"Armor of God" Shelter

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Disclaimer: This article documents the construction of my shelter. Shelter construction contains many inherent risks related to materials, site topography, threat assessment, mitigation approaches, actual threats and safety; to name a few. Safe construction practices must be followed to minimize these risks and dangers. Use of the information in this paper is AT YOUR OWN RISK. It is meant as a public service and represents the author's personal knowledge and approach, not to replace your own experience, common sense or instinct.

I. INTRODUCTION

A. General

A little after 11 a.m. on Tuesday, 3 June 2008, a large tornado swept up from the south. It came over the high ridge behind the house and demolished a high voltage power transmission line running through my property. As it descended down the hill towards the house, it splintered into several tornados. Fortunately the tornados missed the house even though it closely struck on all four sides. I lost around 50 large trees to these beasts. Some trees were torn from the earth at their roots while others were broken in two like twigs. I was in a state of shock. This is what my driveway looked like after the tornados struck. I was cut off from the rest of the world, buried in a pile of trees. It took me almost a year to get *back to normal*. It was finally over after I cut and split a fifteen years supply of firewood.

I began to contemplate building a storm shelter. My house does not have a basement or any safe room to flee to in the event of large tornado.

But if I build a storm shelter, it sure would be nice if I could also use it as a root cellar. That way I could keep a large supply of long shelf-life food storage in an ideal temperature storage environment.

A well-stocked root cellar would mean that my family could survive a great famine. Over history, there have been many great famines that have struck the four corners of the world. When a great famine strikes, one third of the population can slowly starve to death. Starvation is a terrible way to die. A great famine can and will happen again. I think the last time this nation faced the prospect of a great famine was after "the Year Without a Summer" and the winter of 1815/16, which immediately followed, when the farmers in the New England states were forced by starvation to eat their seed corn.

A well-stocked root cellar can help my family survive one more type of threat: great epidemics and plagues, such as a reoccurrence of the bubonic plague, the Spanish flu or a small pox epidemic. Built into my homestead are many features that make the property fairly self-sufficient. If the need arises, we could cut ourselves off from the rest of the world for a year, patiently waiting for the epidemic to run it's coarse. A well-stocked root cellar would give us the ability for a self-imposed quarantine.

But why should I stop there. It wouldn't take much to also include in the shelter design the resiliency for surviving a massive earthquakes, such as the New Madrid earthquakes (4 large ~8.0 magnitude earthquakes between 16 December 1811 and 7 February 1812).

I could also include in the design the ability to survive a reoccurrence of an eruption of the Yellowstone super volcano. This would include the ability to survive a massive ash fall, ground and water pollution and a major global cooling event that would severely constrain crop production.

And going this far, why would I not build into the shelter design the ability to withstand the effects of a nuclear war. With a good design, it would not only survive the hazards of radioactive fallout but also the direct effects of the blast wave from a nuclear explosion.

By incorporating an NBC Filtration System into the design, the shelter would also provide protection not only against nuclear threats but biological and chemical attacks as well.

At this point, the design would also give me a toolset for surviving a large asteroid or comet impacts.

I could add to the design and make the shelter resilient to the effects of a massive solar storm. A large solar storm could damage the electrical power grid across a large segment affecting 100 million people in the United States throwing us in a yearlong blackout.

And then I could build into the shelter protection from an electromagnetic pulse generated by a high altitude nuclear detonation. This pulse can damage or destroy most electronic circuits, which are one of the basic building blocks of modern society. Anything contained in the shelter would be immune.

And going this far, there is one other threat I must deal with, nearby supernova events. In my humble opinion it is the second leading cause of the great mass extinction on planet Earth.

A shelter designed for protection from supernova radiation (very high energy protons or ions) would also provide protection from neutron bomb explosions.

I guess if I am going to the pain and effort to build a shelter, it should be a universal shelter. One that addresses an array of threats, even those I have not yet imagined. There is an economy of scale. Many of the tools needed to survive one cataclysm are applicable for many others. It seems only reasonable to construct a versatile shelter for whatever comes my way.

Some people might think that even discussing an underground shelter means that I am on the fringes of society, afraid of the dark and that I shake in fear of the unknown. But it is quite the opposite. I understand the unknown. I've studied it, quantified it and have general ideas on survivability and construction techniques. Man is characterized by a strong desire for survival. It is ingrained in us, part of our very core and nature. The purpose of this universal shelter is an understanding that *bad things happen to good people*. It is a tool to get *back to normal*.

B. <u>The Name</u>

Since this shelter is unique, it deserves a proper name. I thought about calling it the *Universal Shelter*. But that is so drab. So what should this shelter be called? I thought that maybe a more descriptive name would be a *TEOTWAWKI Shelter*. TEOTWAWKI is an abbreviation for "the end of the world as we know it". That is too complex. Then I thought maybe a *Come-What-May Shelter*. That comes very close to describing the shelter. As I was working my way through the construction process, I found a beautiful medallion, which showed a knight in shining armor. It read, "Put on the full Armor of God. The Lord is my strength. I shall fear no evil." So I bought the medallion and affixed it to the door of the shelter. The shelter will henceforth be called the *Armor of God Shelter*. It is my way of honoring God.

C. Main House

Another element that should be factored in for survival is our main home. It has several unique features, which allows conversion to an off-grid dwelling. Under some threats (epidemic, massive solar storm, great famine) our home will survive unscathed, while in others not so much so. The house has well water pump, driven off 220V electrical power. There is also a spring that feeds into a 1000-gallon spring tank with an old fashion heavy cast iron hand water pump. The house has a septic system for sewage treatment. The house was constructed on energy efficient design, which reduces the expense of heating and cooling the home. During the past 35 years our house was heated in the winter solely with a high efficient wood stove. Currently we have an 8-year supply of firewood compliments of the tornado that struck 7 winters ago. The house has a 500-gallon propane tank that is used to heat water and run the clothes dryer. A full tank will last around a year and a half. The house has a steep hill on one side that acts like a berm that can attenuate some atmospheric shock waves. Many of the features of the home were designed around being self-sufficient. The home has telephone lines with a dedicated landline Scitec emergency phone. The house is also equipped with a 30-foot high lightning rod.

The house has a metal roof, which is resistant to wind and hail damage. I thought that the roof might attenuate the radiation from an EMP threat. Since FM radio waves approximate the frequency of the EMP threat, I tested this theory. In general, the metal roof was ineffective with one exception. The utility room appeared to be fairly well shielded. This is an important room in the house because it contains the water pump electronics, the water pressure system, the water heater, washer and dryer. The pole barn has a 250-watt off-grid solar panel electrical system, which I installed in 1999 and have used continuously since then.

There is one other advantage to my homestead. It doesn't have a mortgage. Thirty-five years ago, I bought 35 acres of land and paid cash. Over the years, my wife and I built our home using a pay-as-you-go approach. (So it doesn't have a mortgage and never had a mortgage. And as long as I am alive it never will.) The important point is that if your home is mortgaged then you really don't own your home – the bank does. And if you miss a payment, you can lose everything. My immigrant grandfather worked and saved for years to finally buy a large farm in Michigan. He had the cash to buy it outright but held back $500 to buy a tractor and other farm supplies. The Great Depression hit and almost overnight the financial system collapsed. The bank closed its doors for good. Even though he had $500 in the bank, the bank went bankrupt and the money was lost. But not his mortgage! The creditors were quickly knocking on his door ready to repossess the home and farm and evict his family making them homeless and destitute. The family pulled together and eventually paid off the mortgage. During those years, my father would work a whole day harvesting corn for only a meager 25¢. It was through hard work like this that the mortgage was finally paid. The lack of a mortgage is one of the approaches, which I have incorporated to shield me and my family from a financial collapse.

D. Root Cellar

From a construction perspective, a root cellar is a buried underground structure. It provides a dark, cold (32° F - 40° F), high humidity (85-95%) natural environment. This natural cold environment maximizes the shelf life of food stored using long shelf-life food storage systems. There are three types of food storage systems that I will use which can provide a shelf life of 25+ years. The *first* is superpails, which are used to store dried grains and legumes (such as wheat, rice, beans, barley, spelt, oats and peas). The grains and legumes are placed in a sealed metalized plastic bag with an oxygen absorber and sealed. These are then placed inside a 6-gallon bucket (superpail). This method is the least expensive and provides the bulk of the food stored. The *second* is #10 tins of freeze-dried food. This is the most expensive method but it offers a great variety of food that can be mixed with grains and legumes to provide tasty and balanced meals. The third is canning quart size and pint size jars where the food has been pressure-cooked.

Early pioneers and settlers used a root cellar as refrigerated storage. In a world without electricity, this root cellar can provide ideal storage environment for various types of fresh foods including: apples, (Jerusalem) artichokes, (dried) beans, beets, broccoli, Brussels sprouts, cabbage, carrots, celeriac, garlic, leeks, muskmelon, onions, parsnips, peanuts, pears, potatoes, pumpkins, radishes, rutabagas, squash, sweet potatoes, tomatillos, tomatoes, turnips and watermelon. Natural refrigeration is an important element in the recovery process – "getting back to normal".

Part of this Years Harvest in Protected Quart Jars

E. Table of Contents

Due to the length of this paper, I have included a table of contents to provide a structure.

II. DESIGN

A. Design Goals

* Tornados to EF-5 and beyond.
* Nuclear Bombs (blast wave to 50-psi peak overpressure, fallout shelter). Designed to survive the blast wave from a 1-megaton nuclear weapon explosion 5,000 feet from shelter. Provide a protection factor of 10,000 against gamma ray radiation.
* Chemical and Biological Attacks.
* Asteroid/Comet Impact Events (blast wave to 50-psi peak overpressure- the edge of hell)
* Nearby Supernova Events (shielding from protons and secondary particles with energies greater than 500 MeV at the earth's surface.
* Neutron Bomb Attacks (14 MeV neutrons).
* Forest Fires and Firestorms.

By virtue of the fact that it is also a buried steel enclosed root cellar, it will protect my food storage and prepper supplies for the following threats:

* Major earthquakes (The New Madrid Fault Line produced 3 earthquakes about a year apart that were between magnitude 7 and 8 on the Richter Scale in the years 1811/1812).
* Yellowstone Supervolcano (1,272 miles away).
* Massive Solar Storm (Supplies for surviving a 1 year loss of the electrical power infrastructure).
* Pandemic (Quarantine - Supplies for a year).
* Electromagnetic Pulse (EMP) attack.
* Global Famine.
* Great Depressions and Civil Unrest.

B. Design Concept

1. General

I decided to utilize a used intermodal-shipping container in the construction of the "Armor of God" Shelter primarily because of its low cost. But there are two weaknesses with this concept that must be addressed. Intermodal shipping containers are designed to support 300 tons of weight on the four corners. But structurally they are fairly weak in the middle and can easily collapse. Secondly, intermodal shipping containers are made of metal, which will rust. Since a used shipping container has been exposed to years at sea aboard transport ships, the container has already suffered some rust damage. Rust can significantly weaken the structural strength and integrity of the shelter.

To provide strength to the container, an internal wooden support system is required. This will consists of 7 square support beams. Each side of a square support beam will use two 2x10 inch pieces of lumber that are combined using liquid nails and screws. The structure will also be integrated with a shelving system that provides center beams. I also incorporated 13 steel adjustable building columns into the design. In general, the shelter has an array of vertical supports spaced every 2 feet. It might be a bit of overkill, but the metal didn't budge when I covered the shelter with 29 tons of gravel.

In order to compensate for the rust weakness, I focused on site location, drainage and outer skin. This type of shelter cannot be buried in the level ground. It can be buried in the side of a hill or can be placed on the ground and covered with a mound of earth. If you dig a hole and drop in a metal shipping container, it can turn the ground around the shelter into a large pool should it rain heavy. Some shelters have been known to rise to the surface because of the buoyancy during a flood. So site selection is an important issue. In my case, I build the shelter into the side of the hill. A hole 12-feet deep was dug into the side of a hill. The shipping container was dragged into the hole. Once at the site location, the container was raised onto solid concrete blocks as footers. A drainage system consisting of plastic drain tiles were laid and covered with gravel, in order to drain any water away from the shelter. Then the top and sides of the shipping container were sealed with 2 inches of foam insulation and then the top was covered with a layer of rubber roofing. And then the shelter was buried.

Shipping containers are available in a variety of conditions. I selected one that had minimal rust damage. It was almost like new. It cost a little bit more but I feel it will pay off in the long run.

Selected Site Location

The shelter is not designed for long-term habitation but rather for short-term refuge during a cataclysmic event. It is not equipped with beds, kitchens, entertainment centers, bathrooms, etc. It is a bare bones very capable survival machine. The idea is to pack people in like sardines for a short period of time until the danger is over. That's why it's called a survival shelter. It is a means for survival.

In general, almost all lumber used in the construction will be treated lumber, to prevent possible damage by termites. In some cases I used oak. I love to work with this type of wood because it is very smooth and strong. When using oak, I predrilled all screw holes that penetrate oak components because the oak strips are thin (2 inches) and otherwise they would split. I used oak plywood on the shelves because I like working with it. I stained and sealed the shelves to give it a nice finish.

Wood must conform to the metal. This requires a degree of wood craftsmanship. I had to make several precision cuts on treated lumber using my table saw and a worm drive portable saw. I have come to love my worm drive saw. It cuts almost with the precision of a table saw. I bought it at Sears on the discount table. Apparently it was a return item. When I got it home and tried to cut with it. It smoked. Electric saws should never smoke; especially not right out of the box. I purchased the saw without an instruction manual, but I was able to obtain a copy on-line. After studying the instruction booklet, I discovered the blade was installed backwards and the blade knockout had not been removed. I remedied the problem and the saw has worked great ever since.

2. Integrated Shelving System

The shelving system is specifically designed around the needs for long-term food storage. There are three types of storage that preserves food long-term, in the neighborhood of 30 years. These are grains stored in 6-gallon super pails, freeze-dried food and food stored in canning jars. The integrated shelving system provides double rows of shelves for superpails. It provides a row for double-stacked #10 tins of freeze-dried food. It provides 2 rows for canning quart size and pint size jars. Superpails are used to store dried grains and legumes (such as wheat, rice, beans, barley, spelt, oats and peas). The grains and legumes are placed in a sealed metalized plastic bag with an oxygen absorber and sealed. These are then placed inside a 6-gallon bucket (superpail). This process of sealing grains in a nitrogen environment will provide shelf lives of approximately 30 years. Freeze dried food can also have a 30 year shelf life.

The shelves will hold up to 76 superpails (approximately 3,420 pounds of beans, rice and other grains). They will also hold up to 304 tins of freeze dried food (meats, vegetables and fruits) in #10 cans. They will also hold up to 716 quarts of food in canning jars. I use the shelves to store some of my prepping supplies, which reduces the actual food storage amounts.

Shelving Framework

3. Shelf Containment System

One of the features built into the shelter is a shelf containment system. The system is designed to keep stored food and other prepper supplies from falling off the shelves and from being damaged. This feature is important for the following threats: major earthquakes, nuclear war, and asteroid/comet impact events.)

The system contains removable oak slats for each shelf except the topmost. The topmost shelve is reserved for non-breakable lightweight items such as toilet paper, sleeping bags, etc. The system contains a permanent oak slat at the end of each shelf. The system uses aluminum window screen mesh to contain items from falling off the backside on the two shelves reserved for canning jars. Additionally, the system contains items to prevent the canning jars from smashing against each other and breaking while contained on the shelves. Super Duty 6" x 8" Bubble Bags (available from Uline) use bubble wrap technology to protect individual quart canning jars. Hard plastic canning jar containers by Jar Box are used to protect a dozen pint canning jars each.

The bubble wrap is a very tight fit on the quart jars. I found that if I dust the outside of the jars with baking soda, the bubble wrap would slide on with significantly less effort.

On the two shelves containing the canning jars, I installed around fifty 5/8-inch brass cardholders so that I could label the contents. Since the contents of the canning jars will no longer be clearly visible, I had to have a means of identification.

4. Container Support Framework

The metal shipping container requires additional structural support to carry the weight loading. This extra support not only applies to the top but also the sides. This is provided by 7 square supports, the interior bracing of the shelving system, a 6x6 beam and 13 steel support beams (adjustable building columns). Each square support rib consists of two layers of 2x10 treated lumber co-joined and constructed to make an interior square support rib for the container. The shelving system uses 2x10 treated lumber as the interior support for the shelves but this also serves as an interior supporting member for the square support ribs. The 6x6 beam and the 13 steel support beams are used to strengthen areas outside the shelving region.

The outer walls of the shipping container are composed of corrugated metal. This shape strengthens the metal but the shape interferes with installation of interior support beams. As a result wooden inserts were created and fit into the corrugations in the two sides of the shipping container prior to fabrication of the square support beam structure. These inserts were shaped using treated 2x4 lumber and held in place temporarily using a dab of 2 part epoxy, until the beam structure was fabricated and installed. The inserts required an angle cut and then a straight cut laterally on each board using a table saw.

5. Earth Arching Design

The shelter will be buried using earth-arching design. When a shelter is buried using granulated soils [sand, gravel, crushed rock], the discrete grains possess the property of "dilatancy". This means that the individual soil particles normally interlock and produce significant shear strength. This design provides great strength for a buried structure to survive blast overpressures. In order to obtain earth arching, the shelter must be buried to a depth of one-half the width of the shelter [or in our case four feet of granulated soil].

6. Drainage System

The metal shipping container requires drainage in order to minimize rust and ensure the shelter provides a dry environment. The shelter location is extremely important. It can be installed into the side of a hill or placed on the surface and a mound built up around it. [Digging a pit and burying the container does not meet these requirements.] Because the shelter is designed to incorporate earth arching, the bed surrounding the shelter will act like a massive drainage pit.

After the cavity was bulldozed and the shelter was moved into position, it was raised and solid concrete blocks were inserted beneath as a strong foundation. A trench was dug around the shelter and a 4-inch drain tile was then buried to drain moisture away from the shelter. Approximately 20 tons of gravel was laid around the shelter and the shelter entrance and then the shelter was buried with earth. The top of the shelter was covered with granulated soil (sand/gravel/crushed rock) to a depth of 4 feet. The mound was then covered with black plastic and then a layer of sand. This area directly over the shelter was covered with paving blocks to a diameter of 16 feet radius. This area was made very level. The mound was shaped by concrete block retaining walls.

This approach accomplishes several objectives. The granulated soil provides an earth-arching effect that strengthens the structure from blast waves. The granulated soil around the shelter with drain tiles drains moisture away from the shelter. The black plastic barrier above the mound sheds rainwater away from the shelter. The level paving block circle provides for the installation of a portable swimming pool to protect the shelter from very high-energy nuclear radiation.

7. Shelter Entrance Tunnel

The entrance tunnel consists of a reinforced 8-foot tunnel, an outer and an inner door. The entrance tunnel shall provide a means of egress from the outside into the buried shipping container. The entire shelter and tunnel will be buried except for the outer entrance door. This outer fiberglass door is the only part directly exposed to the outside. The inner door consists of a 300-lb 12 gauge steel walk in door (blast door) welded to the frame of the shipping container. This heavy metal door is rated by FEMA to withstand an F-5 tornado. This blast door will withstand between a 2-psi and 3-psi peak overpressure from a blast wave. The entrance tunnel serves a secondary function as a staging area for reinforcement of the shelter with sandbags for extreme threats. The shelter can be strengthened to withstand up to a 50-psi peak overpressure by filling the outer end of the tunnel with sandbags just prior to an imminent threat.

The shelter is designed to be a walk in shelter with full size doors. The entranceway to the tunnel is lined with used landscaping blocks. I had built a retaining wall behind the house out of these large solid blocks several years back but the fabrication of these blocks were defective and they were breaking apart. My wife said they had to go. But even though they might not meet the needs of a retaining wall, I thought I could reuse them for the shelter entranceway. The floor of the entranceway incorporates paving blocks. Outside the entrance is a pile of sand in the event sandbags need to be deployed.

8. Above Shelter Staging Area

There are different types of radiation. One of the most dangerous types is high-energy nuclear radiation. Normal shielding such as earth and concrete are less effective against this type of threat. A different type of radiation shielding is needed. This shielding can be optimized by using saltwater. This radiation occurs from nearby supernova events and from neutron bombs. This shelter design includes a staging area directly above the shelter to support a 15-foot diameter 42-inch deep inflatable swimming pool. This staging area must be flat and level. On top of the shipping container is a 4-feet thick layer of gravel covered by is a sheet of thick 10-mil plastic, which was then covered with a thin layer of sand. On top of this sand I set paving blocks. These paving blocks directly cover the shipping container and provide a level 15-foot diameter staging area. The 10-mil plastic provides a barrier to shed rainwater away from the site. The portable pool is only deployed and filled when a threat is identified and imminent.

9. Solar Power Distribution Hub

Several threats can damage the electrical power grid that I rely on daily. The shelter is designed with 2 solar panel systems. One is a normal 12 VDC system and the other is a stored major backup system.

The normal system is located outside the shelter. This minimal system will provide power during the normal life of the shelter. It is an inexpensive 120 VAC, limited power (600 watt), off-grid, modified sine wave system. In the normal phase, two solar panels wired in parallel to a 12-volt D/C (2 x 6 volt) deep discharge lead acid batteries. The voltage converter and all electronics including batteries are stored in a two outdoor plastic boxes above ground and the output A/C voltage, is routed to the shelter and distributed. Approximately half the circuits in the shelter will be live in this mode. This system will provide minimal power to the shelter during normal operations but it is vulnerable to certain threats such as an EMP attack.

Some threats such as massive solar storms can cause major damage to our electrical grid resulting in a power outage lasting over a year. I consider electricity to be one of the core technologies that I would like to recover quickly, if lost. So I also built into the shelter the ability to transition into a full solar power electrical generation and distribution hub.

The stored major backup system can be deployed after a disaster. It is stored within the shelter (including solar panels) to protect it from these threats. This backup system is configured as a 24 VDC solar panel system capable of generating 63 amps of electricity. The inverter can provide 120/240 VAC, full power (4,000 watt), off-grid, pure sine wave electrical power with a maximum continuous current of 222 amps.

When the major backup system is deployed, only the solar panels will be located above ground. All remaining electronics are configured within the underground shelter, and the shelter will become an open power generation system. The solar array will consist of 4 sets of solar panels. Each set of panels will consists of two solar panels wired in series for 24-volt D/C generation. The four sets of panels are wired in parallel. The full phase will utilize 4 deep discharge 6-volt lead acid batteries wired in series. The full phase will utilize a pure sine-wave converter capable of providing 240 volts A/C. [This converter is a part of a very special system; the voltage is purer than most A/C found in the average home. It will easily run computers and all types of electronics. The converter will also provide 240-volt power to run my water pump, which I consider to be a critical system. All components (including solar panels) will be stored in the underground shelter until needed. Some threats can destroy electronics above ground. [Generally it is unwise to operate a lead acid battery within an enclosed container such as an underground shelter because batteries can release hydrogen gas. This gas, because it is so light, will rise up and try to escape. But without proper venting the gas can become trapped and an electrical spark can ignite the gas and cause a massive explosion. That is why when the shelter is used as a power generation and distribution system, all doors will remain open at all times and the vents free to the outside.]

The deep discharge batteries require yearly maintenance – filling cells with distilled water. They can operate for around 10 years before they need to be replaced.

I designed my system around the requirement to power my water pump. My water pump runs on 240V AC power. Therefore the system can provide me with clean drinking water. It will permit me to have hot water. It will provide potable water for my toilets that will keep my sanitation system working smoothly. It will provide power for my refrigerators and freezers. It will provide power for all my electrical tools and electronics. It is a long life system capable of providing power for up to 20 years.

10. Shelter Lighting

Shelter lighting was a design consideration. Solar cell power systems produce restrictively low amounts of electrical energy. The primary solar system for the shelter is a minimal system. I desired the shelter be well lit with minimal energy. I installed 8 UtiliTech Pro LED light bulbs in the shelter. Each bulb provides the equivalent light of a 100-watt incandescent bulb but uses only 22 watts of electricity. Essentially, I can make the shelter almost as bright as daylight.

In addition, the shelving system incorporates back lighting. This consists of 4 strings of 180 bulb C3 LED Christmas lights. Each string is rated for 14.4 watts. This lighting is inexpensively obtained after Christmas sales and it is children friendly. An underground shelter isn't quite so scary when it's decorated with Christmas lights.

