Sustainable Townhouses

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Problem Statement

The majority of new communities built in the United States are designed with the minimal amount of money and time in mind. The underlying theme is: profits before people and the environment. This diminishes the sense of community for the people living in these neighborhoods. The building materials chosen for construction are extracted from distant environments and resources on-site are rarely used. This causes pollution from transportation sources and degrades ecosystems.

In the United States there is a lack of long-term environmental resource preparation or natural resource "planning". The average square foot of a typical house has grown resulting in a larger ecological footprint per American home. Roads and highways have gotten wider and speed limits are faster making many neighborhoods unsafe for children. The lack of welcoming sidewalks and bike lanes makes traveling within these neighborhoods hazardous for everyone and encourages the use of a car. This diminishes the members of a given community's ability to interact with one another on a daily basis. "Collaborative housing attempts to overcome the alienation of modern subdivisions in which no one knows their neighbors and there is no sense of community" (Cohousing 2003).

Another predicament of modern housing in the United States is inefficient energy use. According to Home Energy Saver website, the average house in Arcata uses about 31 kWh per day. An energy efficient home uses about 21 kWh per day, a savings of 10 kWh per day (Home Energy Saver). Most of the energy used goes into heating and cooling a house. The average home in 1949 was 983 square feet. By the year 2000, the average home has increased to 2000 square feet. (Home Trends 2000). Since the average house in America has a "900 square foot 3-car garage, which was the average size of an entire home in the 1950s" (PBS 2003), the amount of resources used has increased dramatically. Much of this increase is due to the design, planning, and development of the building for the demand of consumers.

According to the City of Arcata's General Plan, the vision of Arcata is "not an island separate from the world, but an oasis, offering a world of difference." Arcata strives to maintain a modest growth rate, suppress sprawl through urban growth boundaries, and create a sense of community through interconnected neighborhoods. Sustainability is more and more the way of life for the City of Arcata. Through environmental awareness of the local resource base, alternative wastewater treatment, and the recycling program, Arcata attempts to conserve resources so they may be enjoyed by the 'seventh generation.' (Arcata General Plan)

Within the City of Arcata, there is a 1.5-acre parcel of undeveloped land owned privately by Nick Frank and Nina Groth. Nick and Nina wish to create a sustainable community of "townhouses" within this parcel. They are determined to incorporate sustainable house design, meandering covered pathways, and communal garden areas. Within these three categories the concepts of reducing, reusing, and recycling resources are most important. Resources on-site, such as water, solar energy, and timber, will be utilized as much as possible. A unique sense of community may be created in this type of environment and landscape. This becomes the mission of a team of students who are diligent and determined to make this community extraordinary, and an example of sustainability.

According to "*The HOK Guidebook to Sustainable Design,* 'Sustainability represents the balance that accommodates human needs without diminishing the health and productivity of natural systems'" (Taecker 217). A sustainable community appeals to those who enjoy "living in harmony with [their] local environment and [do] not cause damage to distant environments or other communities now or in the future" (EPA 2003). Arcata, CA. is a world model for alternative living and lifestyles. There is an inherent need for more communities in this area that reflect this sustainable vision that the City maintains. Our challenge is to present alternatives for specific aspects of a sustainable community on an acre and a half of hillside, in Arcata.

Goals and Objectives

Our challenge is to present alternatives for specific aspects of a sustainable community on an acre and a half of hillside, in Arcata.

Goals

1. Provide sustainable options for housing design.
2. Provide sustainable options for paths throughout the property.
3. Provide design for the integration of gardens throughout the community.
4. Provide options for retaining walls using alternative materials.

Objectives

1.

- Incorporate solar heating into the design of the house using a sunspace and radiant slabs.
- Provide solar power and solar hot water heating to decrease conventional energy used in the house by 25%.
- Present different sustainable options for building materials.
- Create a layout where the kitchen and master bedroom (the most utilized rooms of a house) are the most desirable spaces in the house.
- Design housing with the smallest possible footprint.
- Include water catchment systems on all roofs.

2.

- Incorporate different sustainable options for building materials.

3.

