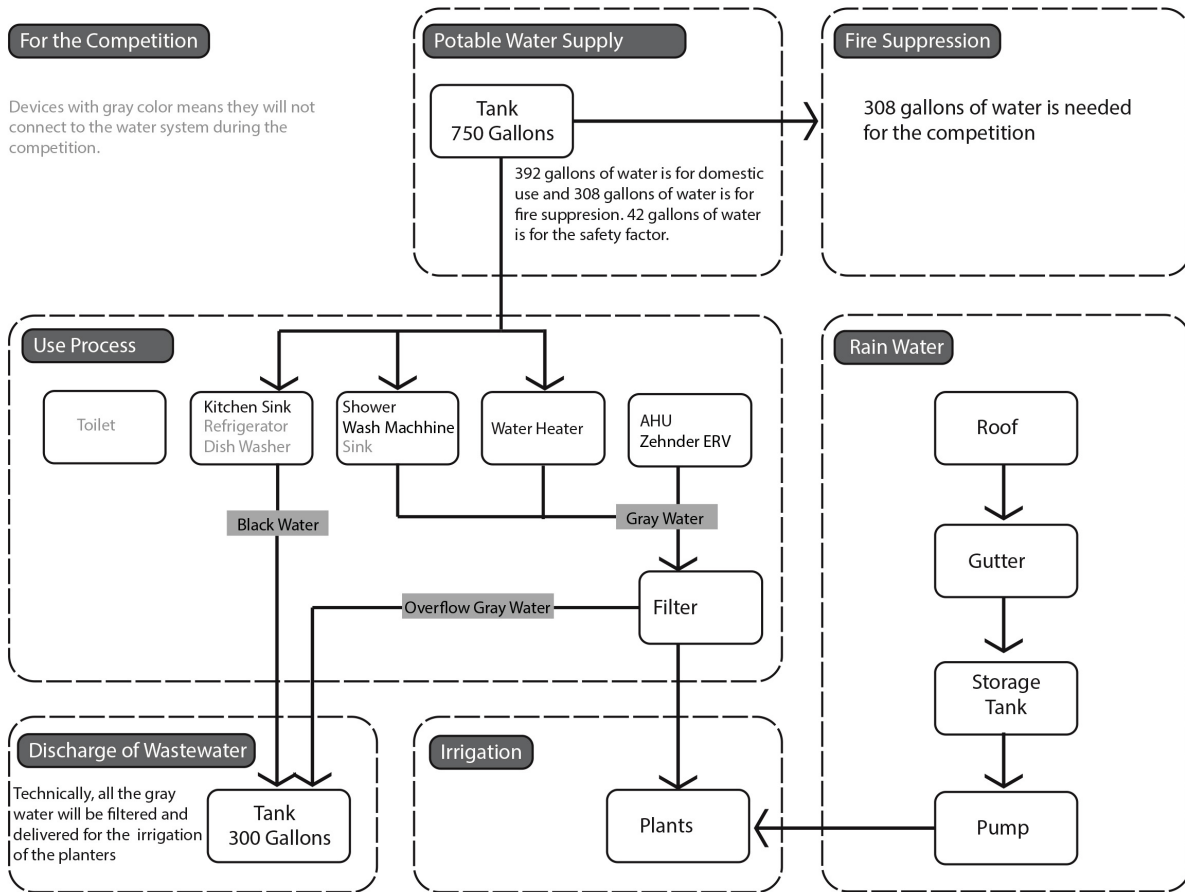
WATER MANAGEMENT

Crete house utilizes water for multiple uses including: potable water, fire suppression, rainwater collection, landscape irrigation and hydronic radiant heating a cooling systems. Rainwater is collected and filtered for irrigation. All the black water will be diverted to a waste water tank.

The supply and waste water tanks are each sized at 400 gallons. Each of these 400 gallons is provided by two 200 gallon plastic loaf tanks that have been ganged together and placed under benches on the rear deck. This water will be for potable water use.

The secondary tank system will be sized at 1100 gallons and will comprise 308 gallons of water for the fire suppression and the rest of the water to act as a thermal sink/ source for CRETE House's water to water heat pump. Because of the large source size, a safety factor is already built in to the fire suppression system.

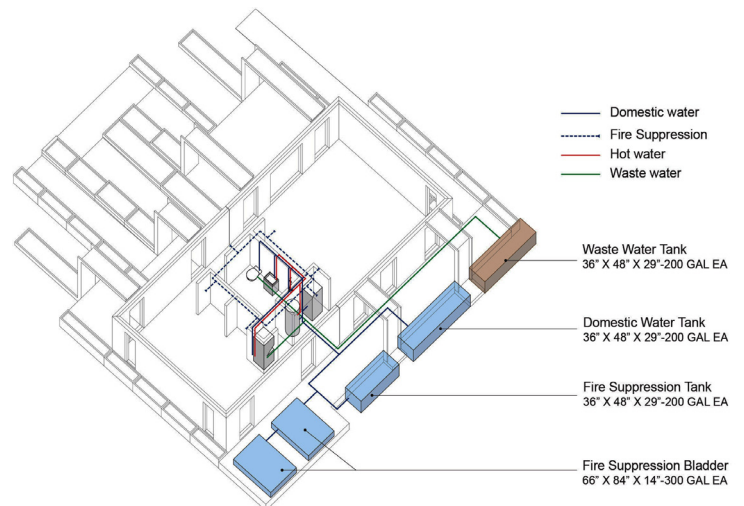
The tertiary tank system is for rainwater collection. There are three rainwater tanks which fit under and within the deck framing. Each tank can store between 200 to 300 gallons of water which will provide approximately 10 days of water for the exterior plants depending on wind, evaporation, and sunlight.



WATER MANAGEMENT DIAGRAM

WATER SYSTEM

CRETE house uses a water to water heat pump. The 1100 gallon fire suppression / mechanical thermal storage tank will provide the source and sink for conditioning the interior of the home through the radiant slabs and through the air handler, if required. Water will be pumped in an open loop design from the tank, through the heat pump and back to the opposite end of the tank to get the highest efficiency possible out of the loop.



WATER DISTRIBUTION DIAGRAM