11. Shelter Vent and NBC Ventilation System

The shelter uses two 4" diameter pipes for ventilation. One pipe can be considered an inlet pipe and the other an outlet pipe. The inlet can be tied into the NBC Ventilation System, Model ASR-100-AV-NBC. The NBC filtration system is comprised of four separate filter media's: a gross filter, a pre-filter, a HEPA particulate filter, and a final carbon fines filter for the collection of nuclear, biological, and chemical (NBC or CBRN) toxins or natural contaminants and allergens such as dust or pollen at 99.97% efficient down to 0.3 microns. The system can be powered by 120 volt AC, 12-volt DC battery backup or using a manual bellows hand pump backup. The system filters around 60 cubic feet per minute (100 cubic meters per hour) of air when run off from electrical power. But this volume is reduced to around half volume when run manually using the hand pump.

12. Break Out Kit

After they dropped off the shipping container in my yard, I found that I could not open the steel entry door. The dead bolts were frozen shut. I thought it might be due to the container being unlevel. But after I leveled it up, the steel door still would not open. What good is a buried underground shelter if one cannot open up the door! Eventually, I drilled a hole in the back of each of the metal boxes in the doorframe which marriages to the three dead bolts. This allows me to apply mechanical force using a punch to free any deadbolt that becomes stuck. To ensure that the deadbolts would never freeze up again, I removed the deadbolt striker plates from the doorframe. It is possible that some of these threats might limit my egress after a disaster. I would hate to be trapped, especially by a 300 pound steel door. Therefore, I included in the shelter a breakout kit.

The breakout kit consisted of (1) a NightStar (no battery) flashlight; (2) a punch, hammer and curved chisel/nail extractor to remove the door hinges; (3) a hex wrench to trip the deadbolt locks from the inside; and (4) a 22-lb steel wrecking bar. Some of these items are stored in the large steel ammunition box labeled “knives”

13. Barter Items

After a major cataclysm, all forms of currency may be worthless. As a result, it may be necessary to barter for items. Bartering is an exchange of goods or services for other goods or services. Some of the common forms of barter materials stored away by preppers for survival situations are: food, water filters, precious metals, ammunition, first aid (antibiotics), toilet paper, candles, batteries, propane, alcohol, cigarettes and books. For my part, I will store two types of goods for barter. These are ascorbic acid and sodium chloride. Both are chemicals and will store indefinitely.

Ascorbic acid or otherwise known as vitamin C is an essential nutrient for humans. Without this vitamin, humans can develop scurvy. Scurvy leads to the formation of brown spots on the skin, spongy gums, and bleeding from all mucous membranes. The spots are most abundant on the thighs and legs, and a person with the ailment looks pale, feels depressed, and is partially immobilized. In advanced scurvy there are open, suppurating (produce and discharge pus) wounds and loss of teeth and, eventually, death. It only takes a miniscule amount of vitamin C to meet the daily requirements. A few pounds of this material purchased from a quality lab can translate to tens of thousands of doses.

Sodium chloride commonly referred to, as “table salt” is an essential ingredient for humans. The sodium in salt helps nerves and muscles function properly. It helps the body regulate water content (fluid balance). Hyponatremia can develop when sodium levels in the body fall below 130 mM. When plasma sodium levels fall below 125 mM, it can cause seizures and coma.

Those that rely solely on grains and vegetables are especially susceptible. In Africa, salt was used as currency south of the Sahara, and slabs of rock salt were used as coins in Abyssinia. Moorish merchants in the 6^{th} century traded salt for gold, weight for weight. Salt is very inexpensive today but in a cataclysm it might be worth it's weight in gold.

14. Security

It is the right of a prepper to defend his life and that of his family and his property. Generally preppers have been inappropriately painted as bloodthirsty gun-toting fanatics. Sociological studies conclude that the vast majority of people will come to the aid of others even risking their lives for total strangers in disasters. This applies to preppers. In many disasters, individuals will generally be locked in place. For example, if a massive solar storm strikes and destroys many of the large power transformers, throwing this country into a yearlong blackout. Many people will find it extremely difficult to flee the large cities. Without electricity, the pumps at gas stations will not function. So people will be left with the fuel in their vehicles. Nor will the stoplights work. If they flee immediately, they will encounter great traffic jams and gridlock. They will burn up their precious fuel while they sit there idling their vehicles. Also the concept of starving masses attacking preppers is also a bit of misconception. If a person is truly starving, he is physically weak and lacks the energy in many cases to mount a full-scale assault. He lacks the vigor to be effective.

But I am not naive or foolish. There is a small minority who look at disasters as an opportunity to cause mayhem. It is for this reason why security for preppers is an important facet. Some threats have a civil unrest component to it, which can lead to general chaos. Our home is in a rural area and most of the civil unrest will be localized in major population centers. But some of it may spill out into the countryside and as a result, physical security may become important. I will not discuss any measures that may be deployed because of OPSEC, but only to say they exist.

C. Other Design Concepts

There were two other design concepts I considered. These concepts were *Synthetic Lumber Construction* and *High-Density PolyEthylene (HDPE) Pipe Construction*.

Synthetic Lumber Construction

Several years ago I came across an interesting product. It was a synthetic lumber made from mineral ash (from coal combustion) and urethanes. The product was called LifeTime Lumber. It was basically fireproof, waterproof, insect resistant and resistant to rot, mold & mildew. A friend of mine cooked a piece of this synthetic lumber in a wood stove for 3 days and the lumber was unaffected. I placed it in a pail of water overnight, and I could not detect any absorption. This material is a builder‘s dream material for underground construction.

Construction would have been very simple. [It would be similar to my entrance tunnel that I used for the shipping container.] After the trench was dug and leveled and the footer blocks and drainage put in place, I would construct the framework out of 8-foot long 6x6 beams of LifeTime Lumber. The structure would be 8 foot wide and 8 foot high and as long as I wished to make it. I would use a 6x6 center post for vertical support. I would tie the structure together with the [ChoiceDek] synthetic decking planks. The decking boards would constitute the outer skin of the shelter. The outer skin on the top and sided would consist of 2 layers of decking board for added strength. The bottom layer would only be one board thick and placed on the inside as flooring. Over the top and sides of the shelter I would spray on a 2-inch thick coating of Icynene insulation. Over this I would place a sheet of EPDM ((ethylene propylene diene monomer) synthetic rubber roofing over the top of the structure. Then I would bury it under four feet of granulated soil.

The main problem with this approach was that the Lifetime Lumber Company went out of business and the product is no longer available.

High-Density PolyEthylene (HDPE) Pipe Construction

HDPE pipes are generally used for water and sewage. They consist of a smooth solid pipe on the inside and a corrugated pipe on the outside. The two plastic pipes are fused together. The pipe is extremely strong and durable. I used corrugated metal pipes in the construction of a bridge. The problem with this type of pipe is that they rust through. In about 15 years they were worthless. I replaced these with 3-foot diameter HDPE pipes and was well pleased with the results. These pipes can be found in larger diameters including 8-foot diameter pipes.

I discussed this concept of using a large diameter HDPE pipe for an underground shelter with ISCO Industries in Louisville, Kentucky [garry.bouvet@isco-pipe.com]. They have significant experience in fusion welding ends to the pipes to make them into underground tanks. A shelter of this type could probably last for thousands of years. Creating the interior shelving for this type of structure would be interesting. This design would be a completely watertight container.

Although I would have liked to pursue this type of design, it fell down to a costing issue. The pipe alone [8 foot diameter by 20 feet RSC 160 pipe] would cost $11,300.

III. CONSTRUCTION

A. Intermodal Shipping Container

An Intermodal Shipping Container is a standardized reusable steel box designed for different modes of transportation (from ship, to rail, to truck). Although they come in a variety of sizes; 20-foot long and 40-foot long shipping containers are predominant. I considered using a 40-foot container, but it wasn't in the cards because transport to the site would be extremely difficult. The topography of my land is fairly rugged. As a result, I decided to design my shelter around a 20-foot intermodal-shipping container. As the container ages, it reaches a point where inspectors determine that it is no longer usable for its mission and the used container must be removed from service. These containers are then refurbished and sold. These containers come in various grades, which are New, Premium, Cargo Worthy (CW), Wind & Watertight (WWT), As Is, Handyman (extensive work).

I purchased my 20-foot shipping container from Pac-Van in Indianapolis, Indiana. The interior dimensions were 19' 4 ¼" L x 7' 9 7/8" H x 7' 8 ½" W. The container weighs approximately 5,000 pounds. The top and sides of the container were made from 14-gauge steel. The bottom rests on heavy steel I-Beams with cutouts for fork lifts. To these bottom I-Beams were welded smaller I-Beams approximately every foot for the length of the container. Over this was a layer of marine plywood 1 1/8" thick, which is the floor of the container. The corners of the shipping container are designed to support the weight of 300 tons.

Interior Shipping Container

Pac-Van sold containers that were graded WWT. But even within this grade there was substantial variation in the containers condition. I explained to Pac-Van my desires to use the container as an underground shelter and that I desired a container with minimal rust. They quoted me an estimated price of $3,400 but the final price was dependant by the exact condition of the selected container. When Pac-Van inducts a used container, they refurbish it by removing rust and resealing the container to preclude rust damage. After a wait of several months, I was brought in to look at several containers. I found a container with minimal rust that looked like it was almost new. I paid a little more for this shelter $3,895, but I felt this additional cost was well worth it.

Pac-Van in addition to refurbishing containers also specialized in retrofitting these containers with doors, windows and interior construction to meet their customer's needs. I ordered a 300-pound blast door but I had no idea on how to install it, so I tasked Pac-Van with this step. They estimated $725 to cut out a hole for the door and install a customer supplied steel door. The final cost including state sales tax was $4,892.65.

B. **Blast Door**

I purchased a blast door from Securall called a StormSafe 320 Residential Storm Shelter Door. The company is located in northern Indiana. The door was rated against FEMA 320 requirements [against wind speeds of 250 mph]. It met or exceeded all tornado and hurricane design criteria. This includes the effects of an F-5 tornado. The door design was tested at Texas Tech University's Wind Science and Engineering Research Center. It was also tested against a static pressure of 2.19 psi held on the door for 10 seconds. In my opinion, this door will withstand a peak overpressure blast wave of around 2.5 psi and with the vertical steel adjustable building column in place, that can probably be increased to around 10 psi peak overpressure. [The blast door is 36" x 80" or 2,880 square inches. The metal steel adjustable column has a design strength load of 18,200 pounds. Therefore using this steel support column should add around 6.32 psi support to the blast door.]

The door is 36” wide x 80” high and weighted 305 pounds. It was constructed out of 12-gauge steel. The door uses three latch driven deadbolts and on the other side three heavy weight ball bearing hinges to secure the door to the metal frame. I ordered an inward swinging door.

The door cost $1555. The cost of shipping was $275 and the cost of packaging was another $100. I decided to try and save some money by transporting the door from the company down to Pac-Van for installation. I drove up to the company with my pickup truck and they wrapped the door in bubble wrap and loaded it onto my truck. It cost me $160 in diesel fuel to retrieve and transport the door.

The metal blast door was welded to the walls of the shipping container. The edge of the doorframe was positioned approximately 139 inches from the back of the shipping container. [Henceforth, the front of the shipping container is defined as the side that has two large metal container doors and the back of the shipping container is the opposite side that is welded steel.]

C. Transportation to Site

Transporting the shipping container to the site was complex. Pac-Van could transport the container to the site using one of their tilt bed trucks for $135.00. But this was a long and very heavy truck that would not make it up my driveway. As a result, the container was moved using an external vendor using a straight truck, which costs $525.00 for the delivery.

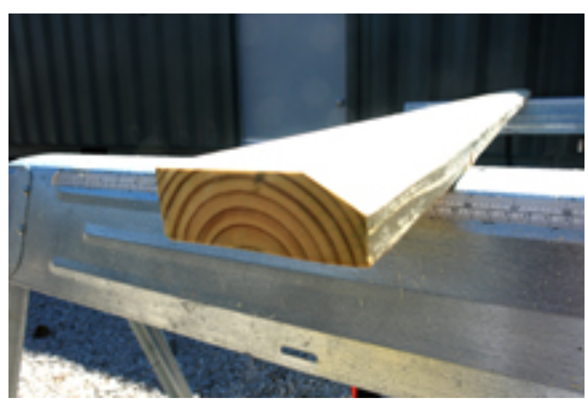
Before the delivery, I walked the route and removed any tree limbs that might get in the way. I also contacted my telephone company and had the telephone lines raised to prevent them from snagging the container. I also measured the width of my bridge because the shipper required a minimum clearance. The bridge varied between 13.5 feet and 16.5 feet, which was sufficient for the vendor.

I had some concern about moving the shipping container during the winter because it might tear up the county roads. As the delivery date approached we were hit by one snowstorm after another, and I repeated shovels my 700 foot driveway, day after day to keep it open. Then on one of the coldest days of the winter when it was below -10° F; the container was delivered. The delivery went smoothly.

The only hiccup was that I was unable to open the blast door. I figured it was either due to the cold or to the fact that the container was resting off level on the ground. Anyways I put it off until the springtime to resolve this issue. When springtime came, I raised the container and using concrete foundation blocks set it on the level. I tried to undo the deadbolts on the blast door but they were still frozen. I opened the back door of the shipping container and was unable to free these deadbolts from the inside. There was a metal cup welded into the frame for each of the deadbolts. I drilled a small hole into the cup and using a punch, I forced each deadbolt open. I removed the striker plate from each deadbolt and that corrected the problem. It meant the deadbolt joints were looser but I felt that it would detract minimally from the overall strength of the doors. [I felt that I could live with this loose joint but on the other hand a door jammed shut in a shipping container once it was buried underground was a catastrophic failure.]

D. <u>Interior Support Structure</u>

It is important to provide additional horizontal and vertical support to the metal shipping container. Thus the concept of square support ribs was conceived. The shelter contains 7 square support ribs. Each rib is comprised of an outer layer and inner layer of 2x10 treated lumber that interlock together. These layers or rings were bonded together using Liquid Nail adhesive and then screwed together.



Spacer Board Cut

The metal shipping container was not perfectly square. It had corrugated steel walls, beams and metal tie downs. Thus the wood had to conform to the shape of the shelter and required special cuts.

I reasoned that the corrugated steel sidewalls needed extra support behind each square support rib. I used treated 2x4 lumber. I made up 14 spacers by laterally cutting these boards. I cut ¼ inch off the long end of each board and a 60 degree angle off one side to make them fit evenly between the corrugated sidewall and the 2x10 support rib. Because the location of some of the support ribs overlapped welded tie-downs hooks in

Spacer Board Installation

the inside metal frame, these spacers were not all cut to equal lengths. There were 6 short spacers, each 87 inches long and 8 long spacers, each 91¼ inches long. I adhered these wooden spacers to shipping container using a dab of two-part epoxy (PC7 Epoxy). I braced each board for 24 hours for the epoxy to set. Refer to As-Built Drawing #2.

The next step was to cut the individual 2x10 boards for construction of the support ribs. I chose 2x10's because they were the largest board I could handle by myself. Again actual as-built had to deviate from theoretical. This is because a large metal brace ran along the top right and left inside of the shipping container. Thus a ¾" by ¾" notch had to be cut along the left outer ring board and the right outer ring board. Also the top outer ring board had to be cut shorter than the bottom. Refer to As-Built Drawings #3.

Support Beams

Each rib was then individually assembled in place. The bottom outer ring was glued and screwed to the plywood shipping container floor. The top outer ring board was lifted into position while the right and left outer ring sideboards were pounded into place. Next the inner ring bottom board was glued and screwed to the outer ring board. Then the top and side inner ring boards were glued and screwed to their respective outer ring boards. As-Built Drawing #4 depicts the construction of the inner and outer rings.

Support Beam Corners

Each square support rib was positioned covering a corrugated depression. These ribs were set from the back end of the shipping container in accordance with As-Built Drawing #1.

After I constructed and installed the square support ribs, I desired to reinforce each of the four corners. I cut up scrap 2x4 and 2x10 treated lumber to form these braces. I used fourteen 2x4 each cut 9½" long and fourteen 2x10 each cut 4" long. I installed the 2x10 braces horizontally on the top joints of the inside vertical support ribs. I installed the 2x4 braces vertically on the bottom joints of the inside vertical support ribs. These I glued into the corners and screwed into place.

After the shelter was relocated into the final site and before it was buried, there were other supports I decided to add. As I began to work up on top the shelter to install the vent pipes, I noticed there was a lot of flex in the metal roof. Since I was about to put 29 tons of gravel directly above it, I wanted to ensure the shelter would not cave in when it was buried.

In addition to the square support ribs, there are additional vertical supports within the shelter. These include ten 2x10 shelf support beams, one 6x6 beam and 12 steel adjustable building columns. As-Built Drawing #5 depicts the layout of the various vertical supports. I wanted to ensure that the entranceway was open and yet structurally well supported. At the (blast door) entrance, there is a series of three sets of two steel adjustable building columns. A 4x6 wooden beam is positioned in the ceiling and supported by each pair of steel adjustable building columns in this entranceway. In general, there is a vertical support every 2 feet throughout the shipping container.

Metal Support Beams

The seven square support ribs also provide horizontal shelter support. I added one more horizontal 4x6 beam at the end of the shelves because this appeared like it might be a weak spot. Additionally I decided to add extra support to the blast door by using a removable steel adjustable building column to brace the blast door against the back end of the shipping container.

E. Shelving

The fabrication of the individual shelves is detailed in As-Built Drawing #6. Each shelf was fabricated using one 137" long piece of 2x4 treated lumber, six 21 7/8" long pieces of 2x4 treated lumber, one 21 7/8" long piece of 2x6 treated lumber, one 65" long piece of 1x2 oak, and one 72" long piece of 1x2 oak. The orientation of the back 137" piece of lumber was oriented vertically as is the front 1x2 oak boards. The seven pieces of 21 7/8" boards are oriented horizontally.


Shelf Fabrication

There will be five normal shelf and five mirror-image shelf assemblies. During the assembly, the top of each shelf board was aligned so that when completed, the plywood that would lay flat on each shelf. Therefore the assembly pieces were flipped upside down on a flat surface when the screws are inserted to join the various boards together.

To prevent the oak boards from splitting, screw holes were predrilled for all oak joints.

The five normal shelves would be placed on the left side of the shipping container looking towards the rear; the mirror image shelves would be placed on the right side of the shipping container. The mirror image shelves are the mirror image of the normal shelves. The dimensions for fabrication in the As-Built Drawing #6 are identical for the two types of shelves and these dimensions are referenced to the back of the shelter.

[Assembling the shelves was confusing. After I assembled a shelf, I needed to place it in the proper orientation and make sure the assembly was correct. Otherwise I reworked it. Once I did the first normal shelf, it was relatively easy to construct the next 4 shelves. Once I constructed the first mirror image shelf, it was relatively easy to construct the next 4 shelves.]

Since the shelf framework was heavy, I decided to pre-mark the square support ribs to make the process of installing the shelf framework easier. I created a marker board, so that I could get an exact height on each shelf. Refer to As-Built Drawing #7. In the end I didn't use the marker board because the corner braces on the square support ribs prevented me from using the marker board properly. So instead I just used a tape measure to mark the boards on the interior vertical support rib.


Bracing Top

Two of the shelves were designated for glass canning jars. I was concerned that the jars might smash against the shipping container wall and break, so I improvised a back support for these shelves. I purchased aluminum window screen rolls and stapled these to the backside of these two shelves. It was a quick inexpensive solution.

At this point I strung the strings of LED Christmas lights to give some backlight to the shelves and stapled these in place.

Bracing Bottom

Next I cut 10 pieces of 2x10 treated lumber that would hold up the outer side of the shelves. Each of these boards was cut 87 9/16" long. These pieces of lumber would not only hold up the shelves, they would also provide vertical support to the shelter. I took 6 of these boards and using scrap pieces of 2x4 lumber and 1x2 oak trim, I installed this scrap lumber to the outer shelf support beams as braces in accordance with As-Built Drawing #8. These 6 braced support beams were used as follows: one each for the back shelf support on the left and on the right side, two for the middle and two for the front shelf support. The other 4 shelf supports were unbraced.

Shelf Installation

The next step was to assemble the shelf structure to the square support ribs. Each shelf was brought in and aligned to the pre-marks and screw in place using Headlock Heavy Duty Flathead Fasteners. Once the shelves were attached to the square support ribs, the braced outer shelf support beams were pounded into place. If a shelf was a little low, it was raised as the boards were pounded into place. Then the outer shelf support beams were screwed into the shelf structures.

I used scrap lumber to brace the inside edge of the bottom inside corners of the shelf support beams and the top of the outside corner of the shelf support beam to reinforce these joints. I cut the scrap 1x2 oak boards into ten 9½" long pieces. I cut 2x10 scrap treated lumber into ten 4" long pieces. The 1x2 oak pieces were installed horizontally on the inside corner of the bottom of each shelf support beam. The 2x10 pieces of lumber were installed horizontally on the outside corner of the top of each support beam. Each of these boards were glued and screwed into place to act as support braces.

Next, I cut up pieces of plywood as the floor in the shelf support area. Two pieces of ¾" plywood was used. They were 96" x 34 ¼" and 44 3/16" x 34 ½". I screwed this plywood into the bottom inner square support ribs. This plywood also acted as a brace to prevent the shelf support beams from buckling inward.

The next step was to cut the ¾" oak plywood that I used on each shelf. This plywood was cut along the centerline to create 2-foot by 8-foot sheets. I required 10 sheets that were 2 feet by 8 feet and 10 sheets that were 2 feet by 41 inches. The shorter sheets would go to the rear of each shelf (back of the shipping container) whereas the longer sheets would go to the front. Before I assembled this plywood, I stained it using 3 quarts of Minwax Early American Stain and then sealed it using one gallon of Clear Satin Helmsman Spar Urethane varnish. As I assembled the shelf plywood sheets onto the shelf supports, I screwed these down for stability. This strengthened them from the effects of ground shock. Once the shelves were in place I did touch up with the stain.

Staining and Varnishing Plywood Shelving

I was concerned that the storage material might come off the front end of the shelves near the blast door, so I screwed 1 x 2 oak permanent containment supports to the support beams. This used fourteen 1 x 2 pieces that were 29" long.

Next I constructed the shelf containment system. I purchased six 12-foot long 1 x 4 oak boards. Next, I cut these boards down to 137 inches. Four of these oak boards I ripped into two (1 x 2) oak boards using a table saw. These boards became the removable containment supports. The top shelf did not require a board because it was designated for light objects like toilet paper and sleeping bags. The next shelf was designated for a double row of #10 cans containing freeze-dried foods. This shelf used a 1 x 4 oak board for support. The next two shelves down were for glass canning jars. These shelves used 1 x 2 oak board supports. The bottom two shelves were for superpails. These shelves used 1 x 2 oak board supports.

Cut Metal Plates in Half

I was unsuccessful in looking for a metal brace to hold these removable oak boards. As a result, I improvised using scrape pieces of oak (1 x 2) and metal plates. I purchased 15 metal plates that were 1½ inches wide and 6 inches long and 1/16 inch thick. I cut each of these plates in the middle in two to create 30 containment supports. As Built Drawing #9 shows the construction of these containment supports.

I drilled the two sets of outermost holes on the metal plates slightly larger so that they would accept the 2-inch screws. I screwed these containment supports through the 1x2 oak pieces onto the 2 x 10 vertical shelf support beams. Every shelf had a removable oak containment board except for the top shelf. I placed these containment supports on the two outer shelve vertical supports beam and on the middle vertical support beam. In screwing the containment supports in place, the goal was to position these so that each removable oak boards would be centered in the middle of each shelf.


Removable Oak Containment Boards

Since the canning jars would not be visible because of the bubble wrap, I mounted 50 brass plated label holders (5/8 x 2½ inch) on to the two shelves designated for the canning jars.

At this point the construction of the support ribs and shelf supports were complete and the shipping container was now ready for relocation to its final site and burial. There was one more step. I had a metal table with a heavy wooden top, which I thought might be nice to have in the shelter as a worktable. I relocated this table inside the shipping container just inside the shipping container doors. It straddled the last square support rib. I screwed some scrap pieces of lumber at the legs to prevent the table from moving freely.

F. Excavation

Excavation

Dragging Shipping Container into Excavation Pit

A hole approximately 26 feet across by 18 feet was dug into the side of the hill. At the back end, the hole was 12 feet deep and it sloped slightly downward towards the front for drainage.

The shelter, which weighed approximately 6,000 pounds when fitted out with shelving and support arches, was extremely difficult for the large excavator to move. As a result it was an interesting relocation and final installation process.