- Design communal composting system for the garden.
- Incorporate native flora in garden and throughout property.
- Design vegetable garden, herb garden, and butterfly garden space large enough to provide the community with goods.

4.

- Incorporate different options for sustainable building materials for the terraces and retaining walls.
- Determine the height requirements for different types of retaining walls.
- Provide designs for certain types of terraces and retaining walls throughout the property.

Alternatives

Goal 1: Providing sustainable options for housing design.

Alternatives are specifically for heating, ventilation, and insulation of the home.

Alternative 1: Heating the home with "solar".

Brief description:

Solar panels used in conjunction with radiant slabs and a sunroom, greenhouse, or sunspace equivalent. The solar panels can be used alone, but for the most optimal functioning of heat yield, the recommendation is to use radiant slabs (thermal mass) and a sunspace or greenhouse as well. A radiant slab is thermal mass such as a large stone, which holds more heat longer. The sunspace (or greenhouse) is an area designated to collect the heat of the sun during the day for it to be dispersed to the rest of the house during the evenings. Liquid solar panels (or hot water heaters) would also be used for the purposes of heating water for domestic use.

Pros:

for solar panels, solar hot water heaters, and a sunspace

- efficient
- no energy bill (after the panels 'pay for themselves' through use over time)
- clean energy
- less energy used overall

for radiant slabs

- efficient (especially when used with solar panels)
- clean energy
- comfortable
- less energy used
- can be used for cooling if necessary

Cons:

for solar panels, solar hot water heaters, and sunspace

- large upfront investment
- large area of house used for the sunspace
- maintenance factors
- need for freeze protection (liquid solar panels)

for radiant slabs

- large upfront expense
- possible need for heat re-distribution in home

Recommendation:

All of the options above, if used together, are the best alternatives available for the purposes needed for the "sustainable townhouses".

Alternative 2: Heating the home with "wood stoves".

Brief description:

Woodstoves are an efficient way to heat the home when in comparison with natural gas, oil, propane, and other natural resources. Although, when woodstoves are used in conjunction with solar panels it becomes a more viable alternative.

Pros:

- large energy source
- will heat the house

Cons:

- greenhouse gases as byproducts
- needs a constant input of resources
- high maintenance (cleaning)

Alternative 3: Having heat circulation using "ventilation towers".

Brief description:

The design of the house becomes just as important as the materials that it consists of when speaking of heating the home. Therefore when one designs the home a proper ventilation system must accompany the creation. Ventilation towers with swinging vents used in conjunction with the proper designing of a house are a simple way to allow the air to properly move through the house heating and/or cooling appropriate rooms as it moves.

Pros:

- even surface temperatures
- no drafts
- constantly circulated air
- yields specific air temperature requested

Cons:

- possibly a non-aesthetically pleasing tower
- possible use of fans
- needs specific design to work properly

Alternative 4: Having ventilation using "alternative design".

Brief description:

The alternative design option would include a specific design (ideally a helical design) of the entire home, so that the air would properly circulate without the use of fans or other electrical appliances.

Pros:

- even surface temperatures
- constantly circulated air

Cons:

- best and easiest for a new home and a new design
- costly to redesign a home

Recommendation:

If the house is new, it is important that the design be focused on using natural processes to circulate air, heat the home, and ventilate. Therefore this option is most ideal if the house is being newly built.

Alternative 5: Insulation that uses "recycled earthy materials".

Brief description:

Within this category the products included are leaves and straw. These options are best used in dry climates.

Pros:

- renewable sources
- high insulation (warmth) value
- low technology
- local materials
- proper for load bearing or infill
- no associated health risks

Cons:

- best in dry climates (no good for Humboldt)
- susceptible to moisture and mold
- flammable
- possible insect infestation

Alternative 6: "bio-insulation"

Brief description:

Within this category there are materials such as coconut fibers, wool, cotton, hemp, and other natural cellulose fibers.

Pros:

- low costs
- renewable
- reduction of carbon emissions at the source
- excellent thermal insulator
- functional
- reduction of dependence on synthetic fibers
- ecological and biological biodegradability
- high insulation (warmth) values

Cons:

- long term applications are disputed
- flammable
- possible moisture content

Alternative 7: Installing a Water-catchment System

Brief Description:

A water catchment system is installed on the roofs of the houses as well as the roofs of the pathways. This entails installing gutters around the perimeter of each unit. Each house is connected by gutters to a main channel on the roof of the pathway and the water is funneled to a tank at a low point on the property. Within the tank, the water is filtered through sand and an assortment of gravel. The water can then be pumped via solar power up to the top of the hill into a large cistern. This water can be used for irrigation, moistening the compost pile and as toilet water. To calculate the size of the cistern, Humboldt rain data, instructions on calculating the amount of rainfall per square foot of roofing, and corresponding capacities of cisterns are included in Appendix 1. In the case the cistern is empty or full, diversion valves are installed at the outlet of the cistern in order to switch from cistern water and city water.

Pros:

- Fulfills objective of having a closed-loop
- Takes advantage of high rainfall in the area providing free, clean water
- Decreased water bill

Cons:

- Maintenance requires clearing roofs, gutters, main channel, and lower tank of debris from time to time
- Requires surveillance of the level of water in cistern in order to switch source of water from cistern to city.

Recommendation:

For the purposes of this project these options would be ideal. The disputed concerns must be taken into account for each individual aspect, but overall these materials would be most appropriate for the "sustainable townhouses".

Overall design of the houses would optimally have the windows south facing, the bedrooms on the top floors of the house, a small footprint overall giving the house many floors, and radiant slabs (or an optional woodstove) on the bottom floor so that the heat may rise and fill the house. The ventilation system, through proper design of the house, would channel the heat through each room and be responsible for an even surface temperature. Water catchment systems on the roofs will make use of rainwater throughout the property.

Alternatives for goal 1 and are broken into concrete and lumber categories.

When designing and calculating costs of construction, understanding the main components of building a home are essential to seeking out their "sustainable" alternative. According to Anderson, there are three main sections of the house that consume the bulk of materials and costs: Concrete and Masonry, Floor, Roof and Wall Framing members, and Sheathing. One thing to consider when shopping for lumber is to be aware of threatened old-growth and tropical species of trees and avoiding these during any part of construction from lumber to veneer. A good resource for lumber that has been harvested responsibly and sustainably is the Forest Stewardship Council (FSC). Lumber certified and stamped by the FSC can be sought out through various databases available on-line such as:

- http://www.smartwood.org
- http://www.certifiedwood.org/search-modules/SearchProducts.aspx
- http://www.fscus.org/

Concrete and Masonry

Concrete and Masonry are used interchangeably within the foundation and footings during the construction of a home. Concrete is most commonly used due to it being the cheaper of the two. Concrete is conventionally an aggregate of gravel, crushed stone, sand, portland cement, and water. Alternatives are available that reduce either the amount of concrete needed or replace the conventional ingredients in concrete.

Alternative 1: Autoclaved Aerated Concrete (AAC)

Brief description:

AAC is conventional concrete with aluminum powder added to create bubbles and air pockets during curing (see Figure 1). "Once the expansion is complete, the material is cut into blocks, slabs or other shapes and moved into an autoclave, an air tight chamber that is filled with pressurized steam…that gives the highly porous concrete its strength and durability." (Marinelli 1995) AAC is roughly one-fifth the density of conventional concrete and although 1-tenth the compression strength, it can be used as material for load bearing walls in low-rise buildings. For specifications and details see Appendix 1a.

Pros:

- Lightweight – easy to transport, handle and assemble
- High insulative value (R-value: 10-24) than conventional concrete (R-0.8/inch)
- Need less material
- Easily worked with carpenters tools
- Non-combustible and resists insects, rodents and rot
- Waste fly ash from coal power plants can constitute ~70% of aggregate
    - Questionable due to lack of data on potential environmental hazard

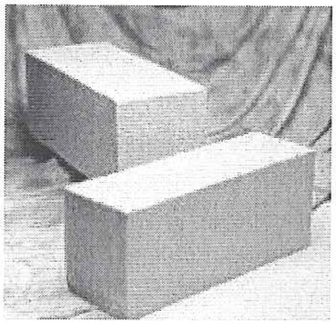

Figure 1: Autoclaved Aerated Concrete

Cons:

- 10 – 15 percent more costly than conventional concrete

Alternative 2: Faswall

Faswall consists of ~85% wood fiber and ~12% Portland cement made into blocks (see Figure 2). The blocks are then stacked, reinforced with steel and filled with conventional concrete. Non-load bearing walls can be filled with insulation instead of concrete and when used above ground can "achieve values as high as R-39." (Marinelli 1995) For specifications and details see Appendix 1h.