The shipping container was moved into the hole by means of an excavator and heavy logger chains and also by attaching a large block and tackle rigging (pulley) to a tree using chains and using the tree as an anchor it was pulled into location using a very large braided fiberglass rope. This was difficult because the shipping container at this point weighed around 3 tons. In order to move the container, it had to be raised up on concrete blocks and wooden beams to reduce friction and dragged into the site. Once at location, it was raised on one side and concrete footer blocks were placed beneath and then the shipping container was lowered back down. This was repeated for the opposite side.

Another problem encountered during installation was the bank that was excavated was very sandy and had a tendency to cave in. Plywood and landscaping beams were used to shore up the sides to prevent cave in. The shoring lumber was removed before final burial because it might become food for termites.

G. Entrance Tunnel

An entrance tunnel was constructed to connect the underground shelter to the outside. Refer to As-Built Drawing #10. I bolted four beams to the outside of the shipping container at the blast door. This is described in As-Built Drawing #11. I used 8" long bolts. The left and right side beams required special cutting on the table saw in order to fit smoothly. The four beams were not joined together but only bolted to the metal walls on the shipping container, or in the case of the 6 x 6 beam to the I-Beam at the base of the shipping container. The exterior side of each bolt including washers and nut were covered with Leak Stopper Rubberized Roof Patch to seal them from corrosion.

Shipping Container to Tunnel Interface

I built a framework out of treated 4x4 lumber for the entrance tunnel. Refer to As-Built Drawing #12. I cut the

4x4's into 16 beams that were 83 ¼" long and 16 beams that were 48" long. Next, I sanded the ends of each cut beam smooth and flat. This framework was held together using two 6" Headlock flathead fasteners at each corner. In addition the top two corners had a USP 12" metal connector screwed into the wood to provide additional support. I predrilled the 4 outer holes on each side of the USP metal connectors and used 3" x 9 high performance exterior screws to lock the 4 x 4 corners together. These tunnel support frames were spaced one foot apart and were set on 6"x8"x16" solid concrete blocks as footers. Refer to As-Build Drawing #13. To this framework, I applied decking boards as siding. Two layers on the top & sides and one layer on the bottom. I used ChoiceDeck because it is composed of 95% recycled material and as a result is almost immune to rot, water damage, termite or insect damage.


Side Beam Cuts

The deck boards were placed two thick on the top and the two sides and were offset. I used 2½ inch high performance screws on the inner layer and 3 inch screws on the outer layer. In constructing the shelter entrance tunnel, I was a little concerned that the screw heads used to secure the decking boards to the support frame might rust out over time. As a result, we took the following precautions. Using a knife, we scraped away the excess plastic around the screw hole. Then we covered each screw with tar (Leak Stopper Rubberized Roof Patch). The outer layer was also sealed with tar at the joints of each decking board and also the seam between the decking boards and the shipping container.

I added a doorframe constructed by 6" x 6" beams to the outside edge of the tunnel. Refer to As-Built Drawing #14. To this I installed a fiberglass door. Because of the temperature difference between the shelter interior and the outside, water would quickly condense on the metal blast door of the shelter during the summer. This exterior fiberglass door was primarily installed as a weather tight door to limit condensation issues on the interior metal door.


Tunnel Support Fabrication

Tunnel Framework

Tunnel ChoiceDek Boards

Exterior Doorframe Beam Construction

Exterior Door

H. Penetrations

I made several penetrations though the Intermodal Shipping Container. These included 2 holes for the electrical power 2AWG twisted copper wiring cables, 1 hole for the battery monitor circuitry, 1 hole for the radio antenna cable, 2 large holes for the vent pipes and several holes to secure the wood beams directly around the outside of the blast door.

Generally when I drilled holes in the metal shipping container, I used cobalt drill bits because they are designed to cut through metal. I usually drilled a small hole to start with and used it as a center to drill the final large hole.

One of the small little problems I had to work out was a radio penetration. I have a Sangean ATS909 radio. Being able to use this radio within the shelter is important. For example, when a strong storm strikes and after the tornado danger is over and the all clear is sounded; it is nice to know we can leave the shelter. But because the shelter is underground and because the shelter is a metal shipping container, radio signals will not pass to the receiver. I solved this problem by penetrating a small hole in the ceiling of the container and running a 50-foot RG-6 coax patch cable to the surface. The coax cable was then connected with the Sangean ANT-60 portable shortwave reel antenna that came with the radio. A strain relief is needed at the shelter penetration point. This I covered over with roofing cement on the outside of the shelter.

I. Drainage System

The tri-axle dump truck that brought the first load of washed river gravel weighed approximately 35 tons loaded. The truck driver refused to drive up my driveway and bridge because he felt that it was not strong enough to support the weight. As a result, I had him dump the load along the side of the road and move the gravel by hand and my trusty Gator utility vehicle. I moved 20 tons of gravel by hand. This gravel was critical for construction because it was used for the drainage system. After that I used a single axle truck that was limited to 10 tons to bring the gravel to the construction site.

Perforated Drain Tile around Shelter

Drain Tile with Sock and Perforated Drain Tile

One of the important features of the construction was to ensure adequate drainage. I set the intermodal shipping container and constructed the shelter entrance on a foundation of 6" x 8" x 16" solid concrete blocks. I laid some gravel down over the entire drain tile run and completely around the shelter. I looped a long 4-inch corrugated perforated drain tile pipe around the structure and then covered this with several inches of washed river gravel. While the site was exposed, a heavy rain could cause a mudslide and cave-in. In order to protect the drainage, I covered the gravel over the pipes with a layer of sediment shield material, in order to prevent fine sediments and particles such as sand and dirt in the drainage water from clogging up the drainpipes. Refer to As-Built Drawing Number #15.

Sediment Shield over Drain Tile

A few days after I wrote this, we had a 5-inch rainfall. There was some major erosion and sand slides into the construction site. It is vitally important that the area beneath the shelter be adequately drained. So I added one more drain tile. This pipe lead directly under the shelter. I dug a trench from the shelter and filled the bottom with gravel. Then I placed a 4-inch corrugated drain tile with a filter sock in the trench with about 5 feet protruding under the shipping container and then covered the tile with more gravel. In all I used about 20 tons of gravel around the base of the shelter, the entrance tunnel and drainage tile run.

At the end of the drain tiles, I installed a drain grate to prevent small animals from entering the pipes and calling it home.

After the shelter was sprayed with 2 inches of Icynene insulation on the exterior (top and sides) of shipping container and entrance tunnel and after it was covered with EPDM rubber roofing, I installed a French drain tile on top the shelter to drain any water collected on the flat roof away from the shelter.

10-Foot French Drain Tile attached to Solid Drain Tile

Left – Perforated Drain Tile Covered with Sediment Shield
Right – Sock Covered Drain Tile under Shipping Container

J. Vent Pipes

The design uses two ventilation pipes, one on either side of the shipping container. When configured with a filtration system, one will be an inlet pipe and the other an outlet pipe.

I fabricated the shelter vents out of 4 (4 x 9 150# Weld Threaded Flanges) and 2 (5 foot long 4" diameter metal pipes – threaded). For each vent, I mated a flange on the inside of the shelter with one on the outside and bolted them together. The metal pipe screwed into the top flange. At the top of the metal pipe I joined a 4" rubber connector, a short 4" PVC pipe and two 4" PVC 90° street elbow. These two elbows were joined together to form a 180° fitting.

I waited until the shelter was placed in the excavation before I drilled the vent holes in the shipping container. I began by identifying their location on the top of the shelter. The holes should be placed 6 inches from the inside rib supports. The holes should be drilled on opposite sides of the shipping container to allow airflow through the shelter.

Vent Pipes

Exterior Flange Attachment

In drilling the 2 holes for the large 4" metal vent pipes, I started by drilling a small hole centered on the corrugated ridge (midway between the two corrugated depressions). As-Built Drawing #16 depicts the location of the two vent pipes on top the shipping container. Then I used a Lenox 4 ½ inch hole bit to begin the cut. This bit was designed for metal but as I began to cut deep into the metal it would bind, which would then send the drill spinning around and smashing my hands. At this stage I switched to an electric jigsaw to complete the cut. Then I used a metal file to finish the hole. Then using the flange as a template, I marked 4 of the 8 flange holes for drilling. These were at the 0°, 90°, 180°, and 270° positions I then drilled these 4 mounting holes for each flange. When assembling the vent pipes assembly to the shelter, I inserted the bolts through the top flange, the hole in the shipping container and then the hole in the bottom flange and then screwed on the nut from the bottom. I used a series of metal washers as spacers between the top flange and the shipping container for two of the holes. Otherwise the vent pipes would rock significantly and this was a way of tightening up the connection. Two inches of Icynene insulation was then sprayed to the top of the shelter with emphasis on sealing any exposed joints. Then I overlaid this insulation with Black EPDM Rubber Roofing and sealed the joint using silicon epoxy.

Interior Flange Attachment

The intermodal-shipping container has two vents, one on each side of the container. Since I installed above ground vents, I no longer needed the container vents. I plugged the holes in these vents with Leak Stopper Rubberized Roof Patch in order to prevent moisture from leaking into the shelter.

Once the shelter was covered with gravel, I spray painted the vent pipes in Rust-oleum non-reflective camouflage spray paint. This paint bonds to plastics, such as PVC pipes. I used two different colors to obtain a camouflage effect.

As the shelter was buried, condensation became a problem due to the temperature differences between the shelter and the outside air. Significant amounts of water would condense in the metal vent pipes and drip into the shelter. In order to solve this problem, the vent pipes can be sealed in several ways. At the top of the vent pipes I can insert Oatey Grippers test plugs. They provide an excellent quick release system. In general during the winter, both vents are sealed in this manner. Rodents will try and enter the shelter during the winter because it is warm. These test plugs not only solve the condensation problem but also the rodent problem. During the other months, I can remove one or both of these test plugs and install an aluminum wire screen over this connection, to prevent insects entering the shelter. On the other side of the vent pipe system, square head threaded metal plugs can be screwed into the weld metal flanges to seal the shelter from the effects of blast waves.

Camouflage Paint

Square Head Threaded Metal Plugs, Oatey Gripper Test Plugs, Aluminum Screen Exterior Coverings

K. Insulation Layer and Outer Skin

During the storage container refurbishment, PAC-VAN applies a special corrosion resistant coating to the exterior of the unit. I desired increased protection from rust so I had an application of 2" Icynene closed cell insulation sprayed on exterior (top and sides) of shipping container and entrance tunnel. Then I placed a 10' x 22' sheet of EPDM ((ethylene propylene diene monomer) synthetic rubber roofing over the top of the container and a 5' x 9' sheet of EPDM over the shelter entrance and glued the two pieces together using Gen Flex G-400 Seam Adhesive.

Shelter Covered with Icynene Insulation with Layer of EPDM Rubber Roofing over top

L. Container Burial and Landscaping

The entranceway into the tunnel was landscaped with heavy landscaping block walls. I built these up to about 5 feet and then filled behind using gravel or earth. I let this ground settle during the winter and then in the spring added another layer (slightly offset) above the first layer. I filled behind this with earth and then added a third layer of blocks, which was then filled behind with gravel to a depth of 4 feet above the shelter. This layer of gravel extended at a minimum of one foot beyond the shelter in all directions in order to obtain the earth arching effect.

First Layer of Landscaping Blocks

Over the EPDM layer on top the shipping container, I covered the shelter with 4 feet of gravel. The weight of 4 feet thick washed river gravel above the container is 58,000 pounds or 29 tons. Provided the structure can be strengthened and the weight distributed, it should theoretically support the weight of the granulated soil. When the shelter was covered, I could not see any significant deformation on the metal walls of the shipping container.

Shelter Burial

All hollow landscaping blocks were filled with gravel before the topper blocks were cemented in place using landscaping block adhesive.

The shelter was constructed using three sets of retaining walls so that the highest retaining wall would allow 4 feet of gravel to be placed above the shelter. This was a requirement to achieve an earth arching effect. After some of the gravel was laid down on the third level, we had a 12-inch rainfall during one week. This water seeped down through the earth around the shelter and began to raise humidity levels in the shelter to unacceptable levels. As a result, I modified the final design slightly to preclude this problem from reoccurring. I sloped the gravel and then set down a top layer of 045 gauge EPDM rubber roofing at a natural slope so that the water would flow away from the site. I cut the roll of rubber roofing to fit the site and bonded the pieces together using seam adhesive. I then filled the rest of the entire site with gravel and leveled it (especially between the two air vents), so that it would serve as a staging area for a 15-foot diameter swimming pool [supernova threat]. Then I covered the entire site with paving blocks. I covered all the paving blocks [entranceway and topside] with 600 pounds of white silica sand and swept the sand between the blocks in order to firm up the flooring. Refer to As-Built Drawing #17.

The shelter because it is buried and designed to work as a root cellar operates at a high humidity level of around 80 percent. When the humidity level reaches around 92 percent, water will begin to condense on the metal post and walls of the shelter. Mildew will form and metal will rust. This is unacceptable. When we had the 12-inch rainfall, humidity levels in the shelter reached around 95 percent. As a result I purchased a high efficiency dehumidifier [Danby Model DDR60A2GP] for whenever this condition occurs. Since I covered the entire shelter topside with EPDM rubber roofing, it appears that heavy rainfalls will no longer present a problem. But during the early spring when the ground thaws, I expect humidity levels will rise in the shelter. So I might be required to dehumidify the shelter a couple days per year.

The following photographs depict the final site construction.

M. Solar Power System

The shelter is designed with two sets of photovoltaic solar panel systems. The smaller [2 panel] system is operational and provides continuous electrical power to the shelter, primarily for lighting. The larger system [6 panel] system is held in reserve stored within the shelter. The electrical configuration of the smaller solar panel system is provided in Drawing 18. Some threats can completely destroy the exposed solar panel system. That is why the backup system is critical. The backup system not only can provide more electrical power but also the backup inverter provides pure sine-wave electricity. Thus the power can be used for very sensitive equipment such as computers. The back-up unit also provides 240-volt power, which allows operation of the well water pump.

I used a large 150-gallon outdoor plastic deck storage container to store the batteries and electronics for the operational system. This type of container is inexpensive, generally water proof, and lockable. Because I used sealed AGM lead acid batteries, I decided it was safe to store all components in one storage container. [If I had used vented lead acid batteries, it would be imperative to separate the batteries from the electronics into two separate containers. Vented lead acid batteries release hydrogen gas which is extremely explosive and the electronic could provide a spark to generate an explosion.] I drilled two small holes on the top of the storage container. I cut off the ends of two plastic disposable pipettes and mounted these into the holes using silicone caulking. This gave me a waterproof bleed valve to vent off any hydrogen gas buildup in the container.

I fabricated the solar panel support structure using Unistrut half slot 12 gauge channels and steel track cover supports. I mounted the metal steel support structure to two 6” x 8” treated lumber posts. I dug two holes in which I placed two used empty plastic 5 gallon buckets. I then placed the posts into the two buckets. I leveled the solar panel support structure and filled the buckets with concrete. After the concrete dried hard, I installed the 2 solar panels onto the solar panel support structure. This was a fixed support structure. I choose the tilt angle of the support structure to maximize the exposure to the sun.

I wired up the solar panel system in accordance with Drawing 18. All wiring used 6 AWG wiring unless otherwise noted on the drawing. All ground leads were tied together in the circuit breaker box. I used large copper crimp connectors to make the connection to the solar panels. Since these were large connections, I purchased a specialized crimping tool to handle these crimps. Because the crimps connectors were slightly too large to fit onto the solar panels, I used a file to grind down the sides to allow them to fit.

I drilled and fitted PVC pipes and connectors to the outdoor plastic deck storage container for all electrical pass-throughs. Once the wiring was run, I sealed these pass-throughs with silicon caulking. The goal was to keep the container fairly watertight.

The location of the outdoor storage container was adjacent to the solar panels. It was along the slope of a hill to avoid pooling of rainwater. Additionally the container was placed onto concrete paving blocks to keep it off the ground.

I set the jumper switches on the Charge Controller as follows. I set the switch to 12 volts. I set the switch to charge control mode. I set the switch to manual equalization. On the potentiometer, I set the charging voltage to 14.4 volts and the float voltage to 13.74 volts. This matched the specs for the type of batteries that I used. [Because the batteries were used and degraded, I upped the voltage a little higher to ensure proper voltage was available to the system.]

The CM/R-50 Remote Meter for Xantrex Charge Controller was mounted on the interior of the shelter to provide constant status of the solar panel system inside the shelter. The remote meter was a front panel with a circuit card attached. As a result some fabrication was required. I purchased a Philmore ABS Enclosure and cut out a rectangular slot for the card and faceplate to mount on. Then I drilled out a side slot for the cable to run through and mounting holes. I drilled a small hole on the top of the container and ran the 50-foot wire to the outside.

I purchased two used 12-volt 120Ah Absorbent Glass Mat (AGM) sealed lead acid batteries for the solar power system. They were Hawker HASP-FT batteries called 6TAGM produced as ArmASafe Plus. [P/N 9750N7025, NSN 6140-01-485-1472] They are maintenance free deep discharge batteries. (They originally sold new for over $1000 but I purchased them used for $200.) The batteries had the same manufacturing date and lot number. Matched batteries perform better in battery system life.

N. NBC Filtration System

The shelter is designed to survive a nuclear blast wave to 50-psi peak overpressure. This includes the shelter inlet and outlet vents. The two vent pipes are sealed using either a square head metal threaded plug or threaded cap. There should be sufficient air in the shelter for several hours. In the event of a nuclear war or asteroid/comet impact, both vents must be plugged. After the blast wave strikes, the vent nearest the NBC filtration system should be removed and the inlet vent will be replumbed to the NBC filter system. The carbon filter used in the NBC filter will be removed from their protective storage and inserted in the NBC filter system. Once the system is made operational and started, the plug in the outlet vent pipe can be removed and a restrictive flow vent pipe inserted.

Metal Cap, Plug & Restrictive Flow Vent Pipe

The Safe Cell NBC filtration system contains 4 filters. These are the gross pre-filter, the fine pre-filter, the HEPA filter and the activated carbon absorber. The gross pre-filter removes the larger particles and the fine pre-filter removes the finer ones. The HEPA filter provides protection from radioactive fallout particles, toxic aerosols and biological agents. The activated carbon filter is effective in removing hydrogen cyanide, phosgene, mustard gas, sarin, ricin and VX nerve gas along with nuclear grade war gases. The activated carbon absorber will be stored sealed to prevent degradation. I repackaged this activated carbon filter into a metalized plastic bag (those used in sealing food for superpails) and heat sealed the bag. This should prevent moisture from entering the bag and contaminating the activated carbon absorber filter.

The NBC filtration system can be powered by common household voltage routed from the house using a large extension cord, from the solar power system, from charged automobile batteries or in an emergency by hand. If the system is powered by hand, the air volume generated by the filtration system will be reduced by more than 50%. Manual operation should only be used as an emergency backup. So provided there is sufficient warning, it is important to remove all the batteries from the vehicles and bring them into the shelter so they can be used to power the NBC filtration system. [If the threat is from a nuclear blast or from an asteroid impact event, the electricity from the solar cell system or house voltage should not be used because a voltage spike could travel into the shelter through the external wiring and damage the filtration system.]

If the threat is from a chemical or biological attack, the shelters AC power should be available from household current to power the NBC filtration system continuously or if the household current goes down then the solar cell system can provide electrical power to run the system during the daytime and batteries during the nighttime.

Metal Support Bracket

I mounted the NBC filtration metal support bracket 24 inches above the floor onto the 6 x 6 treated support post near the table. I predrilled four holes in the metal support and used Headlock Heavy Duty Flathead Fasteners to attach the metal support to the wooden post. I inserted a 4" diameter 12" long galvanized steel nipple into the vent located above the table. To the other end of the steel nipple I attached a rubber flexible coupling. Then I created a PVC pipe using 4" Schedule 40 PVC pipe and a 90 degree coupling that would reach the end of the table. This is because the NBC filtration system came only with a 60-inch long flexible pipe and that was an insufficient length to reach the inlet port mounted on the ceiling of the shelter. I shall henceforth refer to the rubber coupling attached to the PVP piping assembly as the "Vent Inlet Assembly".

Vent Inlet Assembly

The Safe Cell NBC filtration system can be thought of as two systems. It can be used as a basic system consisting of 3 filters (gross pre-filter, fine pre-filter and HEPA filter). This configuration can be used for normal venting of the shelter. The other system consists of 4 filters (gross pre-filter, fine pre-filter, HEPA filter, and activated carbon filter) provides full filtration from nuclear, biological and chemical (NBC) weapons. The filtration system mounting brackets are designed for the full system. But the problem is that the shelter typical operates at 80 percent humidity and the carbon absorber will draw this moisture into the carbon filter and degrade it. Therefore it is important to expose the carbon filter to the air only when a NBC threat occurs. Until then it must be stored sealed from the moisture. As a result I have decided to mount the steel filter bracket and plumb the venting as if it were to be operated as a full system. But I will store the filtrations system as a fully functional basic system (which will still provide basic filtration) unmounted.

So in operation, the shelter is normally sealed at the exterior inlets using (Oatey 33403) 4" Grippers test plugs. If a chemical or biological threat occurs, these test plugs are removed. The carbon filter is removed from the metalized plastic bag and inserted into the NBC filtration system and the system is configured for mounting on the wooden post. The "Vent Inlet Assembly" is attached to the steel nipple at the top of the shelter. The other end of the "Vent Inlet Assembly" is attached to the flexible pipe that is attached to the inlet of the NBC filtration system. The third threat is nuclear which contains an atmospheric blast wave. So the approach here is different. The shelter venting must be sealed from this blast wave. This is accomplished by threading a 4" galvanized steel cap over the steel nipple and waiting it out. As the threat diminishes, the steel cap is removed and replumbed into the NBC filtration system in order to filter out nuclear fallout from the air supply.

For NBC filtered operations, the 4" outlet pipe is too large. The shelter will leak some air from the door seal and from the marine plywood floor. So a rubber restriction flow attachment was fabricated from a 4" diameter 6 inch long steel nipple, a small piece of rubber EPDM roofing material and a 5" diameter flexible clamp. Once assembled the rubber was cut with a knife to produce a restrictive exhaust opening. This should allow a slight overpressure to build up in the shelter. This overpressure relieves the occupants from wearing gas masks and protective clothing, enabling them a safe and comfortable environment.


DO NOT LOAD MORE THAN 10 CARTONS HIGH
DO NOT LOAD MORE THAN 1
DO NOT LOAD MORE THAN 1

O. Lessons Learned

This shelter is unique and the design is unique. Anytime one builds something new, one must expect problems along the way. These problems become challenges that must be overcome. At this point the shelter is approximately 2 years old. I feel it is time to recap some of these challenges.

#1. Even though this was only a 20-foot long shipping container, it was extremely heavy and difficult to relocate to the excavation site for installation. The shipping container was moved into the hole by means of an excavator and heavy logger chains and also by attaching a large block and tackle rigging (pulley) to a tree using chains and using the tree as an anchor it was pulled into location using a very large braided fiberglass rope. In the initial failed attempts to move the shelter into place, we pulled over a tree by its roots. In the end we succeeded by raising the shelter onto solid concrete footer blocks and sliding the shelter along on the blocks in order to minimize friction. As we moved the shelter along, the concrete blocks that were freed in the rear were relocated to the front of the shelter. This is similar to the techniques used by the early Egyptians in moving massive concrete stones to create the pyramids. Originally I thought about using a 40-foot long shipping container. If I had done this, it would have required a construction crane to move the shelter into position.

#2. I knew moisture was a major threat to shelter design. And I took the following steps to minimize this threat including: mounting the shelter on solid footer blocks, running drain tiles around and under the shelter, spraying 2" Icynene closed cell insulation on the exterior of the shipping container and entrance tunnel, covering the shelter with a layer of EPDM rubber roofing, and covering the gravel pit above the shelter with another layer of EPDM rubber roofing that was contoured to shed rainwater away from the shelter. But even having done this, I still found that moisture was a great enemy. Water will always find a way.

The moisture threat came from 3 sources. The first was from the ground moisture. The second was from condensation. And the third was from rainwater.

The first winter after I completed the shelter, we had a severely cold winter. The temperature was below 0° F for several weeks. The ground froze very deeply. During the spring when the ground thawed, a small stream of water flowed from under the shelter through the drain tiles into my driveway for almost 2 solid weeks. This confirmed the importance of including the drain tiles in the construction design.

Condensation was a major problem. The temperature within the shelter could be well over 20 degrees F different from the outside of the shelter. So condensation from the hot moist air outside would collect on the metal shelter door and also the exterior shelter entrance tunnel door. This moisture would rust the metal door, cause visible mildew in the entrance tunnel, and raise the moisture levels inside the shelter. This moisture was almost impossible to remove naturally by airing the shelter because of the temperature difference.

So in the end, the solution was to use a dehumidifier. It was important for this dehumidifier to operate in cold temperature. I purchased a Danby Model DDR60A2GP 60-pint dehumidifier. This dehumidifier operates down to 41° F and was very efficient. It would easily pull the moisture out of the shelter within a few hours. Unfortunately after using it for a day or two, the unit would break. So I replaced it **twice** under warranty. The final unit was a Model DDR60B3WP. This unit had a strange caution on the power cord. The caution required the unit be moved into position and plugged into electrical power for a period of almost a day before it was turned on for the first time. This caution was only a tag on the power cord and did not appear in the owner's manual. I complied with this warning and this last unit worked very well and reliably. So I would highly recommend the unit provided this caution is followed. I suspect that the issue was a design flaw. The unit uses minimal refrigerant and the liquid refrigerant must be pooled at a precise location prior to use otherwise the compressor motor might burn up.

The third source of moisture was from rainwater. The gravel bed above and to the sides of the shelter is somewhat like a large swimming pool. If any rainwater could find its way into the gravel bed, then it could create a bad moisture problem. Although I took great pains in sealing the shelter, rainwater found a way of going past the diversion channel and in through one spot under the concrete blocks into the gravel bed. As a result the moisture permeated into the shelter and the humidity levels in the interior of the shelter reached almost 98%. All the walls, shelves and goods inside the shelter had a layer of visible moisture. The interior walls began to rust. Exotic mold began to form on the shelves. This mold looked like 2-3 inch long drips suspended in the air. I was able to use the dehumidifier to remove the moisture and then I cleaned the walls and shelves with Jomax House Cleaner and Mildew Killer. I repaired the leak into the gravel pit in the following manner. I dug out the penetration hole and stuffed it with natural clay that I purchased in a craft store. Then I put a small layer of EPDM rubber roofing material over the hole and backfilled it with dirt. I also raised the mound of dirt that made up the diversion channel so that it would drain further away from the shelter.

After these changes, I was very pleased with the ability of the shelter to withstand moisture. By using the dehumidifier once or twice per year, I could control the moisture levels within the shelter to 85% maximum humidity.

#3. Originally, I decided to make the shelter a complete stand-alone solar electrical system. But because I wanted to use a dehumidifier, I changed the design to make additional electrical power available to the shelter. I had an outdoor light near the house. I disconnected this light and spliced in a long cable run to the interior of the shelter entrance tunnel. This total cable run from the house was approximately 300 to 400 feet. Since there is a voltage drop in long cable runs, I decided to use heavier cabling (10/2 wires) to minimize this voltage drop. I encased the cable in black plastic tubing prior to burying it, in order to reduce the possibility of the cable being nicked by a shovel. It was important to make the splice joint waterproof. I used a short PVC pipe and two end caps. I drilled a hole in each end cap for the wiring. I spliced the cables together inside the pipe and packed the pipe with silicon caulking and sealed the end caps to the pipe with PVC glue.

#4. Another problem I encountered was with the batteries that made up the solar electrical system. I was way too optimistic in the time required to construct the solar panel system. As a result, I purchased 2 sealed lead acid batteries way too soon. They sat for almost a year before I had the solar system up and running. Lead acid batteries degrade if they are not charged and discharged regularly. The batteries I purchase were used to begin with and having them sit for almost a year almost destroyed them. In the end, the solar panel system works and provides me with lighting when I enter the shelter. The batteries are degraded which impacts their electrical storage capacity. Several years from now when the batteries finally give out, I will replace them and the electrical system will then be up to the design capacity.

#5. The shelter was designed with one entrance/exit door. I ran into significant problems with the door locks. I tasked the Intermodal Shipping Container resellers with the installation of the metal blast door. When the shipping container was delivered onsite, I was unable to open the door due to the dead locks begin jammed. I drilled small holes in the back plates of each dead bolt and forced each deadbolt open one at a time. This allowed me to finally open the door. I removed the strike plates from each deadbolt, which gave it sufficient play to prevent jamming. The metal doorframe provided sufficient structural support and acted as an imbedded strike plate. When the Shipping Container was buried, all seemed to work fine for a while. But one time when I was inside the shelter, the doorknob refused to open. I giggled the knob for several minutes and it finally opened. But then several months later, that same doorknob refused to unlock from the outside. I used several types of oil to try and free the jam but to no avail. In the end, I ordered a replacement doorknob and I drilled out the core of the doorknob. It took several hours to finally free the lock but I was able to open the door. The jam was not in the doorknob or lock but in the latch mechanism. I thought originally that due to the high humidity levels, that the doorknob became rusted. But that was not the case. I inspected the doorknob and it was completely rust free. I suspect the cause of the problem was that the doorknob was damaged during installation. As a result I added other items to the break out kit including more screwdrivers. The doorknob kit includes an installation sheet, catch-release tool and a hex wrench. These should be stored inside the shelter in the break out kit.

#6. Most threats are short-lived and will be resolved within minutes or hours, such as a tornado threat. As a result, the original shelter design concept did not focus on long-term habitation. I did not want to create a shelter similar to a luxury suite in the Hilton, equipped with an entertainment center, wet bar and spa. The operative word in Survival Shelter is "survival". But after reviewing the threats I felt some accommodations were in order. Some threats such as those posed by radioactive fallout may require habitation for days or weeks. As a result, I purchased 4 hammocks and installed 8 mounting brackets on the ceiling support beams.

#7. I tested the interior shelter's capability to shield against an Electro-Magnetic Pulse [EMP]. The shelter provides significant shielding but there was a little leakage around the metal doorframe. As a result I decided to store sensitive electronics (such as radios) in another layer of shielding. I used large Mylar bags (the same type used in long term grain storage) to provide this additional protection. I placed the sensitive electronics in bags, folded it over to close it shut. Additionally, I purchased a couple rolls of aluminum tape, which can be taped over the door seams, to minimize leakage.

IV. THREATS AND IMMEDIATE DISASTER PREPARATION

A. Tornadoes and Storms

Threat: Around 1,000 tornadoes strike the United States each year. A handful of these are major tornadoes, F-4 and F-5. These major tornadoes can have wind speeds between 207 and 318 mile per hour. These tornadoes are extremely destructive and can level well-constructed structures and turn cars into missiles flying through the air. Although it is not commonly known, Indiana is the recipient of many of these major tornadoes. The prime purpose of the shelter was to provide shelter from this natural adversary. The only exposed and vulnerable area of the underground shelter is the entrance door. The 300-pound steel blast door used in this shelter is rated by FEMA to withstand the force of an F-5 tornado.

Preparations: The approach to this threat is to enter the shelter when a local tornado warning is declared (or the signs of an approaching tornado is observed), close the inner door and turn the 3 deadbolts on the blast door and wait for the danger to pass. Storms can produce lightning that can pass through the buried metal shipping container. Avoid direct contact with the metal walls, ceiling and blast door and the two metal posts near the table because they directly attach to the ceiling. The shelter is equipped with an external antenna, which can be connected to a multiband radio, so that the all-clear signal can be monitored.

B. Global Famine

Threat: In the past, great famines occurred in the four corners of the globe. They cause mass migration, slow painful starvation and high mortality rates. In many, a third of the population perishes. People resort to eating the bark from trees, selling themselves or their children into slavery, mass suicides and cannibalism. Great famines are scenes of utter horror. Some of these events are described in “A Chronological Listing of Early Weather Events”, which is available at http://www.breadandbutterscience.com/Weather.pdf

The shelving system in the shelter is specifically designed for the storage of long-life (30 year) foods, such as grains and beans in superpails, freeze dried food in number 10 tins, and food pressure-cooked and stored in canning jars.

The shelter is designed as a root cellar. It is the ideal temperature to store food over long periods of time. Food storage techniques have made dramatic improvements over the last few decades. Combine this with the root cellar environment and it makes if feasible to store a year’s supply of food to provide a buffer to the devastation brought on by a great famine.

Preparations: The shelter contains a supply of stored food. No preparation is required for this threat other than protecting the food stores.

C. Plague and Epidemics

Threat: Over the centuries, great plagues have struck the Earth. The plague called the “Black Death” killed between 30% and 70% of the population in Europe during 1346 and 1350. The 1918 flu pandemic called the Spanish Flu killed around 75 million people worldwide between 1918 and 1920.

Preparations: The approach to deal with the threat from plagues and epidemics is a self-imposed quarantine. Perform a final stock up on supplies. Set up physical barricade and mark the property as quarantined. No one-in-or-out until the danger has passed. Since the property is fairly self-sufficient, since it is stocked with a good supply of food, since the property has a clean supply of water available and the means to generate electricity; it makes this approach feasible.

D. Major Earthquakes

Threat: We live on the fault line of the New Madrid Earthquake. Within a period of 3 months (between 16 December 1811 and 7 February 1812), this fault produced 3 major (7.5-8.0 on the Richter scale) earthquakes that were felt over approximately 1 million square miles. A similar earthquake today could devastate the region (Alabama, Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri, and Tennessee) for many weeks. Unlike California, whose homes are primarily resilient single story wood construction, the Midwest contains many homes of stone and brick and much of the construction is fairly old. A major earthquake in the Midwest will be devastating because the geology will transmit shock waves over greater distances and because most construction has not been designed for this threat.

Major earthquakes occur without warning and when they occur, there is insufficient time to seek shelter. So why is it important to consider earthquakes in shelter design? A massive earthquake can devastate our region, destroying our transportation, energy and communications infrastructure. The shelter is designed with a shelf containment system that will prevent the food and other prepper supplies from being damaged by major earthquakes.

In California, I lived through a major earthquake. One thing I remembered was our kitchen. Everything in the refrigerator was on the floor. Glass was broken. All the cupboards were emptied on the floor. Dishes were broken. Our kitchen floor was one giant heap of food and broken glass. All this debris had to be cleaned up and discarded.

Most roads were impassible because the stoplights no longer worked and massive traffic jams ensued. Some highway overpasses had collapsed. Some houses and buildings were destroyed, especially those made of concrete bricks and stone.

The aftershocks were constant. We would race into the house to retrieve something and then when the ground began to rumble again, we would race outside. If you were driving when an earthquake hit, it was important to hold the steering wheel straight. As the freeway swings back in forth in front of you, there is a tendency to try and correct based on sight but this causes an overcorrection which can lead to driving off the side of the freeway.

If the New Madrid Earthquakes were to occur today, one might expect the following: Many bridges and overpasses would be damaged or destroyed, which would quickly choke off transportation. Many building especially those constructed of brick, stone and concrete would be destroyed causing many fatalities. In the Midwest, there are many old buildings of this nature. In California buildings are designed for this threat. But here we are vulnerable. For several days, major power and utility outages would produce havoc. In major cities, fire trucks trying to respond to fires would be snarled in traffic caused by inoperative stoplights. Ambulances would fare no better. Gridlock would set in. Communications would be jammed. Food, water, fuel, window glass and a good nights sleep would be in short supply.

Preparations: Earthquakes strike without warning and there will be insufficient time to run to the shelter in the event of an earthquake. Immediately after a major earthquake, turn off the gas supply at the propane tank until you can verify the gas lines are undamaged. The shelter is specifically designed to safely store stocks of food, water and prepper supplies without sustaining any damage. After a major earthquake there will be a constant stream of aftershocks. One of the safest places to weather aftershocks is in a stationary car or truck away from anything that might tend to fall upon it.

E. Super Volcanoes

Threat: The eruption of a super volcano can cause localized and a global disaster. The nearest known super volcano is the Yellowstone Caldera located 1,272 miles as the crow flies from our home. The last super-eruption occurred 680,000 years ago. Our home is located generally downwind of this super volcano but the distance is large. The danger from the eruption of this volcano is tied to the ability to survive a massive ash fall, ground and water pollution and a major global cooling event that would severely constrain crop production.

Preparation: Generally, one would not need to seek safety in the shelter for this threat. The following steps should be immediately taken. Fill up all water storage containers. Use N-95 facemasks as the ash begins to fall. Cover the air filters in vehicles with pantyhose to prevent ash from entering combustible motors. Improve sealing off the house to limit the entry of volcanic ash (such as sealing off the house for air leaks during the winter). Filter all drinking water. Periodically check water for acidity using pH meter. One might need to chemically neutralize the acid content in water in order to prevent ingestion of lithium. For a period of time (~ 1 year), one should avoid eating contaminated fresh produce and animals. The food stocks in the shelter should be used.

F. Nuclear Attack

Threat: Nuclear war is a threat. There are around 17,000 nuclear warheads in the world today. The prospects for this type of warfare are increasing because terrorist organizations and rouge nations are gaining access to this type of weaponry and because the U.S. is gravitating towards unilateral disarmament.

There are several good references that describe the threat from nuclear bombs and disaster preparedness techniques. These include "The Effects of Nuclear War" by the *Office of Technology Assessment*, "Would the Insects Inherit the Earth?, Civil Defense Shelters: A State-Of-the-Art Assessment – 1986" by *Oak Ridge National Labs*, and "Nuclear War Survival Skills" by *Cresson H. Kearney*.

The detonation of a nuclear warhead produces an explosive blast wave, ground shock, direct nuclear radiation, direct thermal radiation (heat and light), electromagnetic pulses, and the creation of radioactive particles (fallout).

This shelter is designed to act as a nuclear weapon blast shelter and a radiation fallout shelter. The shelter will withstand greater than a 50-psi peak overpressure wave because it is designed using earth-arching design. The shelter openings and penetrations must also be able to withstand these blast waves. The two vent pipes are designed to be sealed using either a square head metal threaded plug or threaded cap. The metal door of the shelter is rated for around 2.5-psi peak overpressure. The use of a steel adjustable building column to brace the center of the door to the back of the shelter should enhance the protection to about 10-psi. To achieve a 50-psi blast protection for the entrance, the entrance tunnel must be filled with sandbags. For this purpose, a pile of gravel is available under the front entrance walkway and empty sandbags are being stored. With sandbags in place, the shelter and its occupants can survive a 1-megaton nuclear weapon explosion 5,000 feet [0.95 miles] or more from the shelter. The granulated soil above the shelter will provide shielding from radioactive fallout with a protection factor of 10,000 against gamma ray radiation. The shelter will provide sufficient protection from most of these weapons because the property is located away from major targets and large cities. The nearest small town is 5 miles away.

The shelter is designed to cut the dosage from radioactive fallout to 1/10,000 of the dose above ground. High levels of radiation are lethal to the human body. But radiation levels fall off rapidly after a nuclear explosion (by the rate of the half life of the radioactive particle). The threat from low levels of non-nuclear radiation is overhyped by the anti-nuclear movement. The human body has a built-in immune system that repairs damage from low doses of radiation. [Chronic radiation is beneficial below 0.7 Grays per year or 70 rads per year. It only becomes dangerous above that level.] Therefore, one may be able to leave the safety of the shelter a few days after a nuclear attack. I store a Geiger counter and a Civil Defense radiological survey meter in the shelter in order to determine when the levels have dropped sufficiently to exit the shelter. For me it is a judgment call. I also stock M95 respirators and water purification units in the shelter. In shifting to above ground after a nuclear attack, it is advisable to avoid breathing or ingesting radioactive particles.

Preparations: Perform the following actions:
* If the 4" Grippers test plugs are installed on the outside vent pipes, remove them.
* Locate the large pipe wrench stored inside the shelter in the large steel ammunition box labeled "knives". Install the 4" square head threaded metal plugs into the inside weld threaded flanges of the outlet vent pipe. Install the 4" steel cap on the steel nipple on the inlet vent pipe. This will seal off the shelter vents from the nuclear blast wave.
* Remove the two drainage grates and seal the drainage pipes with sandbags. (This is to prevent air migration into the shelter from below.)
* Remove 12-volt batteries from cars/trucks and take these along with the 6-volt deep discharge batteries, which are part of the solar cell system into the shelter.
* Bring in extra drinking water supplies and ready to eat food into the shelter.
* Turn off the gas valves on the propane tank. Cover the tank with "Dam it up" bags. These are sandless sandbags that contain an absorber. Each bag is 14" x 26" and will expend out to 4" when soaked. After covering the tank, soak these bags with water.
* [If there is sufficient time, fill the entrance tunnel with sand bags to increase the effectiveness of the shelter to the impact blast wave.] At the beginning of the entranceway there is a bed of gravel. Remove the paving blocks and use this gravel to fill the sandbags.
* Enter shelter and seal it. Throw the 3 dead bolts on the blast door and install the vertical steel support beam to support the middle of the door.
* Hours after a nuclear attack and as the air becomes stale, remove the stored sealed activated carbon absorber from the metalized plastic bag and install it in the NBC filtration system. The necessary tools are stored in the large steel ammunition box labeled "knives". Mount the system on the steel mounting assembly attached to the 6" wooden beam. Remove the two plastic shipping caps from the unit. Remove the stored emergency hand pump and attach it to the unit. Remove the stored flexible pipe (60" inlet hose) and attach it to the inlet of the filtration system. Attach the system to a battery using the stored power plugs.
* The exterior of the shelter may be damaged by the nuclear blast wave, specifically the exposed portion of the inlet and outlet vents. Remove the cap from the 4" steel nipple and inspect the pipe for free open access to outside air. If the vent pipe is plugged use the stored steel wrecking bar to open up the air inlet.
* Connect the "Vent Inlet Assembly" to the threaded steel nipple in the air inlet in the ceiling. Attach the flexible pipe to the "Vent Inlet Assembly" which is attached to the NBC filtration system. Now turn the unit on and filtered air should start to flow into the shelter.
* Remove the threaded metal plug from the outlet vent pipe. Inspect and verify free open access to outside air. If the vent pipe is plugged use the steel wrecking bar to open up the air inlet. Then screw in the steel nipple with rubber restriction flow attachment to the outlet vent pipe.

* Locate the potassium iodide tablets stored in the Medical Kits in the shelter. Begin taking a daily dosage. This will help block radiation from damaging the thyroid. For infants and small children, the pill should be crushed. Babies under 1 year of age should only take a half dose.
* If the batteries run dry, go to manual operations.
* Locate the tools comprising the Break-Out Kit stored within the shelter. These may be needed to force exit from the shelter. Also locate the Geiger counter and Civil Defense radiological survey meter. As radiation levels fall to acceptable survivable limits, exit the shelter. Use M95 respirators to prevent breathing in contaminated fallout dust. Use water purification units to scrub drinking water.

G. <u>Biological Attack</u>

Threat: This threat is described in "A Citizen's Guide to Terrorism Preparedness and Response" by *the American Council on Science and Health*. Biological agents include bacteria, viruses and toxins. The types of agents are divided into three categories. The Category A agents, the highest priority, include anthrax, botulism, plague, smallpox, tularemia and viral hemorrhagic fever. In general, most gases used in biological attacks are heavier than air. Otherwise they would be quickly dissipated. Natural sources of heat and UV radiation (sunlight), water (precipitation), and wind can reduce the effectiveness of many agents in an open-air setting. Since my home and shelter is in a low population rural area, located part way up a steep hill, I do not see a biological attack as a major threat. But having said this, the shelter is equipped with an NBC filtration system should a threat materialize.

One of the NBC filters (the activated carbon absorber) will be stored sealed in the shelter to prevent degradation and aging. I suspect that the electrical power grid will remain operational during this type of attack. The inverter in the solar panel system has an optional hookup for an A/C input. So in the event of an attack from this type of threat, it seems advantageous to tie the solar power system into the electrical grid so that all the various type of power will be available to continuously run the NBC filtration system (electrical grid, solar power, battery power and backup mechanical power) in the shelter. The battery chargers can charge up the batteries during the daytime and also power the NBC filtration system.

Preparations: There are several steps listed but executing these steps may be limited by the immediacy of the threat.
* If the 4" Grippers test plugs are installed on the outside vent pipes or the 4" square head threaded metal plugs on the two inside weld threaded flanges, remove them.
* Remove the two drainage grates and seal the drainage pipes with sandbags. (This is to prevent air migration into the shelter from below.)
* Connect an extension cord between the A/C in the house and the solar panel system.
* Remove 12-volt batteries from cars/trucks and take these along with a 12-volt charger into the shelter.
* Bring in extra drinking water supplies and ready to eat food into the shelter. Bring in non-scented household bleach (Clorox) into the shelter.
* Enter shelter and seal it. Use duct tape to seal any gaps between the door and the frame.
* Remove the stored sealed activated carbon absorber and install in the NBC filtration system. Mount the system on the steel mounting assembly attached to the 6" wooden beam. Remove the two plastic shipping caps from the unit. Remove the stored emergency hand pump and attach it to the unit. Remove the stored flexible pipe (60" inlet hose) and attach it to the inlet of the filtration system. Plug the filtration system into the electrical wall outlet and also to a stored 12-volt battery. {The filtration system is designed to run off A/C power and charge backup batteries at the same time.]
* Connect the "Vent Inlet Assembly" to the threaded steel nipple in the air inlet in the ceiling. Attach the flexible pipe to the "Vent Inlet Assembly" which is attached to the NBC filtration system. Now turn the unit on and filtered air should start to flow into the shelter.

* Remove the threaded metal plug from the outlet vent pipe. Screw in the steel nipple with rubber restriction flow attachment to the outlet vent pipe.
* If external A/C power is lost, operate using power from the solar panel system. If that power runs dry; switch to automobile/truck batteries. If that runs dry, go to manual operations.
* Locate within the shelter the stored Reactive Skin Decontamination Lotion in the first aid kit. This is an excellent product for decontaminating the skin from most biological and chemical agents. Also locate the stored Fels-Naptha hand soap. Soap and water and diluted bleach are commonly used to decontaminate chemical and biological agents.

H. <u>Chemical Attack</u>

Threat: This threat is described in "A Citizen's Guide to Terrorism Preparedness and Response" by *the American Council on Science and Health*. Chemical agents are usually containerized in liquid form but are released as a gas or aerosol. These agents can cause exposure by attacking the skin, by ingestion, or by inhalation. They fall into 4 categories: blister (mustard gases, Lewisite), blood (arsine, hydrogen chloride, cyanide), choking (phosgene, cyanide, chlorine) and nerve agents (Sarin, Soman, Tabun, VX). In general, most gases used in chemical attacks are heavier than air. Otherwise they would be quickly dissipated. Natural sources of heat and UV radiation (sunlight), water (precipitation), and wind can reduce the effectiveness of many agents in an open-air setting. Since my home and shelter is in a low population rural area, located part way up a steep hill, I do not see a chemical attack as a major threat. But having said this, the shelter is equipped with an NBC filtration system should a threat materialize.

One of the NBC filters (the activated carbon absorber) will be stored sealed in the shelter to prevent degradation and aging. I suspect that the electrical power grid will remain operational during this type of attack. The inverter in the solar panel system has an optional hookup for an A/C input. So in the event of an attack from this type of threat, it seems advantageous to tie the solar power system into the electrical grid so that all the various type of power will be available to continuously run the NBC filtration system (electrical grid, solar power, battery power and backup mechanical power) in the shelter. The battery chargers can charge up the batteries during the daytime and also power the NBC filtration system.

Preparations: There are several steps listed but executing these steps may be limited by the immediacy of the threat.
* If the 4" Grippers test plugs are installed on the outside vent pipes or the 4" square head threaded metal plugs on the two inside weld threaded flanges, remove them.
* Remove the two drainage grates and seal the drainage pipes with sandbags. (This is to prevent air migration into the shelter from below.)
* Connect an extension cord between the A/C in the house and the solar panel system.
* Remove 12-volt batteries from cars/trucks and take these along with a 12-volt charger into the shelter.
* Bring in extra drinking water supplies and ready to eat food into the shelter. Bring in non-scented household bleach (Clorox) into the shelter.
* Enter shelter and seal it. Use duct tape to seal any gaps between the door and the frame.
* Remove the stored sealed activated carbon absorber and install in the NBC filtration system. Mount the system on the steel mounting assembly attached to the 6" wooden beam. Remove the two plastic shipping caps from the unit. Remove the stored emergency hand pump and attach it to the unit. Remove the stored flexible pipe (60" inlet hose) and attach it to the inlet of the filtration system. Plug the filtration system into the electrical wall outlet and also to a stored 12-volt battery. {The filtration system is designed to run off A/C power and charge backup batteries at the same time.]
* Connect the "Vent Inlet Assembly" to the threaded steel nipple in the air inlet in the ceiling. Attach the flexible pipe to the "Vent Inlet Assembly" which is attached to the NBC filtration system. Now turn the unit on and filtered air should start to flow into the shelter.