Pros:

- ¼ the weight of conventional concrete
- Can be worked with carpenter's tools
- Good soundproofing
- Noncombustible and insect resistant

Cons:

- Twice as expensive as concrete
- Difficult to recycle due to wood fibers

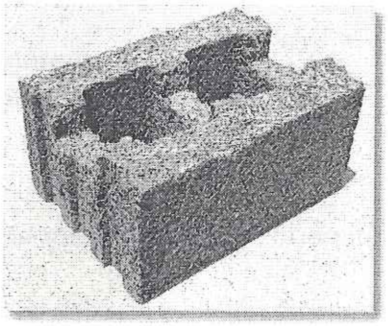

Figure 2: Faswall

Alternative 3: Insteel 3D

Insteel 3D is a construction panel with load-bearing capacity composed of CFC-free expanded polystyrene, sandwiched by welded steel wire mesh and shotcrete or soil cement is applied on site (see Figure 3). For specifications and details see Appendix 1b.

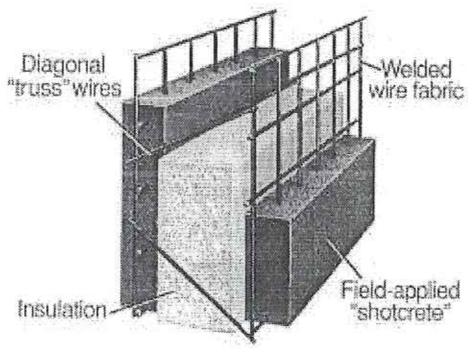

Figure 3: Insteel3D

Pros:

- Lightweight – easily transportable
- Overall cost savings = 30% over concrete
- Easy to cut – doesn't required specially skilled labor
- Scraps can be used similar to drywall scraps
- Wire can be made out of recycled steel
- Foam core can vary in width

Cons:

- Recycling difficult due to different components
- Lack of data on electromagnetic fields possibly created by wire mesh

Lumber

" Some Suggestions for a New Approach to Timber Use:

- Think about whether you really need to use new timber

  - Would a secondhand material suffice?

  - Use the lowest grade and smallest-sized pieces of timber appropriate for the job

  - The common practice of ordering full lengths and then cutting them up into small pieces makes no environmental sense at all.

- Do not throw out offcuts

  - Put them aside and use them on the next job.

  - Use standard and utility appearance-grade timber, rather than select-grade

  - Particularly if the surface is going to be painted or otherwise hidden.

- Do not ask for blemish-free timber (clear-grade) and do not insist on stringent colour-matching specifications

  - This leads to increased wastage and downgrading of timber to lower-value applications.

  - Consider using furniture made from knotty, or 'feature-grade' timber

  - It will not only be just as effective, more individual and visually interesting, it will also be cheaper!

- Use jointed timbers, whenever possible

  - Timber can be joined on its ends by finger-joints and metal nail-plates, or on its width, by glue-laminating.

- Be aware that composite beams are more often than not stronger than timber - They also use less timber in acquiring their strength than clear grade timber beams.

- Buy timber from (smaller) sawmillers who can demonstrate a commitment to optimising wood-recovery during milling

  - ie, by radial sawing, band-sawing, laser sawing, portable milling, etc."

(Choice of Materials 2003)

Framing lumber:

Framing lumber refers to all the wood used to make the floor framing, wall framing and roof framing or trusses. Typically the conventional material for wall framing is Douglas Fir, the hemlocks, southern pine, the spruces, pines and white fir. Typically the requirements for good framing lumber are good stiffness, good nail-holding ability, freedom from warp and ease of working. (Anderson 43)

Alternative 1: I-joists

I-joists is a wood composite with the cross-sectioned shaped like the letter "I" (see Figure 4). The top and the bottom of the I are made of solid wood or laminated veneer lumber and the vertical portion is made out of plywood or oriented strand board. For specifications and details see Appendix 1d.

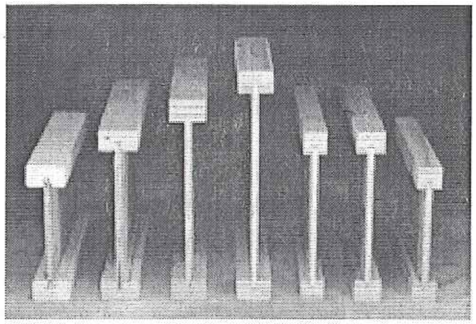

Figure 4: I-joists

Pros:

- Carries the same load – or more than solid lumber
- Uses 50% less wood fiber
- Uses less energy to produce compared to solid lumber

Cons:

- Aesthetics

Alternative 2: Laminated Veneer Lumber (LVL) or Glue-laminated Lumber (Glu-lams)

Small pieces of lumber are glued together to create large structural pieces of lumber (see Figure 5). The larger the pieces that are glued together the more weight the newly created lumber can withstand. For specifications and details see Appendix 1e.

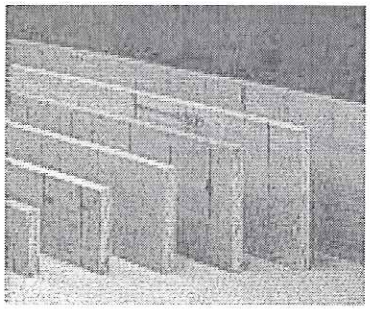

Figure 5: Laminated Veneer Lumber

Pros:

- Uses lumber from smaller trees (can even come from different trees) which helps preserve larger older trees
- Engineered to be more reliable and consistent (no warping) than solid lumber

Cons:

- Aesthetics

Alternative 3: Salvaged Woods/Naturally Felled Lumber

Salvaged woods encompass any woods previously used for construction. Wood recovered from old buildings is such an example. One to be aware of and avoid is old telephone/utility poles because they contain creosote and asbestos. Naturally felled lumber is what it says…the Redwood on the property is a prime example (see Figure 6). For properties of Recycled Lumber see Appendix 1c.

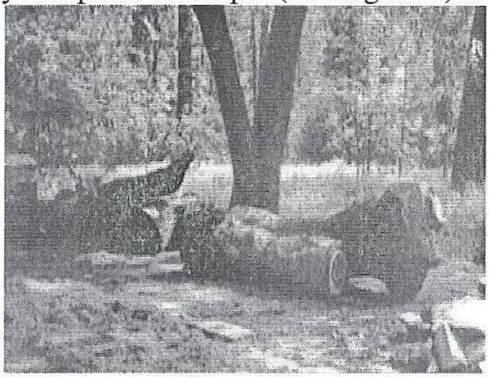

Figure 6: Naturally Felled Tree

Pros:

- Re-uses wood – doesn't kill any new trees

Cons:

- Depending on how well the wood was cared for it may need to be tested for structural integrity
- Nails, holes, rot etc…

Sheathing Lumber:

Avoid all product made of urea-formaldehyde resin – which is virtually all particleboard and wall paneling and other types of hardwood plywood found in the local lumberyard or home center, unless the label states specifically that they have been bonded with less-toxic resins. (Marinelli 1995)

Alternative 1: Straw Board

"Strawboard panels are made of solid core, compressed wheat or rice straw (see Figure 7). High pressure and temperatures forces the straw to release a natural resin, which binds the fibers together. The compressed panels are then covered with 100% recycled 69# or 85# paper liners and adhered to both sides with water based non-toxic glue."