* Remove the threaded metal plug from the outlet vent pipe. Screw in the steel nipple with rubber restriction flow attachment to the outlet vent pipe.
* If external A/C power is lost, operate using power from the solar panel system. If that power runs dry; switch to automobile/truck batteries. If that runs dry, go to manual operations.
* Locate within the shelter the stored Reactive Skin Decontamination Lotion in the first aid kit. This is an excellent product for decontaminating the skin from most biological and chemical agents. Also locate the stored Fels-Naptha hand soap. Soap and water and diluted bleach are commonly used to decontaminate chemical and biological agents.

I. Asteroid/Comet Impact

Threat: The effects of a comet or asteroid impact are very similar to that of a very large nuclear bomb without the radioactive fallout component. There may be days, weeks, months or even years of advance warning prior to the impact. The threat is described in detail in the "Comet and Asteroid Threat Impact Analysis" available at http://www.breadandbutterscience.com/CATIS.pdf . Disaster Preparations are described in "Impact Disaster Preparedness Planning" available at http://www.breadandbutterscience.com/IDPP.pdf

Preparations: Generally there are two approaches to this threat (1) evacuate the area of impact (outside the 1-psi shock wave) or (2) shelter in place. If the second option is selected and the threat is imminent, perform the following actions:
* If the 4" Grippers test plugs are installed on the outside vent pipes, remove them.
* Locate the large pipe wrench stored inside the shelter in the large steel ammunition box labeled "knives". Install the 4" square head threaded metal plugs into the inside weld threaded flanges of the outlet vent pipe. Install the 4" steel cap on the steel nipple on the inlet vent pipe. This will seal off the shelter vents from the asteroid/comet impact blast wave.
* Remove the two drainage grates and seal the drainage pipes with sandbags. (This is to prevent air migration into the shelter from below.)
* Remove 12-volt batteries from cars/trucks and take these along with the 6-volt deep discharge batteries, which are part of the solar cell system into the shelter.
* Bring in extra drinking water supplies and ready to eat food into the shelter.
* Turn off the gas valves on the propane tank. Cover the tank with "Dam it up" bags. These are sandless sandbags that contain an absorber. Each bag is 14" x 26" and will expend out to 4" when soaked. After covering the tank, soak these bags with water.
* [If there is sufficient time, fill the entrance tunnel with sand bags to increase the effectiveness of the shelter to the impact blast wave.] At the beginning of the entranceway there is a bed of gravel. Remove the paving blocks and use this gravel to fill the sandbags.
* Enter shelter and seal it. Throw the 3 dead bolts on the blast door and install the vertical steel support beam to support the middle of the door.
* Hours after an impact event and as the air becomes stale, remove the stored sealed activated carbon absorber from the metalized plastic bag and install it in the NBC filtration system. The necessary tools are stored in the large steel ammunition box labeled "knives". Mount the system on the steel mounting assembly attached to the 6" wooden beam. Remove the two plastic shipping caps from the unit. Remove the stored emergency hand pump and attach it to the unit. Remove the stored flexible pipe (60" inlet hose) and attach it to the inlet of the filtration system. Attach the system to a battery using the stored power plugs.
* The exterior of the shelter may be damaged by the impact blast wave, specifically the exposed portion of the inlet and outlet vents. Remove the cap from the 4" steel nipple and inspect the pipe for free open access to outside air. If the vent pipe is plugged use the stored steel wrecking bar to open up the air inlet.

* Connect the "Vent Inlet Assembly" to the threaded steel nipple in the air inlet in the ceiling. Attach the flexible pipe to the "Vent Inlet Assembly" which is attached to the NBC filtration system. Now turn the unit on and filtered air should start to flow into the shelter.
* Remove the threaded metal plug from the outlet vent pipe. Inspect and verify free open access to outside air. If the vent pipe is plugged use the steel wrecking bar to open up the air inlet. Then screw in the steel nipple with rubber restriction flow attachment to the outlet vent pipe.
* If the batteries run dry, go to manual operations.
* Locate the tools comprising the Break-Out Kit stored within the shelter. These may be needed to force exit from the shelter. One should be able to exit the shelter approximately 24 hours after an impact. Use M95 respirators to prevent breathing in contaminated dust. Use water purification units to scrub drinking water.

NOTE: Most earthquakes produce shock waves that travel horizontally along the earth's crust. But there are exceptions. On 5 February 1783, a massive earthquake struck Sicily. This was a vertical earthquake. During this earthquake people were thrown 20-30 feet in the air. Persons trapped inside buildings when the earthquake struck were buried alive in the rubble. Individuals near the shoreline were swept out to sea by the tsunami and drowned. It was estimated that 40,000 people perished from this earthquake. A massive comet or asteroid impact on the opposite side of the earth will produce a shock wave that will very quickly pass through the earth and produce a vertical earthquake on the opposite side of the planet. This shockwave will travel back and forth producing a ring effect (multiple vertical earthquakes or aftershocks). To survive such a threat, I would recommend that individuals don several thick layers of clothing and coats, wear a helmet such as a motorcycle helmet or bicycle helmet and relocated to an open field prior to impact.

J. **Massive Solar Storm**

Threat: This threat is described in detail in the "Solar Storm Threat Analysis" available http://www.breadandbutterscience.com/SSTA.pdf The main threat is the loss of major EHV power transformers in key power generation stations. These are very expensive, unique, long lead-time equipment. Their damage can result in a multi-year electrical power outage for about 100 million people in the United States.

A massive solar storm by itself is of minimal direct danger to individuals. Earth's atmosphere and magnetic field will shield the planet from the particles generated by the solar storm. But we live in a modern society that is highly dependant on electronics and electricity. The shelter contains a solar panel electrical system capable of generating 63 amps of electrical power when the sun shines. This system can provide needed energy to run the water pump providing clean water. It can provide additional energy to run refrigerators/freezers, provide power for the propane water heater and clothes dryer circuitry, run the clothes washer, home computers and electronics, etc. In addition because transportation and goods transport will be restrictive during a sustained power outage, the shelter will provide stored provisions and foods.

Preparation: The nature of this threat does not warrant seeking safety within the shelter. As a precaution, one should turn off the gas at the propane tank, unplug electrical wall outlets, and throw the main circuit breaker. There will be several hours of warning before the Coronal Mass Ejection strikes Earth. As a result, there are several steps that can be taken to make survivability less stressful. These are detailed in the "Solar Storm Disaster Preparedness Plan" available at http://www.breadandbutterscience.com/SSDPP.pdf

K. Electromagnetic Pulse (EMP) Attack

Threat: The main threat from an electromagnetic pulse attack is the destruction of modern society through the destruction of electronic circuits. This threat is described in detail in “Getting Prepared for an Electromagnetic Pulse Attack or Severe Solar Storm” by *Jerry Emanuelson*. This report is available at http://www.futurescience.com/emp/emp-protection.html Another source is “High Altitude Electromagnetic Pulse (HEMP) and High Power Microwave (HPM) Devices: Threat Assessments” which is a *Congressional Research Service Report to Congress* and is available http://www.history.navy.mil/library/online/hemp_hpm.htm The scope of this threat is not well defined. Experts vary significantly on their assessment of the dangers from this threat.

Electromagnetic Pulse (EMP), and more specifically Nuclear Electromagnetic Pulses (NEMP) and High-Altitude Electromagnetic Pulse (HEMP) damage electronic circuits. This threat can destroy much of what we take for granted in the modern world such as computers, televisions, cell phones, radios, etc. But electronic are now built into almost all of our modern appliances and equipment such as automobiles, refrigerators, microwave ovens, cash registers, the electrical power grid. This threat in general is not life threatening to living organisms but can be fatal to electronic circuitry.

A general mechanism for protecting against this type of threat is to secure the object in a Faraday cage. One simple mechanism to assess the effectiveness of shielding from an EMP is to test it using an FM Radio. This is because an FM signal is near the frequency of the pulses created by a HEMP. When a FM Radio is placed in a properly shielded container, the signal will go dead.

The shelter because it is a metal enclosure and also because it is a buried structure is immune from the effects of EMP. Any electronics placed in the shelter will survive this threat (provided it is unpowered and unconnected). [An EMP may destroy the solar cell panels and associated solar system equipment above ground but will not affect the main back-up system stored within the shelter.] Several common items are available that are Faraday cages for example used military surplus metal ammunition boxes and steel metal drums. For example, I store my emergency short wave radio in a small ammo can. There are 55-gallon metal drums that will work, but these are a little too small for my desires, so I obtained two 80-gallon metal drums for EMP protection. These are typically used for spill containment, so it is important when purchasing to ensure they were not contaminated.

I tested the shelter prior to burying it in the ground and it proved to be effective at blocking FM radio signals. But in testing the metal drums I observed an interesting phenomenon. As I placed the radio into the drum the radio signal went dead. This was despite the fact that the metal lid was removed. This showed that the threat was somewhat directional. FM radio signals travel horizontally. Since a HEMP weapon detonation will occur several hundred miles above the Earth’s surface, it will have a vertical component. The area (around 800 miles in diameter directly below the blast) will have a vertical component to the pulse. As a result, many items may provide shielding to this threat. These include automobiles and trucks with metal body, metal storage buildings and pole barns with metal roofs, houses with metal roof shingling, and many multi-story commercial buildings. [In general, multi-story commercial buildings are constructed by welding panels of corrugated steel to the I-beam frame and then using these as permanent forms; concrete is poured into them. These corrugated metal sheets can act as a shield.]

There are several items that because of their size would be difficult to protect from an EMP attack. Top on this list are automobiles and trucks. They contain built in computer systems that could be easily damaged. I conducted a quick test. I took my emergency radio and tuned it to a strong FM signal. I covered the antenna with a washcloth and then the entire radio with aluminum foil. The radio went dead. Thus aluminum foil can block the EMP pulse. Therefore it may be possible to protect equipment from damage using aluminum foil. For example if the wiring harness is unplugged from the vehicles computer and the computer covered by aluminum foil, it might protect this vulnerable element of automobiles and trucks.

Preparations: This type of threat does not damage individuals but is murder to electronics. Therefore one does not need to take shelter during an EMP attack. If this threat becomes imminent, take the following steps. To protect electronic circuitry from this threat, it is also advisable to unplug them from their outlets and to turn off the main circuit breaker in the house. The HEMP weapon can produce peak currents of tens of millions of amps. It is very important to unplug the power line to the water pump. The power lines can act like a large antenna and induce major voltage spikes into electronic circuitry. These voltage spikes can arc across the main circuit breaker and they can also travel up the neutral and ground wiring. In the shelter throw the main circuit breaker and ensure the radio antenna is disconnected from the emergency radio. Remove each of the LED lights in the shelter from their light sockets and unplug the Christmas LED lights.

Locate the large pipe wrench stored inside the shelter in the large steel ammunition box labeled “knives”. Install the 4” square head threaded metal plugs into the two inside weld threaded flanges to seal off the shelter vents.

The door seal allows some EMP wave to penetrate the shelter. So in order to enhance the protection, use 2 inch wide Aluminum Foil Tape and tape around the gap in the doorframe.

Any electronics stored within the shelter with the door closed should be immune from this threat. So relocate vulnerable and critical electronics into the shelter. This would include solar panels, voltage converters, emergency backup generator and any other electronics that will fit.

Wheel the two large 80-gallon steel drums into the house and store smaller electronics (such as computers, radios, dvd’s etc.) in the steel drums and close and seal the lid.

Protect embedded electronics (such as computer built into vehicles) by unplugging electrical connections and covering them with aluminum foil.

L. Nearby Supernova

Threat: A nearby supernova (an exploding star) is a very dangerous and least understood threat. For most people, it will be a scientific curiosity as a new brilliant star is born and grows to the size of the moon or the sun. But the sky will darken and the sun and moon will turn to blood and then the dying will start.

Most supernovas occur in distant galaxies millions of light years from earth. They appear as a new star that will fade away in time. They generally pose little danger to our planet. The supernovas that are of concern are those, which are relatively close, in the range of 30 to 2,000 light years from Earth. [One upcoming supernova of concern is the explosion of the star Betelgeuse, a red supergiant estimated to be 640 light years from Earth. This is a northern hemisphere star.]

An exploding star rips atoms apart and accelerates some of these fragments, the protons and pieces of atoms (ions), to near light speed and releases these particles to the universe. These fragments are called Galactic Cosmic Rays (GCRs). The faster these particles travel, the higher their energy levels. Since these GCRs are travelling at near light speed rather than at light speed, the first wave will collide with our solar system several days after the new supernova becomes visible. And as time goes on, the succeeding particles will carry less energy and be less dangerous.

As these high energy GCRs collide with earth's atmosphere, they will break down the molecule that comprise our atmosphere. The bonds that hold oxygen molecules (O_2) and nitrogen molecules (N_2) will be blasted apart. In many cases the atoms will recombine to form nitrogen oxides. Nitrogen dioxide is a reddish brown gas that will color the appearance of the sun and moon with a bloody hue. The collision will also start a cascade of particles with sufficient energy to reach the surface of the planet.

This threat and a preparedness plan is described in detail in "Supernova: Disaster Preparedness Plan" available at http://www.breadandbutterscience.com/SDPP.pdf

High-energy nuclear radiation is one of the most deadly forms of radiation. It is roughly ten times more effective at causing biological damage compared to gamma or beta radiation of equivalent energy exposure. It can cause instantaneous neurological damage producing sudden death. The ionization from these particles as they collide with cells in the body can generate an electrical shock that can stop a beating heart. This radiation can cause bone marrow damage. When this form of radiation strikes the brain, it can cause permanent damage producing dementia. This can turn individuals into murdering barbarians and on a large scale can destroy the fabric of civilization. It can increase cancer risk, primarily leukemia. It can also cause genetic mutation.

In general, the human body with its immune system is capable of dealing with exposure to lighter forms of radiation. But the heavy forms, high-energy nuclear radiation, are very destructive to the DNA creating double breaks in the DNA molecule, which causes genetic mutations.

Many of the survivors will only be able to speak gibberish. Without the ability to speak, read or write; people lose the tenants of society and civilizations and nations disintegrate and come to an abrupt end.

This nuclear radiation will not only affect humans but will also genetically mutate bacteria and viruses. This will in turn spawn major epidemics in man and beast (i.e. deadly variants of the black plague, rinderpest).

High-energy particle radiation can also be very deadly to electronics; especially transistors, semiconductors, integrated circuits and computer chips.

Preparations: Salt water is a much better shield from high-energy nuclear radiation than earth, stone, concrete, steel or even lead. By better, I mean low cost, readily available, and very effective. As these particles pass through a shield medium, they must be slowed down through elastic scattering. Hydrogen is the lightest nuclei available to slow down these particles and one of the most concentrated forms of hydrogen is found in water (H_2O). Other atoms (boron, cadmium, chlorine, iron, fluorine, lithium and potassium) are very efficient at absorbing nuclear particles once they have been slowed. Adding salt (which contains chlorine atoms) provides dramatic improvements to the efficiency of the nuclear radiation shielding. One of the least expensive and most commonly available salts is water softener salt.

Perform the following steps:

* When a nearby supernova is first observed, the shelter must be augmented to shield from this threat. This must be done before the first wave of GCR's strike earth. The shelter was constructed with a circular flat level staging area directly above the shelter. The shelter contains a 15-foot diameter 42-inch deep inflatable swimming pool. This swimming pool must be set up and filled with water. To the water must be added 200 pounds of salt, generally water softener salt.

* It is important to establish timing of the threat window by observing when the new star rises and sets each day because this will become a new clock. This must be done before the first wave of particles strike. This time will be critical in determining when it is safe to leave the shelter. The timing of this threat is analogous to getting a bad sunburn. One does not get sunburned standing outside during the middle of the night, nor in the early morning hours, nor when the sun is setting. Rather one gets sunburned when the sun is directly overhead. In a similar manner, this high-energy nuclear radiation threat exists when the large second sun (supernova) is directly overhead. At other times, one can leave the shelter and move about safely. One needs only spend about 8 hours a day in the protective shield offered by the shelter. Particles that strike the atmosphere at near-horizontal angles will dissipate their energy in the atmosphere and never reach the ground. It is primarily the vertical component that is threat. (But the length of this time window can vary by its orientation in the sky.) It is important to bring a watch or mechanical clock into the shelter in order to track threat window exposure timing.
* Turn off the gas valves on the propane tank. Cover the tank with "Dam it up" bags. These are sandless sandbags that contain an absorber. Each bag is 14" x 26" and will expend out to 4" when soaked. After covering the tank, soak these bags with water.
* Bring in extra drinking water supplies and ready to eat food into the shelter.
* Verify shelter vent pipes are open.
* Unplug the home's water pump.
* Since electronics can sustain damage, protect critical electronics (such as the solar panel system components, portable emergency backup generators) either by relocating them into the shelter or externally with water shielding. I would also protect fuels such as gasoline and diesel fuel from this exposure.
* Locate the Geiger counter and civil defense radiation meters stored within the shelter. These instruments can be used to determine when it is safe to leave the shelter.
* The initial wave of GCRs should be observable by coloring in the sky, by radiation detected using Geiger counters, and by the loss of satellites feeds (such as GPS and communications). Enter and remain in the shelter whenever there is a high-energy nuclear radiation threat. Over the next several weeks and months after the first wave of GCRs strike; the energy levels of the GCRs will decrease and they will reach a point when they no longer pose a threat at the surface of the planet.
* A nearby supernova may produce some very energetic electrical discharges. Should this occur, avoid direct contact with the metal walls, ceiling and the metal blast door. Also avoid contact with the two metal posts next to the table that directly contact the ceiling.
* Locate the Marine Goop and the Patch Repair Kit stored within the shelter. It may be necessary to patch up the swimming pool and refill it with water and salt after leaving the shelter in preparation for the next exposure cycle.
* A nearby supernova may also spawn several other long-term threats including massive floods, global cooling, famines and human and animal plagues. These will be global threats and will impact areas of the globe that were minimally exposed to this nuclear radiation. The shelter is equipped with food stores and a major solar power electrical distribution system that can power the well's water pump, which can provide clean drinking water.

M. <u>Neutron Bomb Attack</u>

Threat: Neutron bombs are a specialized type of atomic bomb. The principal killing mechanism for a neutron bomb is the intense pulse of high-energy neutrons, rather than radioactive fallout, thermal heat or blast wave. They were designed to destroy tank columns. These weapons enhance the generation of high-energy nuclear radiation (with energy levels approaching 14 MeV neutrons) that could easily penetrate the heavy metal armor of battle tanks and inflict a lethal dose of radiation to the tank crews.

Since this shelter is designed to stop 500 MeV protons and since protons and neutrons have approximately the same mass, the shelter should easily shield against 14 MeV neutrons generated from a neutron bomb blast.

In general this threat does not produce an atmospheric blast wave because the weapon is detonated very high up in the atmosphere.

Preparations: In order to protect against this type of threat, the 15-foot diameter 42-inch deep inflatable swimming pool would have to be pre-deployed in the staging area directly above the shelter. Deploy the pool and fill with water and 200 pounds of water softener salt. Bring in extra drinking water supplies and ready to eat food into the underground shelter. Turn off the gas valves on the propane tank. Cover the tank with "Dam it up" bags. These are sandless sandbags that contain an absorber. Each bag is 14" x 26" and will expend out to 4" when soaked. After covering the tank, soak these bags with water.
As a threat becomes imminent, enter the shelter and secure the door.

A neutron bomb is designed to kill living organisms but not destroy property or infrastructure. But that is not entirely true because a neutron bomb can damage and destroy electronics. Therefore if time permits it is advisable to move any important electronics (such as exposed solar panels and power converters) into the safety of the shelter.

N. <u>Financial Collapse and Civil Unrest</u>

Threat: History shows the economy can experience period of economical collapse. These conditions can product severe, prolonged depression with high bankruptcy rates and high unemployment and a breakdown in normal commerce caused by hyperinflation. These periods of financial and economical collapse can produce civil unrest.

To protect against this threat, our home and property is debt free. It never had a mortgage and as long as I am alive; it never will. When you have a loan, the property is not really yours; it belongs to the lender. Even if the property is almost completely paid for, if one is not able to make the monthly loan payments; the property can easily be taken away, making individuals homeless.

The storage of a year supply of food in the shelter (root cellar), means that no matter how hard conditions become, I can put food on the table for about a year into an economical collapse. Also the sustainability features of the home and shelter means that the complex can survive as off-grid.

This threat also has a civil unrest component to it, which can lead to general chaos. Our home is in a rural area and most of the civil unrest will be localized in major population centers. But some of it may spill out into the countryside and as a result, physical security is important. I will not discuss any measures that may be deployed because of OPSEC, but only to say they exist.

O. <u>Thousand-Year Flood</u>

Threat: Water is a very strong force and should not be taken lightly. Floods periodically occur. Some are minor; some are severe. We have a small creek that runs across our property. I have a modified Kentucky bridge that crosses the creek. The bridge has two 3-foot diameter HDPE pipes and over 150 cubic yards of concrete. The bridge is designed to direct the flow over the center of the bridge should the water flow exceed the capacity of the pipes or if the pipes become plugged by debris. Around once per year, normally in the early spring, we experience a flood. Since our creek handles the drainage of thousands of acres, the flood will occur quickly within 2 hours after a heavy rainfall. The water will rise sometimes 5 feet above the top of the bridge. Branches, trees, sometimes roots and all will flow down the flooded creek and plug the pipes. After the water level drains down, then comes the clean up. I have developed a system to remove this debris. Using a long wire rope attached to my Gator utility vehicle, I drag the debris to the brush pile. Sometimes I have to use my chainsaw to cut the debris so I can remove it. It can be difficult to cut wood, which is waterlogged or partially submerged. After the debris dries out, we set off a small bomb fire. Generally this is at a small family get-together where we cook sausages and roast potatoes and feast on wood debris left by the flood.

The creek feeds into a river. A day or two after a heavy storm, the river level will rise and flood the bottomlands. As the water level rises in the river, it will sometimes back upstream and the water will flow slowly backwards up the creek. In the past during the 18th and 19th centuries, there have been great floods placing vast tracks of land underwater. This far exceeds anything the modern generation has experienced. A great thousand-year flood could affect millions of people, making them homeless.

Our house is built up the side of a large hill. It is my belief that a thousand-year flood would not reach the house. Our approach to this disaster would be to hunker down during the flood and then perform a major effort in cleaning up debris after the water level drops.

P. <u>Great Winter Storm</u>

Threat: History shows that great winter storms can occur in the Midwest, where the depth of snow can reach 6-feet deep on the level with drifts 50-feet high. These great winter storms can bring everything to an utter standstill. In the past, people would burrow through the snow to create tunnels to adjacent homes and buildings. Some people were trapped in their homes completely covered over with snow for weeks, unable to get out. In the modern world, this type of storm can also go hand-in-hand with an electrical power outage, which can prevent people from heating their homes. Most furnaces will not operate without electricity. Impassable roads can prevent people from obtaining groceries or restocking their fuel (heating oil, propane).

We heated our home solely with wood for 35 years. So in the event of a great winter storm (like those that occurred during the cold times 200 years ago or during the last Little Ice Age), we should be able to keep warms. If the electricity goes out, we have kerosene lanterns for light. Without electricity, the water pump will not run, but snow can be melted and filtered to generate pure drinking water. The septic system should still work fine but melted snow will be used to flush the toilets. It may be necessary to climb onto the top of the house and manually remove the snow from the roof. Also snow is an excellent insulator. The ground above buried water and septic line pipes can be covered with snow, which will protect these pipes from freezing and breaking. It may be time to use my snowshoes, which I keep for this type of disaster.

Refer to the Solar "Grand Minima" Preparedness Plan available at
http://www.breadandbutterscience.com/GMDPP.pdf

Although the house is fairly well insulated, it would loose too much heat under extreme cold conditions (such as below -50° F) that lasted for an extended period of time. This heat loss would primarily occur at the windows. Therefore if there is sufficient preparation time available, the windows could be insulated by using batts of Kraft-faced fiberglass insulation attached to the inside of the windows. The sliding glass doors could be better insulated by using sheets of rigid foam insulation attached to the outside and supported with a plywood exterior frame.

Q. <u>Forest Fire and Firestorms</u>

Threat: Forest fires have struck the Midwest in the past. They are generally associated with very dry weather, high temperatures and prolonged drought conditions. When a major drought is combined with high winds they can produce massive firestorms.