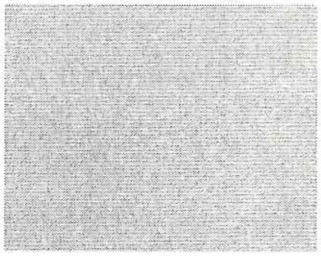

Figure 7: Straw Board

Pros:

- Formaldehyde-free
- Not made from trees
- Uses what would typically be a waste product

Cons:

- Not local

Alternative 2: Medium Density Fiberboard

MDF is comprised of recycled wood fibers (see Figure 8) that are bound with a synthetic resin. Most versions are made with a formaldehyde resin that when out gasses is toxic. This is important because MDF has a higher content of binding material than plywood and other sheathing products. This product is not recommended for exterior panels such as roofing and exterior sheathing. For specifications and details see Appendix 1f.

Pros:

- Formaldehyde-free
- Made from recycled wood
- Easy to work with (no grain)
- Accepts finished well

Cons:

- Aesthetics

Figure 8: Wood Fibers

Alternative 3: Bio-board

Bio-boards are made of any agricultural waste fibers, but for this alternative I will suggest hemp (see Figure 9). Hemp can be quickly grown, and due its long fibers offers strength and durability. For more information on industrial hemp see Appendix 1g.

Pros:

- Formaldehyde-free
- Not made from trees
- Uses what would typically be waste products

Cons:

- Not as readily available in the US increasing costs (shipping)
- Not local

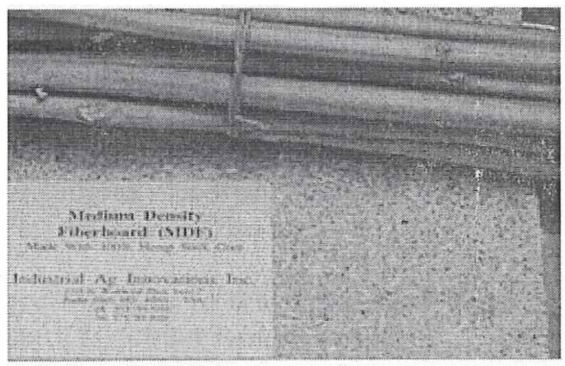

Figure 9: Hemp Board

For more information on Medium Density Fiberboard (MDF) Made With 100% Hemp Stalk Core Industrial Ag Innovations Inc., 2725 N. Westwood Blvd, Suite 7, Poplar Bluff, MO 63901 USA
ph 573-785-3355
fax 573-785-3059

Goal 2: Provide sustainable options for paths throughout the property.

Alternative 1: Recycled-glass pavers

Brief description:

Glass pavers are made by a Seattle craftsman and inventor who spent years trying to develop ways of using waste glass. His discoveries led to the creation of the jewel-like recycled glass tiles, which are perfect for kitchen and bathroom tiling projects. But he recognized that to make a significant dent in the post-consumer waste glass piling up in landfills, he needed lower-cost products suitable for large-scale paving projects. The new recycled-glass pavers are the first result of that continuing research.
(Environmental Home Center 2002)

Pros:

- Made by a family business in Seattle.

- Made entirely from waste glass.
- Manufacturing process generates less than half the greenhouse gases needed to make concrete pavers. Cement production is one of the most energy-intensive of all manufacturing processes because it begins by basically melting rock. In huge kilns, manufacturers heat limestone and other ingredients to 2,700 degrees Fahrenheit. Many kilns burn coal, which releases nitrous oxides, sulfur oxides, particulates and other things that we don't want in our air. Probably most worrisome, it also releases large amounts of carbon dioxide, the primary greenhouse gas contributing to global climate change. The chemical reaction that takes place with the limestone also releases large amounts of carbon dioxide. Together, the coal burning and the chemical reaction typically add up to about 631 pounds of carbon dioxide being dumped into the atmosphere for each cubic yard of concrete. A ton of cement produces more than a ton of carbon dioxide. Cement accounts for 7 to 8 percent of all carbon dioxide emissions worldwide-a stunning effect of a single industry. Recycled-glass pavers, on the other hand, put to good use some of the energy that originally went into making the glass. To make them, broken glass pieces are heated just to the point where the edges soften and are able to fuse together. Each paver generates less than half the greenhouse gases needed to make a concrete paver of the same size and strength. For each square foot, you save the release of five pounds of carbon dioxide.
- Recycled-glass pavers, steppingstones and edging pieces are thinner, lighter, denser and stronger than brick or concrete, yet they require far less energy to make.
- The 1-inch-thick pavers were tested at the University of Washington and found to be as strong as 1½-inch-thick bricks and 2½-inch-thick concrete pavers.
- Non electricity conducting

Cons:

- Ease of replace ability unclear at this point.
- In time, the walking surface of the sand finish style may erode to the point of no longer having the rough texture. This may lead to a non-slip surface.
- Expensive
  - 8-inch x 8-inch tile $ 7.29
  - 12-inch x 12-inch tile $ 14.59
  - 14-inch round stepping stone(Plain surface or embossed design) $ 21.89
  - 4-inch x 16-inch tile or edging $ 7.29

Alternative 2: Plastic lumber

Brief description: Plastic lumber is recycled high-density polyethylene (HDPE) and sometimes other additives, such as fiberglass and plant fiber, extruded into common lumber profiles. (Resco 2003)

Pros:

- Manufactured from 100% recycled HDPE plastic.
- Longer life than wood.
- No splinters
- Highly resistant to decay.

- Immune to termites and other insects.
- Highly abrasion resistant.
- No additional tasks needed…no sealer, no paint.
- Easy to clean with any soap and water…graffiti resistant.
- Relatively inexpensive; generally about $1.00 per board foot.

Cons:

- Possibly slippery when wet.

Alternative 3: Recycled class 2 aggregate base materials.

Brief description: This is a mixture of construction grade three-quarter-inch pieces of asphalt, concrete, and rock. After packing down, the aggregate material may be used as a walkway. It is sold for $8.50 per ton with a minimum purchase price of $30. A delivery truck is available upon request for $65 per hour. There is no glass in the material. It is not relatively slippery when wet. Sold by Kernen Construction (707) 496-1081 in Blue Lake, CA. Ask for Pinky (this is his real name!).

Pros:

- Recycled asphalt and concrete.
- Longer life than all materials considered.
- Decay proof
- Highly abrasion resistant.
- No additional task needed…no sealer, no paint, etc.
- Extremely inexpensive.
- Easy to replace.

Cons:

- May be considered aesthetically less pleasing than other materials.
- May become unpacked, which may cause problems for carts, gurneys and other small-wheeled objects.

Recommendation:

Class 2 aggregate base material is recommended over all other alternatives for pathway throughout the property. It is least expensive, will likely last the longest, and re-uses concrete and asphalt.

Goal 3: Provide design for the integration of gardens throughout the community.

Alternative 1: Terraced

Brief Description:

Located above retaining walls along trails throughout the property, especially in the southeast corner (west-facing slopes). Terraces may contain space for vegetables, fruit trees, flowers and shrubs, and herbs. Plants grown in the gardens should be native whenever possible, and sun and shade tolerances taken into account depending on the location of each terrace (see Appendix). Paths above and below terraced gardens should be permeable to allow for gravity flow of rain and irrigation water. Irrigation water should be obtained from the water catchment system located on the property, and will mostly be utilized in the drier summer months. Composting bins will be located in a central area (near townhouses) and compost distributed to each terraced garden as needed.

Pros:

- Garden space integrated throughout property.
- Easy access along paths.
- Includes food, butterfly, and herbal areas.
- Includes communal composting area.
- Incorporates native flora into property.
- Efficient use of space.

Cons:

- No central location.
- Water must be transported to each upper terrace during summer.
- Compost must be transported to each terrace.

Alternative 2: Flat Area

Brief Description:

Located in area of more gradual slope, especially the northwest corner of the property. This will be a large central garden, with spaces for vegetables, flowers and shrubs, fruit trees, and herbs throughout the garden. Plants should be native whenever possible, and sun and shade tolerances taken into account depending on the location of each plant (see Appendix). Irrigation water should be obtained from the water catchment system located on the property, and will mostly be utilized in the drier summer months. Composting bins will be located adjacent to the garden and compost distributed throughout the garden as needed.