In 1871, a prolonged and widespread drought and high temperature turned the Upper Midwest of the United States into a tinderbox. On 8 October 1871, a furious storm with extreme gale force winds roared through the Midwest setting off a series of firestorms from Wisconsin and Illinois, across the entire state of Michigan, and finally stopping at Ontario, Canada. In Northeastern Wisconsin and Upper Michigan, the firestorm destroyed between 1.2 and 1.5 million acres of forest and took between 1,200 and 2,400 lives. The fire quickly spread throughout the entire city of Chicago, Illinois. It burned for two days and devastated the entire central business district of Chicago. The fire killed at least 300 people, destroyed 3.3 square miles of buildings, made 90,000 people homeless. The fire swept from one side of the state of Michigan to the other side, from Lake Michigan to Lake Huron. Holland, Michigan was reduced to ashes, Manistee nearly consumed, Glen Haven destroyed. The Saginaw Valley and territory northwest as far as the Au Sable River were fire swept. The fires reached the "Thumb" region of Michigan. Port Huron, Sand Beach, White Rock and Forestville completely destroyed and two thirds of the population of Huron and Sanilac County were left homeless. The fire burned 2 million acres between Lake Michigan and Lake Huron. Rough estimates place the death toll in this region as greater than 500 people. The estimate of total property damage from this fire in today's dollars exceeded $7 billion.

My house and property is wooded contain approximately 1,000 large trees. The trees and vegetation insulate the area from droughts by its remarkable ability to retain moisture. But a prolonged multi-year drought could make this forest vulnerable to fire. The underground shelter is designed to provide protection to the extreme heat generated by a forest fires and firestorms and to the lethal gases created.

Preparations: The time to prepare for this type of disaster is long before the disaster strikes. In a prolonged drought when trees and shrubs begin to die, perform a major cleanup. Cut down trees and shrubs near any structure and clear the area around the house, pole barn, underground shelter and propane tank. Remove the debris into piles and when it is safe to burn, burn these shrub piles. The wood can be used as firewood so long as it is stored far away from any structures.

There are two approaches for large forest fires and firestorms. Either evacuate to a safe region or stay and fight the fire and then shelter in place. If I stay, prepare the shelter in the following manner:
* If the 4" Grippers test plugs are installed on the outside vent pipes, remove them. I would probably remove the plastic/rubber top portion of the two vents because they might melt and burn.

* Remove the two drainage grates and seal the drainage pipes with sandbags. (This is to prevent air migration into the shelter from below.)
* Remove 12-volt charged batteries from cars/trucks and take these along with the 6-volt deep discharge batteries, which are part of the solar cell system into the shelter.
* Bring in extra drinking water supplies and ready to eat food into the shelter.
* Remove the stored sealed activated carbon absorber and install in the NBC filtration system. Mount the system on the steel mounting assembly attached to the 6" wooden beam. Remove the two plastic shipping caps from the unit. Remove the stored emergency hand pump and attach it to the unit. Remove the stored flexible pipe (60" inlet hose) and attach it to the inlet of the filtration system. Plug the filtration system into the electrical wall outlet and also to a stored 12-volt battery. {The filtration system is designed to run off A/C power and charge backup batteries at the same time.]
* Connect the "Vent Inlet Assembly" to the threaded steel nipple in the air inlet in the ceiling. Attach the flexible pipe to the "Vent Inlet Assembly" which is attached to the NBC filtration system. Now turn the unit on and filtered air should start to flow into the shelter.
* Remove the threaded metal plug from the outlet vent pipe. Screw in the steel nipple with rubber restriction flow attachment to the outlet vent pipe.
* If external A/C power is lost, operate using power from the solar panel system. If that power runs dry; switch to automobile/truck batteries. If that runs dry, go to manual operations.
* Turn off the gas valves on the propane tank. Cover the tank with "Dam it up" bags. These are sandless sandbags that contain an absorber. Each bag is 14" x 26" and will expend out to 4" when soaked. After covering the tank, soak these bags with water.

Years ago I use to back burn the weeds and grasses in the field below my property in the spring. But one year, it almost got away from me. The winds picked up and the flames rose 50 feet into the sky like a fire tornado. The interesting observation was that as the fields burned, the heat become quite intense but 30 minutes later, I was able to safely walk through the burnt fields. There simply wasn't that much fuel to burn.

But woods are a different story. They contain a large amount of fuel and the fire will last hours.

My property contains a few natural firebreaks. There is a creek that crosses one side of my property. My concrete and brick driveway is another small firebreak. It might be possible to back burn the fields to create other firebreaks, if the winds are not too great. Remember in back burning always start the fire to burn against the prevailing wind. It might be possible to burn a small area to create a small firebreak and then burn a larger area taking advantage of the smaller firebreak. Flat head shovels are handy in snuffing out the fire at the end of a back burning. I have my own water sources including my well, a 1,000-gallon spring tank and over 10,000 gallons of creek water next to the bridge. I have a trash gasoline power water pump, 300 feet of 2" hose and a fire nozzle.

The winds can carry burning embers great distances. My home has a metal roof and the outside walls are brick. A little water placed at a strategic time might well save the house during this type of threat.

If the fire becomes too difficult to cope with, enter shelter and seal it. Use duct tape to seal any gaps between the door and the frame.

After a major forest fire, it is important to quickly plant the hills with quick growing rye seeds to prevent soil erosion that can produce major mudslides.

V. PARTS LISTS

20-Foot Intermodal Shipping Container

Intermodal Shipping Container –Condition: Wind and Watertight (WWT)
Installation of Blast Steel Door
Transportation of Container to Site

Doors

Securall FEMA320 HD36x80-0 Blast Door
12 gauge steel door & frame
FEMA rated to withstand F-5 tornado
Transportation fuel to deliver blast door
Milliken Millwork Ohio Fiberglass Entry Door
Doorknob and Deadbolt for Fiberglass Door

Excavation and Burial

3 ½ days of earth excavation and site preparation (~26 feet across by 18 feet), relocation of shipping container to site, and burial of shipping container.

Insulation and Outer Skin

Application of 2" Icynene closed cell insulation sprayed on exterior (top and sides) of shipping container and entrance tunnel
Black EPDM Rubber Roofing 060 Gauge (10 foot x 25 foot), Material Type GST
Black EPDM Rubber Roofing 045 Gauge (10 foot x 50 foot), Material Type LSFR
Gen Flex G-400 Seam Adhesive

Solar Panel Electrical Systems

8@ Kyocera KD140SX-UFBS, 140 Watt Solar Panels
1@ Magnum Inverter MS4024PAE, 4000 watt pure sinewave Inverter
1@ Magnum Inverter MM612AE, 600 watt mod-sinewave Inverter
2@ Xantrex/Schneider C60-12/24 Charge Controllers
1@ Xantrex/Schneider CM/R-50 Remote Meter
1@ Xantrex/Schneider BTS/35 Cable
1@ MidNite Solar MNDC250 Mini DC Disconnect Box 250 amps
1@ MidNite Solar MNDC125 Mini DC Disconnect Box 125 amps
1@ MidNite Solar MNDC-GFP63 Ground Fault DC Circuit Breaker 63 amps
1@ MidNite Solar MNEPV-60 DC Circuit Breaker 60 amps
2@ MidNite Solar MNEPV-20 DC Circuit Breaker 20 amps
1@ Large Deck Box
1@ Philmore ABS Enclosure PB413
1@ Philmore Mod Phone Cord 14 feet, 75-230
2@ Hammond Manufacturing 1427CG13
1@ Hammond Manufacturing 1427CG7
4@ Unistrut Half Slot 12 Gauge Channel 10 foot long
4@ 8 foot long 6 x 8 treated lumber
2@ Steel Track Cover Supports (5 packs)
2@ used AGM Sealed Lead Acid Batteries 6TAGM, Hawker HASP-FT, P/N 9750N7025
NSN: 6140-01-485-1472, Charging Voltage: 14.4 V., Float Voltage: 13.74 V.
4@ Crimp on Battery Connectors

NBC Air Filtration System

NBC Filtration Ventilation System ASR-100-AV-NBC
Emergency Backup Hand Pump
4" diameter 12" long galvanized steel nipple
4" diameter 6" long galvanized steel nipple
6@ 5½ inch long x 3/8 hex bolts
3@ 4" diameter PVC 90° (long sweep) elbows
2@ 2 foot long 4" diameter PVC pipes
1@ 4" flexible coupling

Lumber

4@ 8 foot long 6 x 6 treated beams
1@ 6 foot long 6 x 6 treated beam
4@ 8 foot long 4 x 6 treated lumber
25@ 8 foot long 4 x 4 treated lumber
66@ 8 foot long 2 x 10 treated lumber
2@ 8 foot long 2 x 6 treated lumber
2@ 10 foot long 2 x 6 treated lumber
10@ 12 foot long 2 x 4 treated lumber
30@ 8 foot long 2 x 4 treated lumber
95@ 8 foot long ChoiceDek decking planks
6@ 12 foot long 1 x 4 oak boards
3@ 8 foot long 1 x 2 oak boards
28@ 6 foot long 1 x 2 oak boards
8@ 4 x 8 sheets of ¾" oak plywood

Electrical

1@ Siemens 100 amp main load center
9@ Siemens 20 amp 1-pole circuit breakers
1@ Siemens 30 amp 2-pole circuit breaker
50 feet #2 AWG copper stranded wire
500 feet #6 AWG copper stranded wire
125 feet #6 AWG solid copper wire
100 feet 12/2 copper wiring with ground Type NM-B
1@ copper coated grounding rod
2@ 5/8" ground rod clamps
1@ #2 AWG split bolt
7@ #6 AWG ring terminals
20@ 15 amp duplex receptacle outlets
1@ 20 amp 220 volt receptacle outlet
2 @ 20 amp single pole switches
8@ metal square wall electrical boxes (2 gang)
1@ metal wall electrical box (1 gang)
1@ toggle switch nylon wall plate
1@ 220 volt receptacle wall plate
7@ double duplex wall plates
1 pack of 100 NM/SE 3/8" cable connectors
3@ NM/SEU ¾" cable connectors
1 box of 400 electrical twist wire connectors
1 roll 3M #88 heavy duty electrical tape

Lighting

8@ pull chain porcelain lampholders
8@ 4" octagonal plastic ceiling boxes
8@ UtiliTech Pro, 23 watt, 1600 lumen LED bulbs
8@ decorative pulls (for porcelain lamps)
8@ strings of C-3 LED Christmas lights

Air Vents

10 foot long 4" diameter galvanized steel pipe cut in two and threaded
4@ 4" x 9 150# weld threaded flange
2@ (Rubber) flexible coupling
2@ #64 metal clamps
4@ 4" PVC 90° street elbow
2 foot 4" Schedule 40 PVC pipe (cut in two)
2@ Oatey 33403 4" Grippers test plugs
2@ Square head threaded plug for 4" black pipe

Hardware

FastenMaster Headlock Heavy Duty Flathead Fasteners (box of 50)
- 3 boxes of 2 7/8"
- 3 boxes of 4 ½"
- 1 box of 6"

Grip Rite High Performance Exterior Screws (5 pound box)
- 1 box of 1 5/8" x 8
- 1 box of 2" x 8
- 3 boxes of 2 ½" x 9
- 4 boxes of 3" x 9

25@ ½" x 10" hex bolts
12@ 3/8" x 8" hex bolts
25@ ½" hex nuts
12@ 3/8" hex nuts
Washers
18@ 1 3/8" x 6" USP metal nail plates
15@ 1 3/8" x 12" USP metal nail plates

Drainage

1@ 4" solid corrugated drain tile (100 feet)
1@ 4" French drain tile (10 feet)
1@ 4" perforated corrugated drain tile (100 feet)
1@ 36 inch x 100 feet sediment sheet
1@ 4" perforated corrugated drain tile with sock (100 feet)
3@ 4" drain tile couplers
1@ 4" snap end cap for drain tile
2@ 12" black square basin grates
1@ 3' x 300' black fabric 3 ounce

Metal Support Posts

TAPCO 3" Steel Adjustable Building Column
- 4@ Size 7' 0" – 7' 4"
- 7@ Size 7' 3" – 7' 7"
- 2@ Size 7' 9" – 8' 1"

Concrete Blocks

670@ "Jumbo J" landscaping blocks (15½ x 12 x 7)
400@ "Jumbo J" concrete caps (7½ x 13½ x 3¾ solid)
40@ 6x8x16" solid concrete blocks
38@ Provantage landscaping block adhesive
869 sq. ft. solid 4" thick paving blocks (factory overruns)
600 pounds of white silica sand

Gravel

153.6 tons #8L gravel

Miscellaneous

6 tubes Liquid Nail Extreme Heavy Duty Adhesive
8 tubes Clear Silicon Caulk
1 gallon Leak Stopper Rubberized Roof Patch
3 quart MinWax "Early American" #230 Stain
1 gallon Helmsman Clear Satin Spar Urethane varnish
1@ ¾" x 100 feet FTNSF 160 psi plastic pipe (for encasing buried electrical wires)
1@ 36" x 25 feet aluminum screen
3@ Rust-oleum spray cans of camouflage paint
1@ Daptex Plus foam sealer
2@ Philmore FC72B Coax to Stereo Connectors
1@ Philmore 65-1045B/10 Strain Relief
1 QVS CC400-FF Stereo Audio Coupling
1 PPEC MMA-F6-50BK 50-foot RG-6 Patch Cable
50@ Brass Plated Label Holders (5/8" x 2½") with Screws

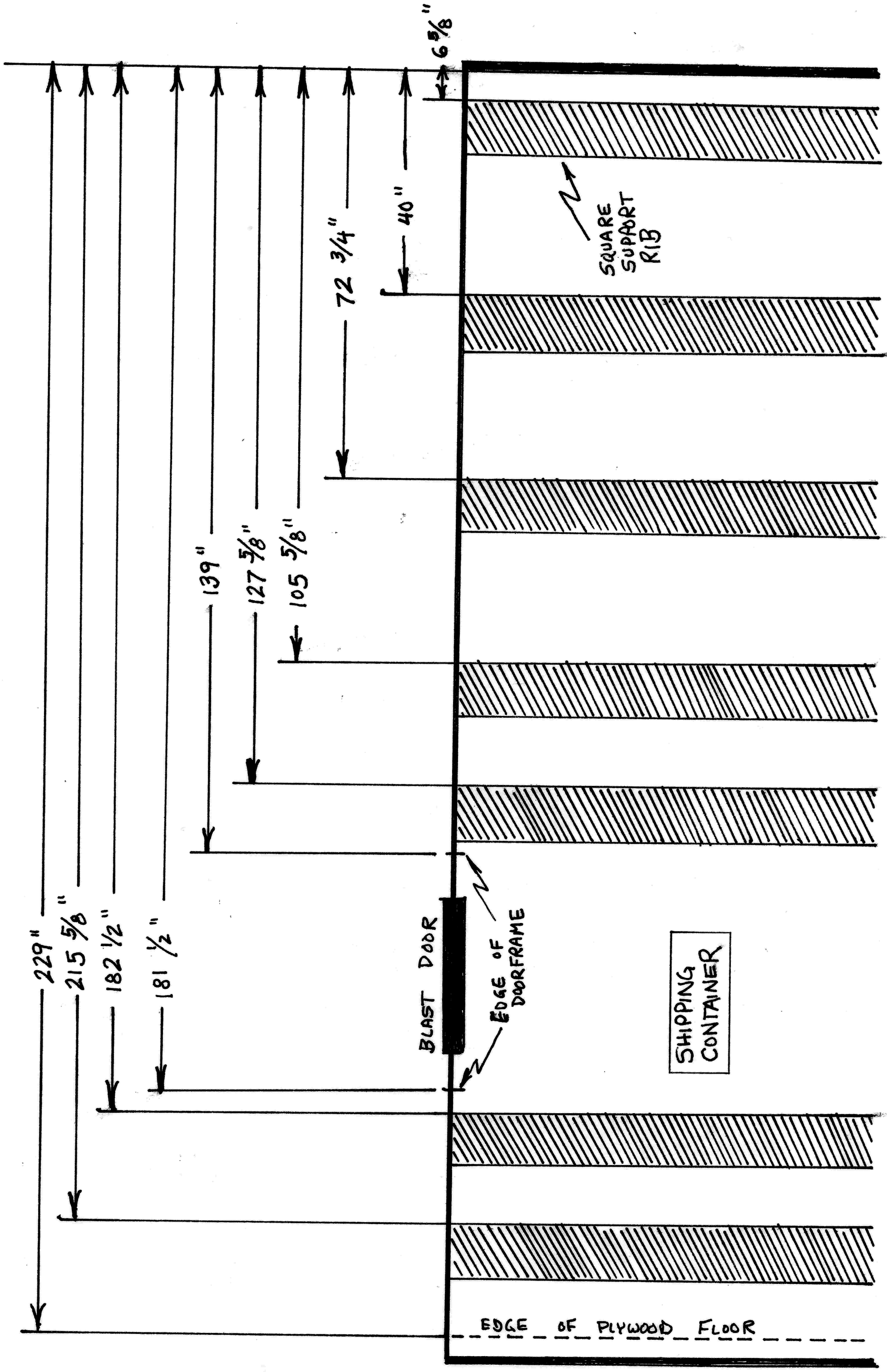
VI. COST BREAKDOWN

Total Cost

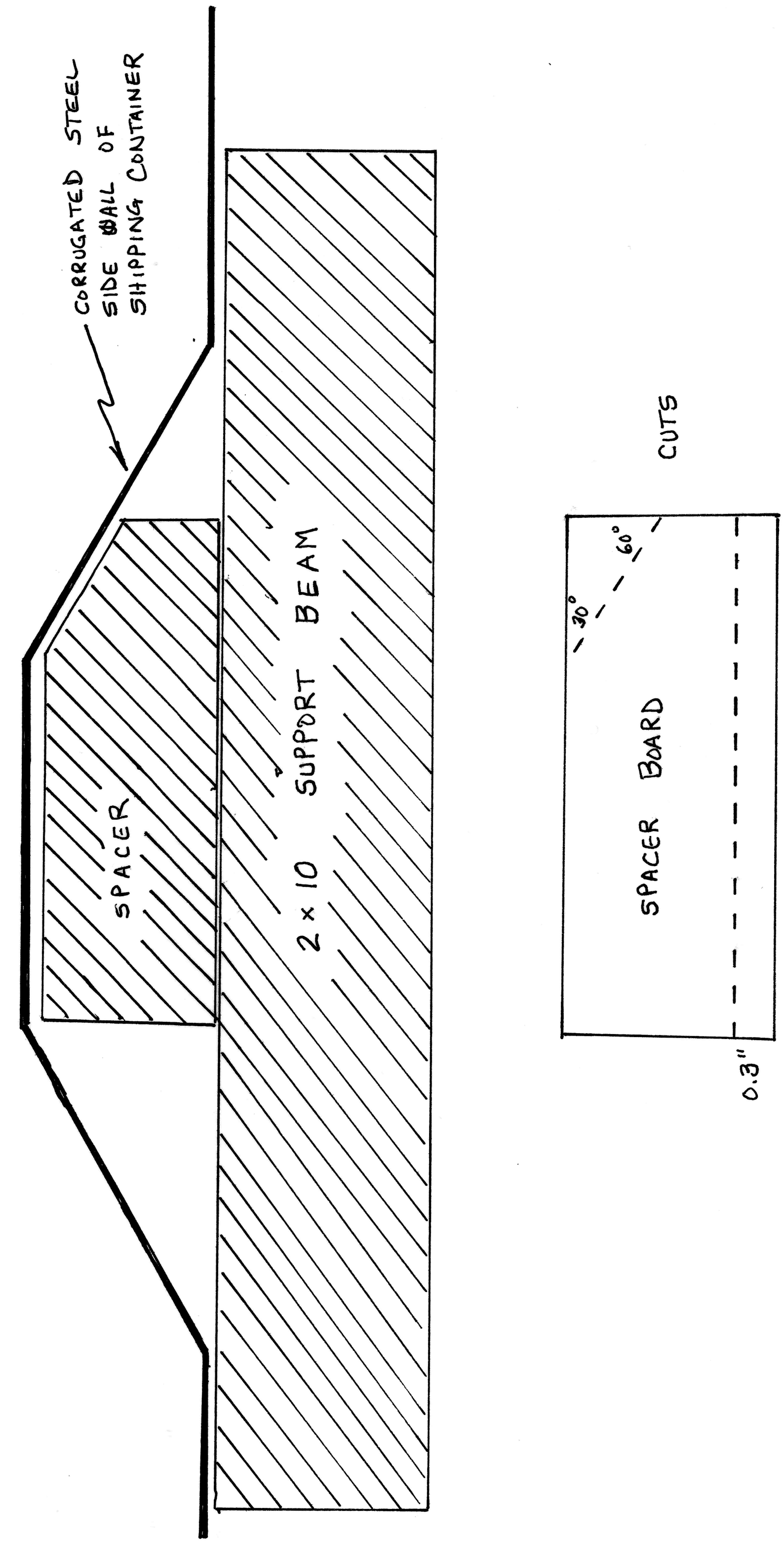
20-Foot Intermodal Shipping Container	$ 5,427.65
Doors (Steel Blast Door + Entrance Fiberglass Door)	$ 2,196.81
Excavation and Burial	$ 2,975.00
Insulation and Outer Skin	$ 2,517.16
Solar Panel Electrical Systems	$ 6,785.11
NBC Air Filtration System	$ 3,218.99
Lumber	$ 3,090.92
Electrical	$ 842.16
Lighting	$ 352.25
Air Vents	$ 375.89
Hardware	$ 560.00
Drainage	$ 318.11
Metal Support Posts	$ 787.91
Concrete Blocks	$ 5,290.67
Gravel	$ 2,450.58
Miscellaneous	$ 306.71
Total Cost (As-Built in 2014 dollars)	$ 37,494.92

[Note: some of these items were items that I had on-hand, so I priced out these items as if they were purchased new. These included some landscaping blocks, #2 AWG copper strand wire, EPDM rubber roofing, GenFlex seam adhesive, 4-inch metal pipes and 4-inch weld threaded flanges. I had a retaining wall behind the house that was degrading because the landscaping blocks were not fabricated correctly. I tore this retaining wall apart and used it in the shelter construction and replaced it with new Jumbo J retaining landscaping blocks.]

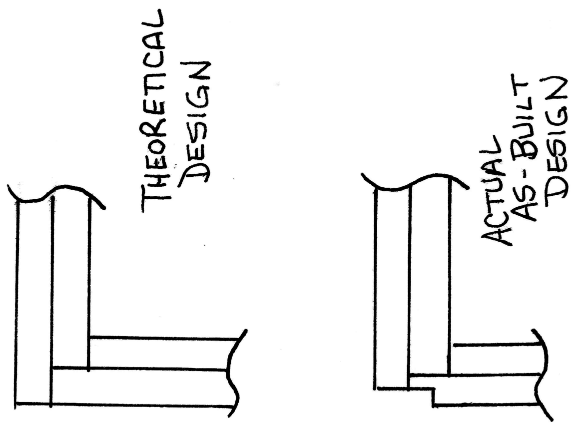
VII. AS-BUILT DRAWINGS

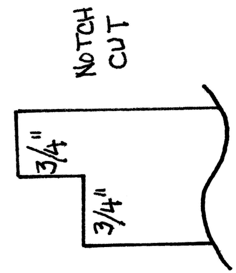


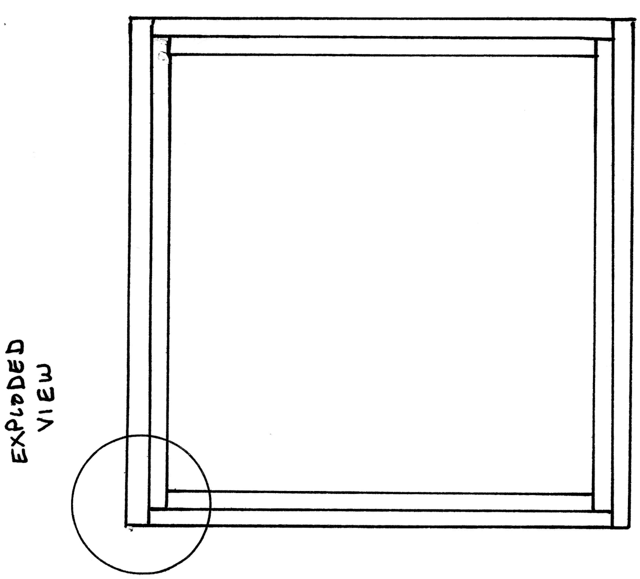
Drawing 1 Layout of 7 Square Support Ribs (Top Down View)



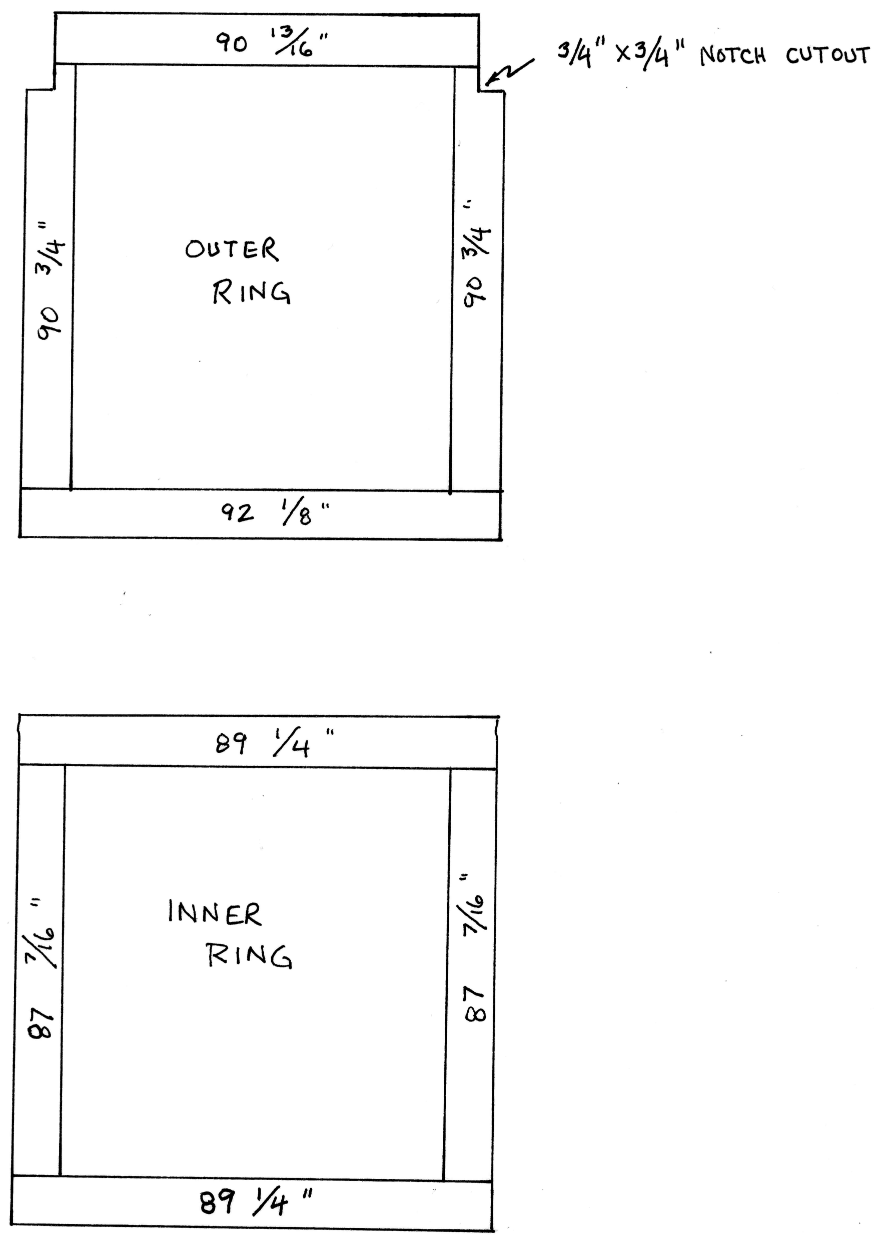
Drawing 2 Spacer Board



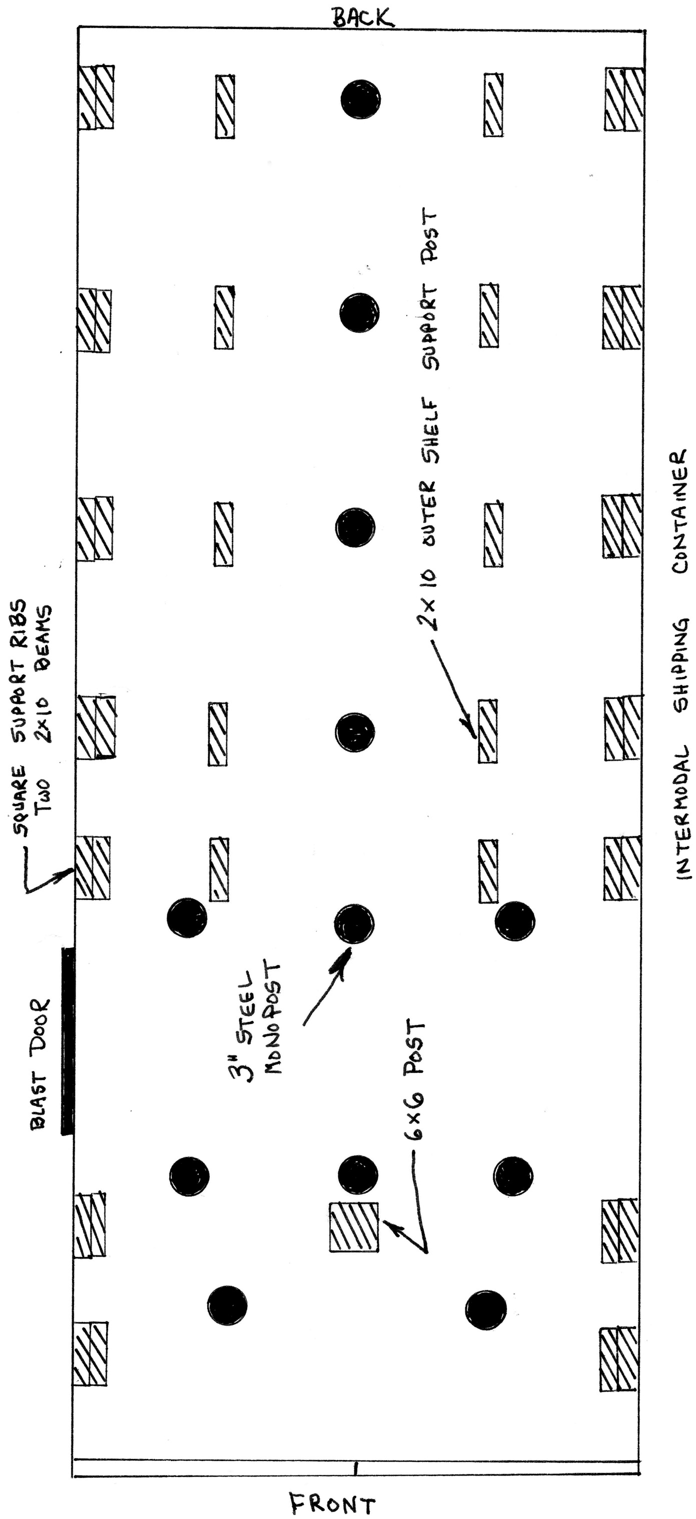




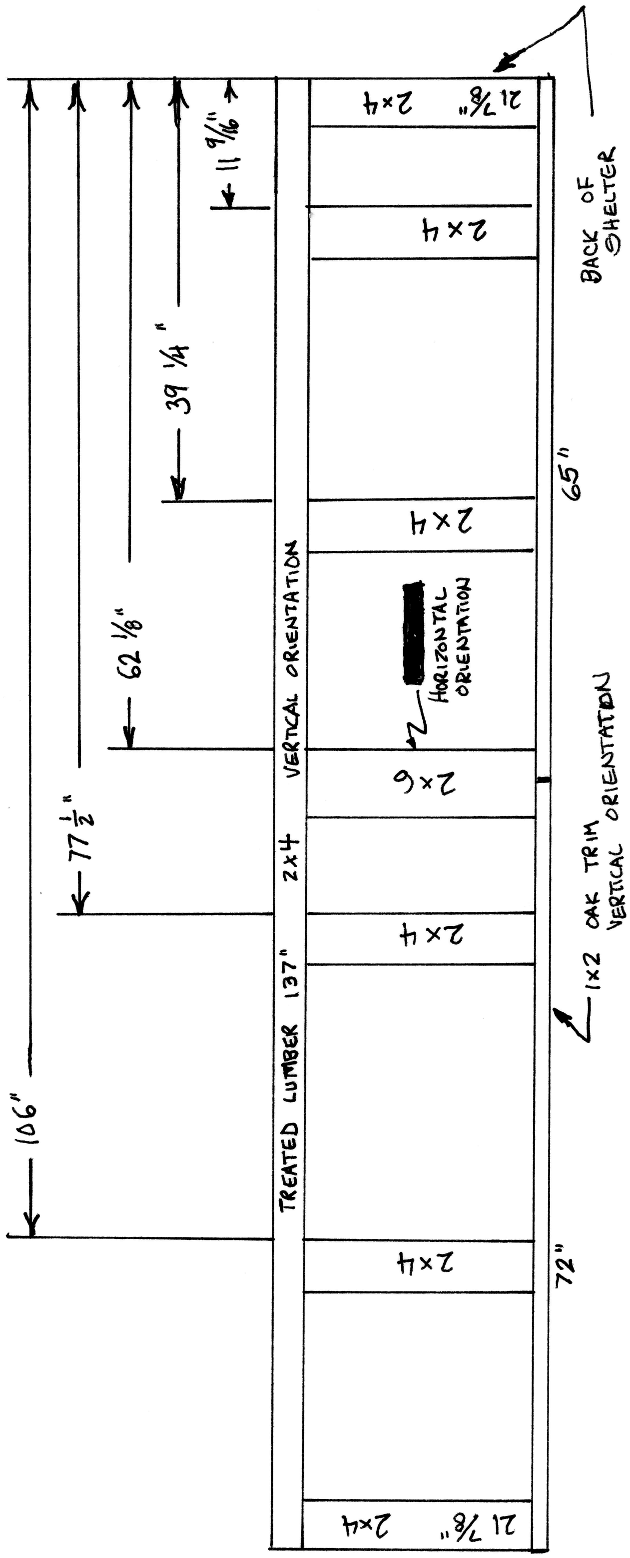
Drawing 3 Square Support Ribs (Details)



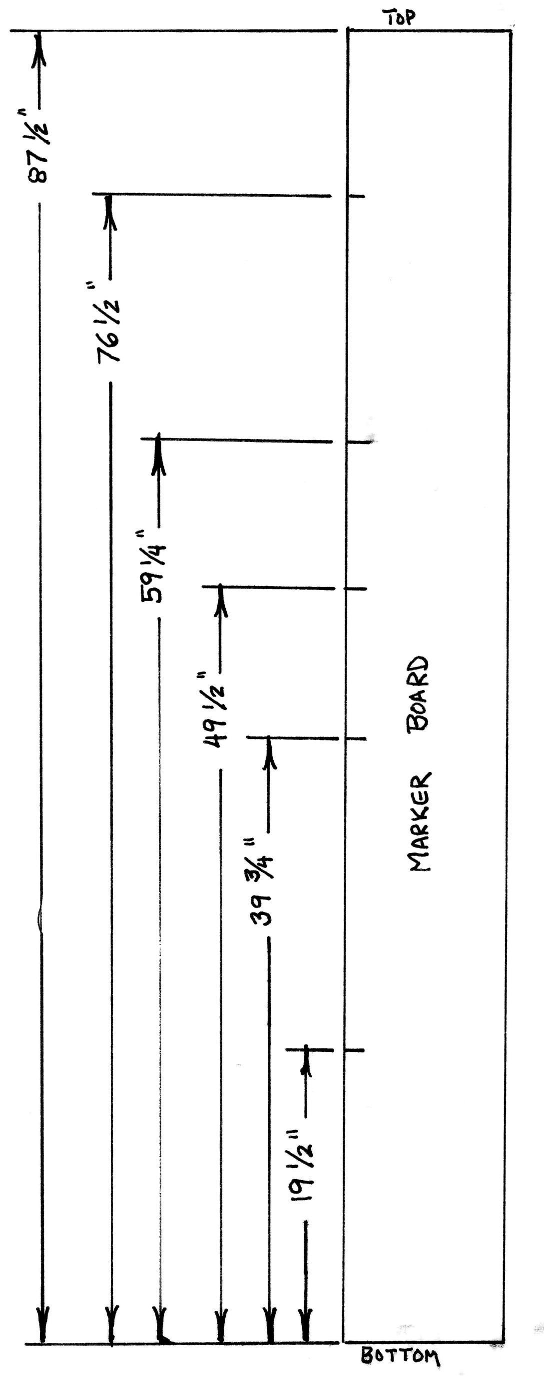
Drawing 4 Square Support Ribs (Inner and Outer Rings)



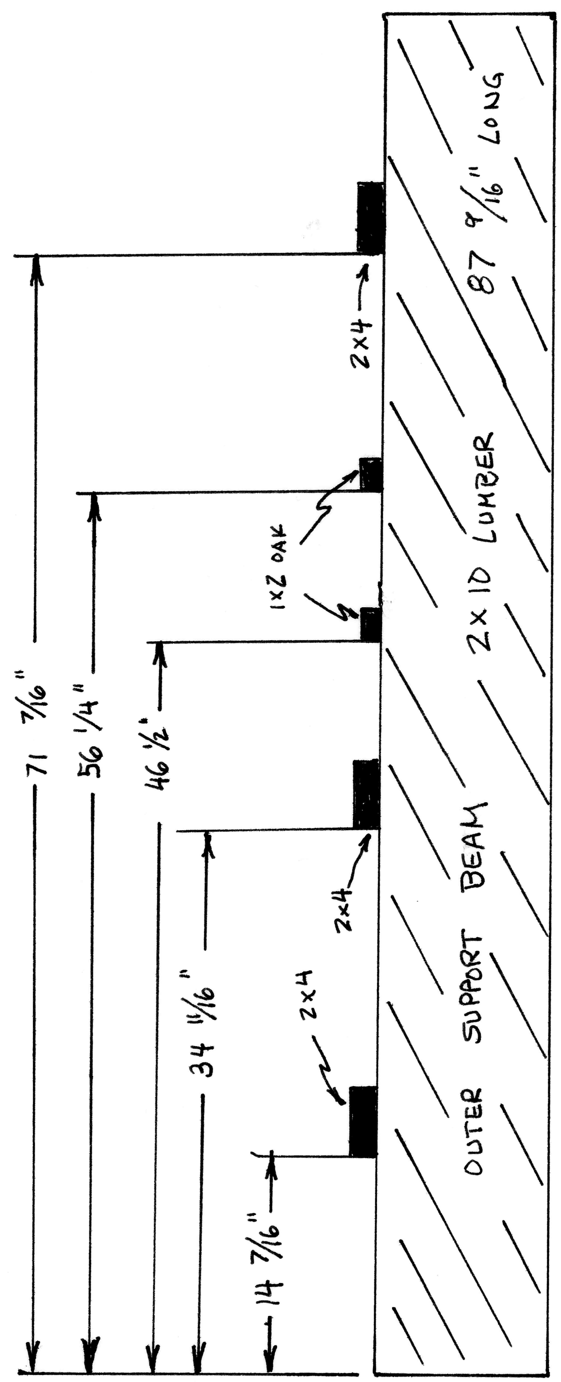
Drawing 5 Vertical Support Beams (Top Down View)



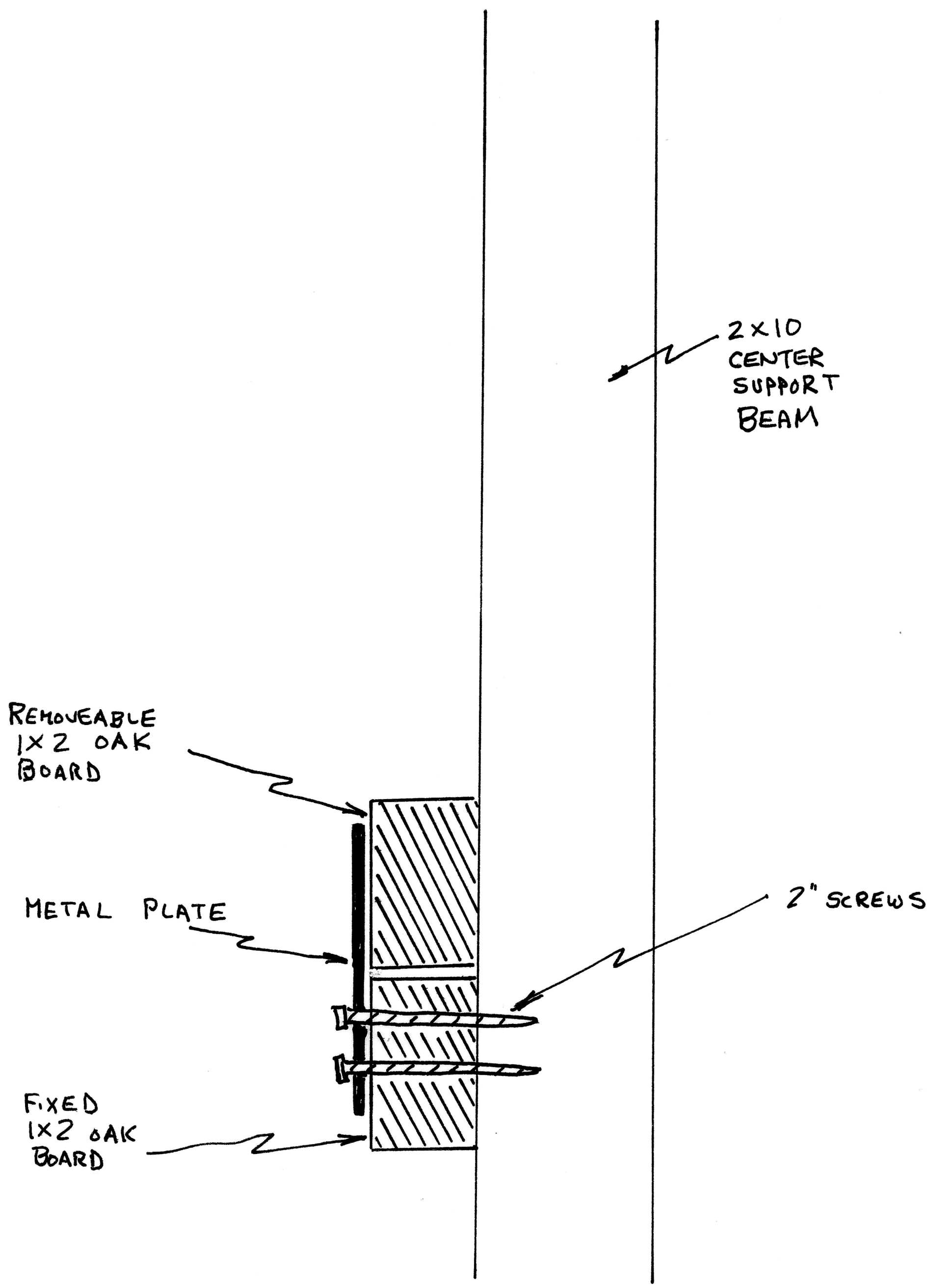
Drawing 6 Shelf Fabrication (Top Down View)



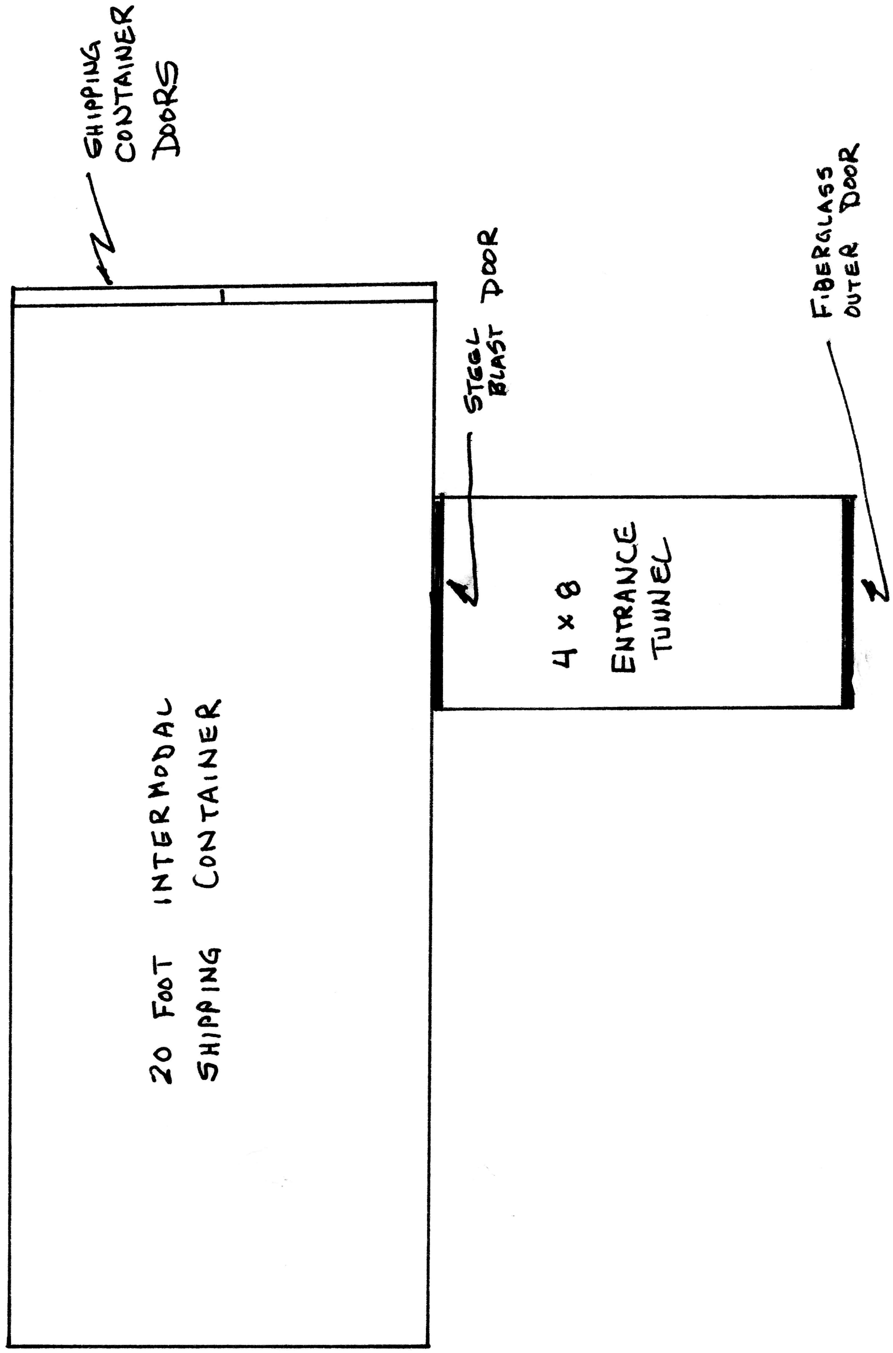
Drawing 7 Marker Board



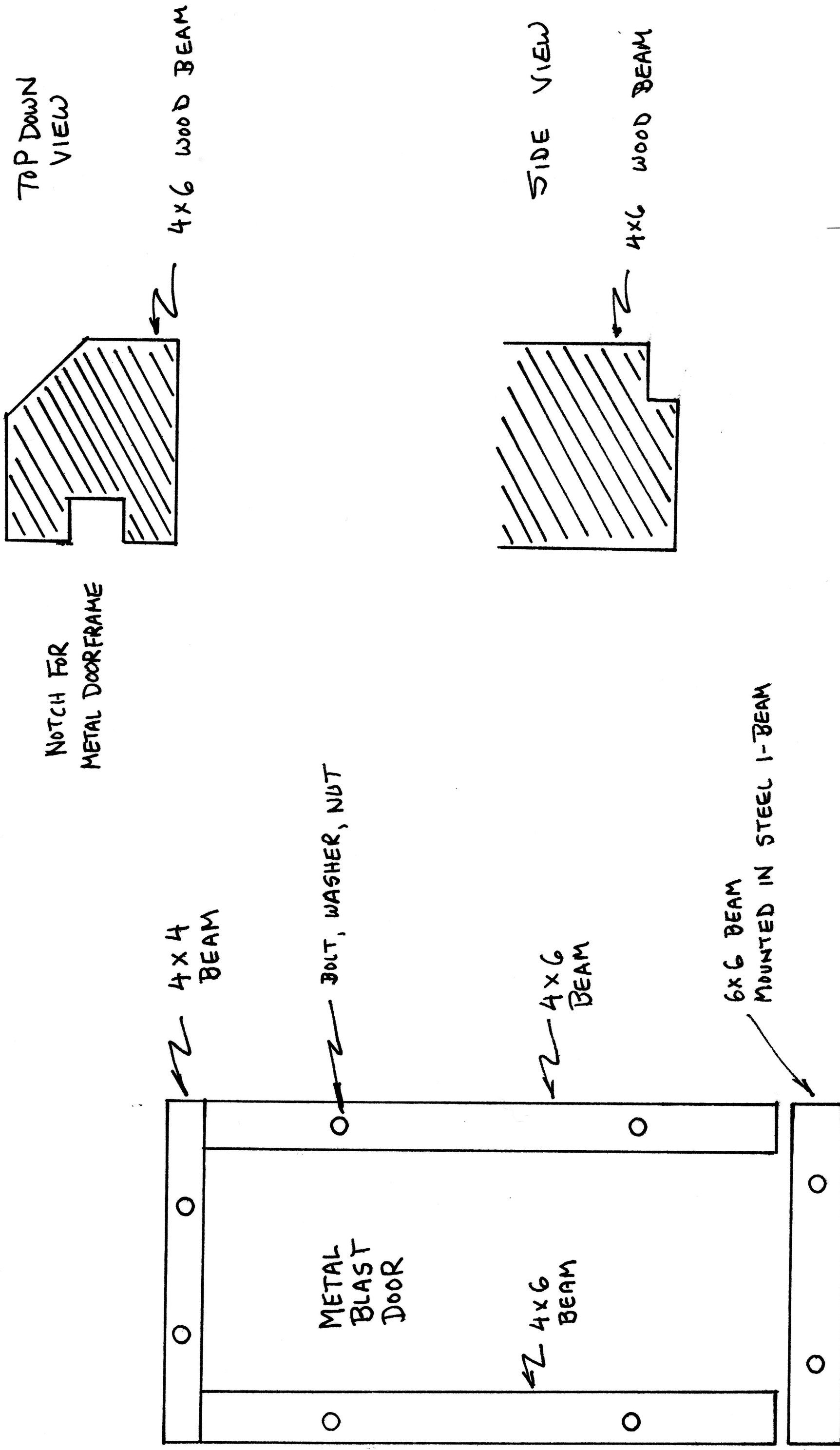
Drawing 8 Shelf Wooden Braces on Inner Support Beams



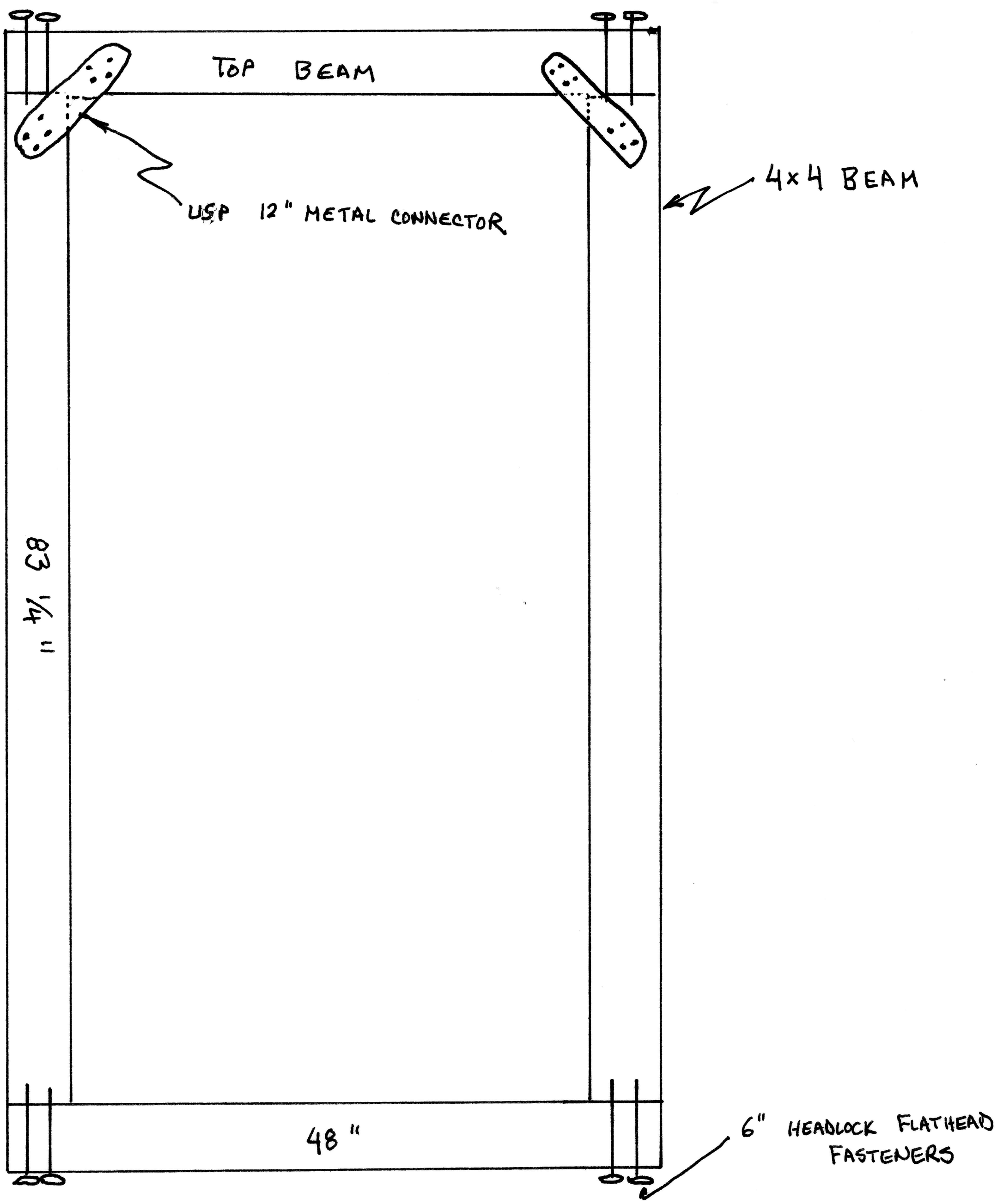
Drawing 9 Shelf Containment System



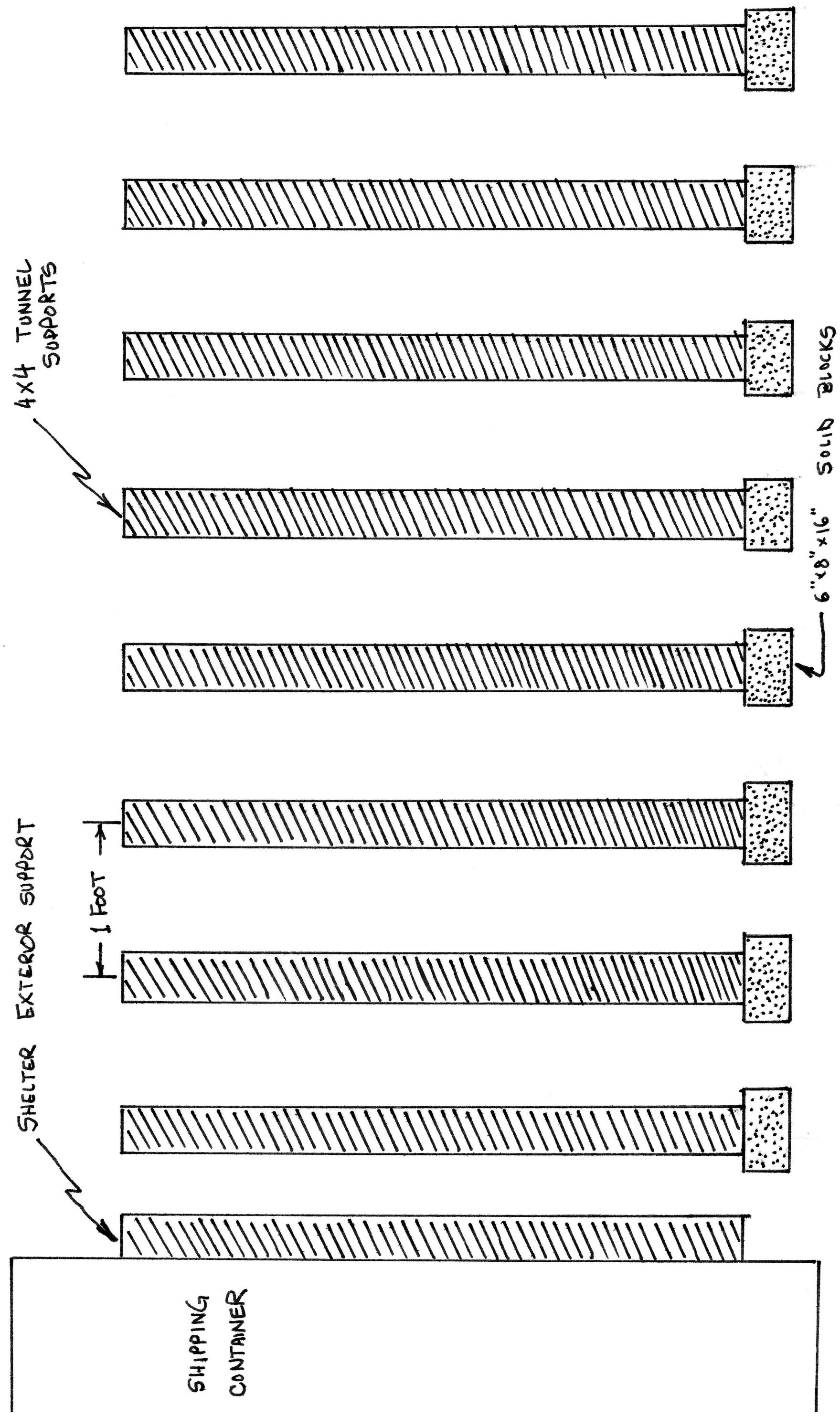
Drawing 10 Shelter Layout



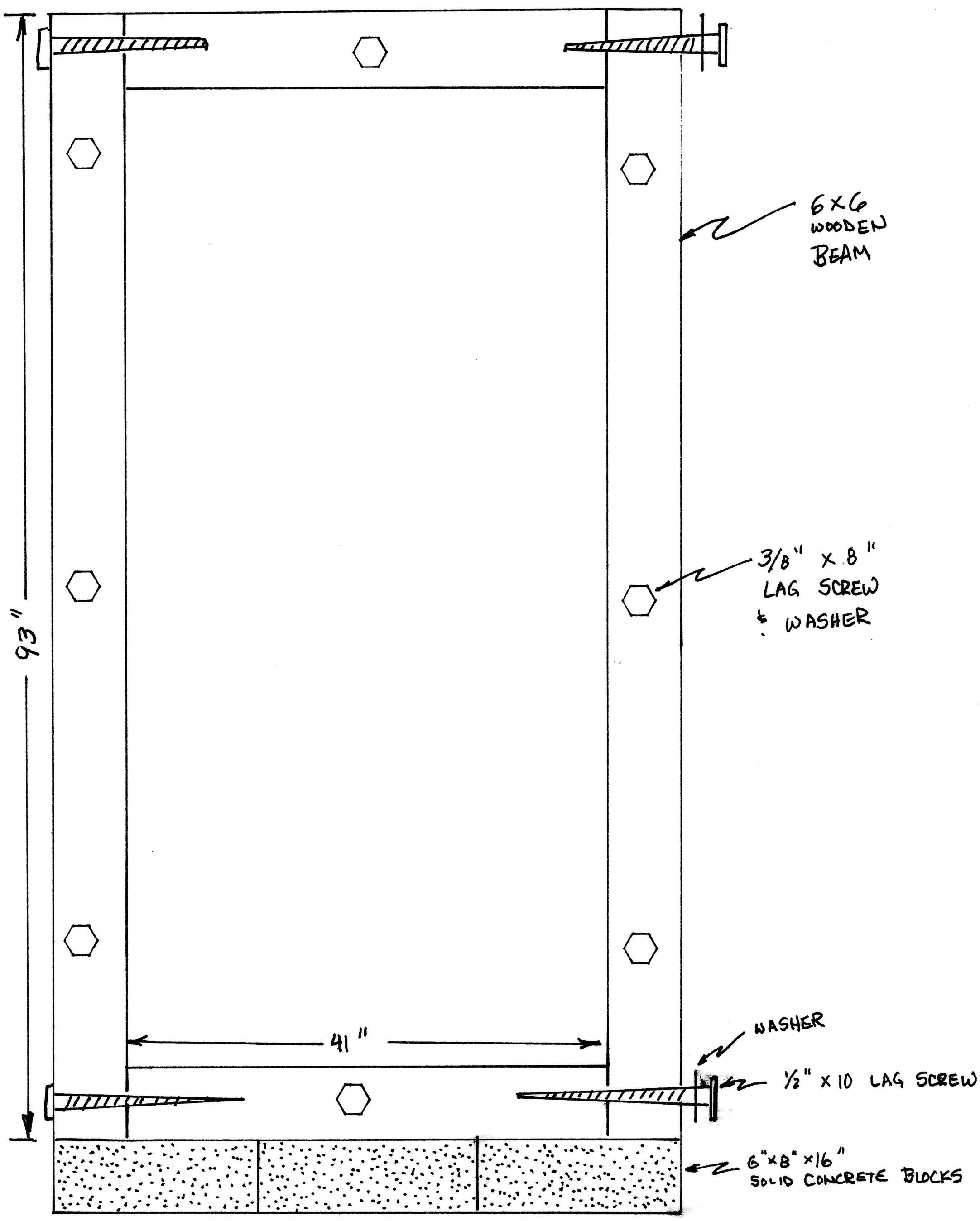
Drawing 11 Exterior Blast Doorframe Support



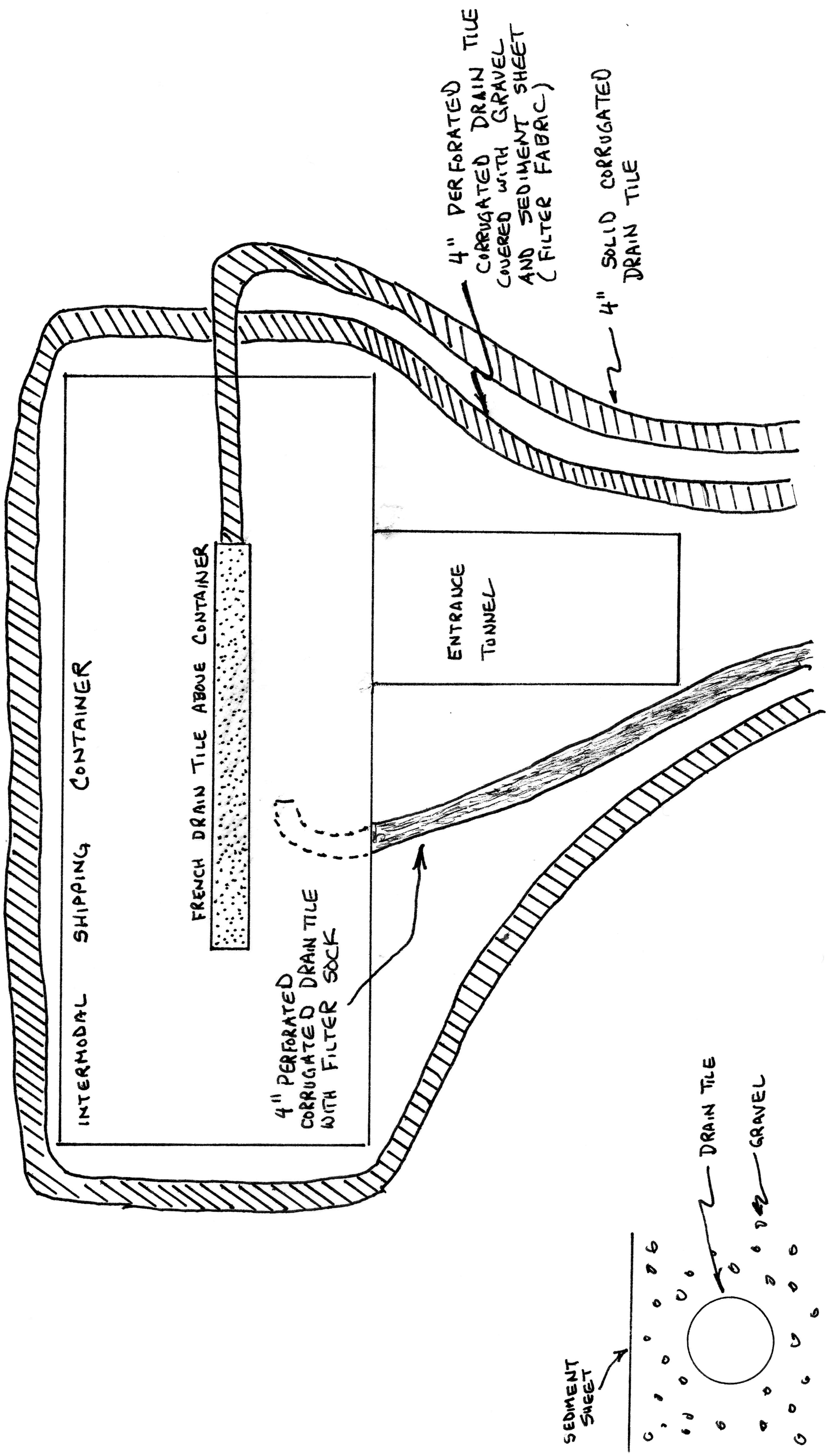
Drawing 12 Entrance Tunnel Support



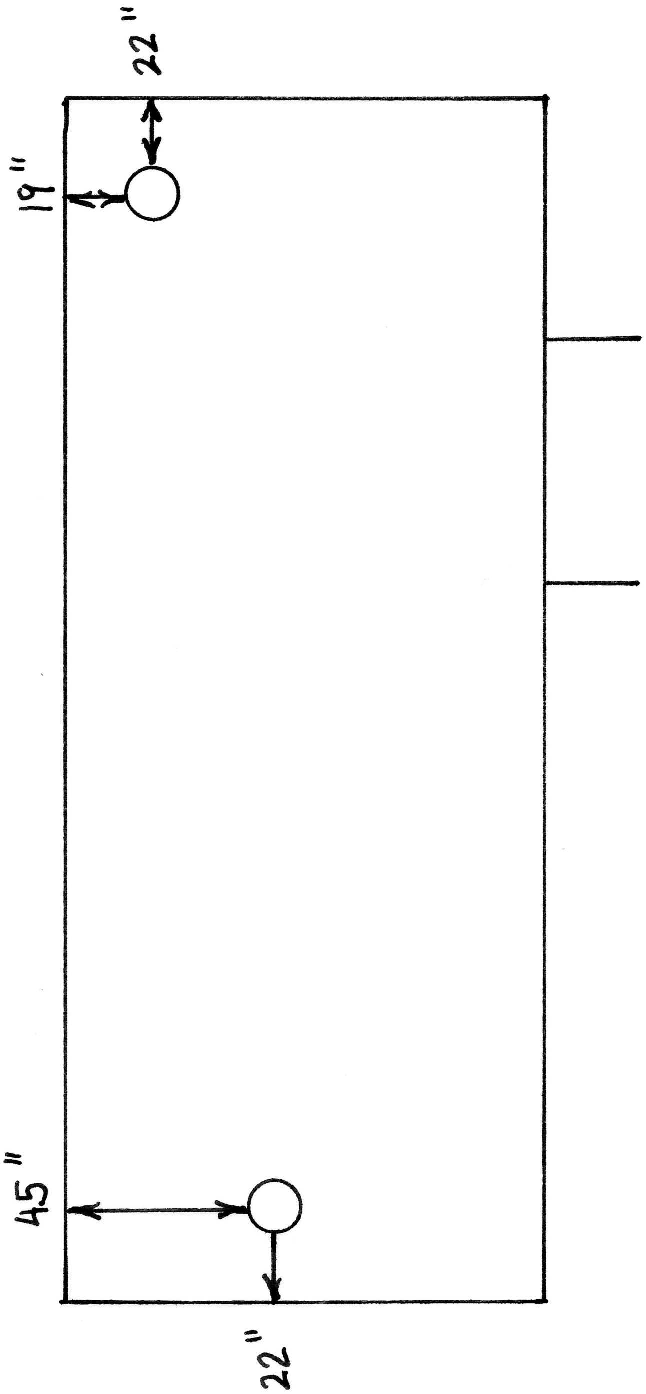
Drawing 13 Foundation of Shelter Tunnel Supports



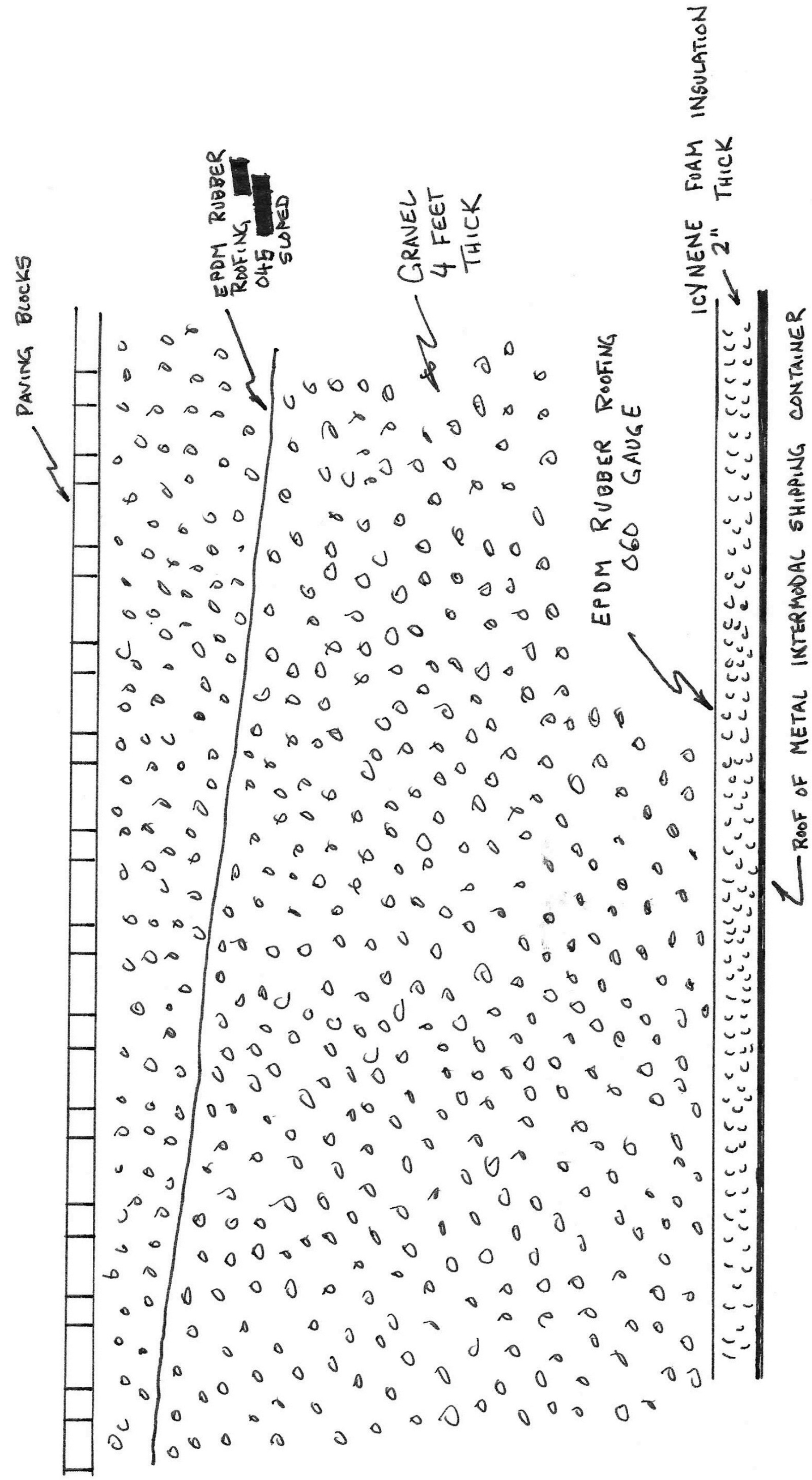
Drawing 14 Tunnel Entrance Doorframe



Drawing 15 Drain Tile Layout (Top Down View)



Drawing 16 Placement of Air Vents (Top Down View)



Drawing 17 Above Shelter Composition (Cross Section View)

Drawing 18 Solar System Electrical Configuration