Pros:

- Central location.
- Easy access from townhouses.
- Includes food, butterfly, and herbal areas.
- Includes communal composting area.
- Incorporates native flora into property.
- Irrigation transported to one area.

Cons:

- Located on prime townhouse building site.

Alternative 3: Wetland

Brief Description:

Located in the wetland area of the property (the southwest quarter). This garden will be primarily along the edge of the wetland area to provide easier access to community members. Plants should be native whenever possible, and sun, shade, and moisture tolerances taken into account depending on the location of each plant (see Appendix). Irrigation and composting will most likely not be needed for the wetland garden.

Pros:

- Central location.
- No irrigation needed.

- Incorporates native flora into property.

Cons:

- No communal composting system.
- Less diversity of useful plants.
- Less accessible

Recommendation:

Terraced gardens (Alternative 1) are the recommended alternative for this project. While a central garden located in a flat area (Alternative 2) would be most desirable, the owner of the property values that area for townhouses much more highly than for garden space. Terraced gardens meet all the objectives outlined for this project, while also allowing easy access to garden produce along the paths. They make efficient use of the space above retaining walls, which may otherwise be overlooked as useless. Fruit trees and shrubs planted below retaining walls may also grow to hide the walls themselves, a desirable condition according the owner of the property. They also provide a greater diversity of useful plant life compared to that of a wetland garden.

Figure 1 shows a rough delineation of areas on the property that are mostly sunny, shady, or moist. These are color coded so that they may be cross-referenced with the plants listed in the Appendix.

Infrastructure for garden areas should be set up during construction of paths and retaining walls. Garden space should be leveled and set aside above retaining walls wherever feasible, and planted according to sun and moisture tolerances. Separate areas may be delineated for butterfly, herb, and vegetable garden plants, or all of these may be incorporated into the same spaces. (See Appendix 3a) An approximately 15 square foot space for composting bins should be set aside during construction of townhouses (see Appendix 3b).

Goal 4: Provide options for retaining walls and terraces using alternative materials.

Alternative 1: Do not build a retaining wall.

Brief Description:

This alternative would not require the use of a retaining wall. Other sources such as vegetation would have to be used to keep disturbed soil in place within the property.

Pros:

- The site would not have the visual impact of a retaining wall.
- No extra resources would have to go into covering up or raising the aesthetic quality of a retaining wall.

Cons:

- Humboldt County has many intersecting fault lines running through it causing the disturbed soils to become unstable.
- During the construction of the community much of the soil will be displaced, compacted, or moved.
- The soil will be highly unstable during this time so any other disturbances such as heavy rain or geologic movement could cause damage.
- Without a retaining wall to keep the soil from moving landslides is a possibility.

Alternative 2: Build an 8-foot retaining wall for the parking area out of concrete.

Brief Description:

This wall will be necessary if a flat parking area is desired. The retaining wall will hold the soil in place under the parking area. Due to the height of the wall and the geologic stability of the area there are not many options for the types of materials used to build the wall. Concrete blocks and steel braces can be purchased and stacked using a variety of methods to create the wall.

Pros:

- The wall can be built to any height desired.
- The wall can be engineered to withstand plate tectonic movement.
- With the use of irrigation methods the wall can withstand pressure from water.

Cons:

- The materials used to construct a concrete retaining wall are not the best resource for meeting the goal to use sustainable materials.
- Concrete walls are not very visually pleasing to people and could have an effect on the marketability of the community.

Alternative a: Due to the unappealing aesthetic quality of a large concrete wall in a sustainable community a mural could be painted on the wall. This would give the community an artistic outlet while beautifying the huge wall.

Alternative b: Incorporate the interpretive sign within or on the wall. If the retaining wall is used then the space should be utilized. Since the wall would be 8 feet high and possibly 20 feet wide (the width depends on the size of the parking lot) and it will be at the beginning of the community, then there is no better place to put an interpretive sign then on the retaining wall.

Alternative 3: Build 6-8 Foot retaining walls using Gabions.

Brief Description:

Stack 6 x 3 x 3-foot Gabions filled with 4 to 12 inch rocks on top of each other 6 to 8 feet tall. The retaining wall would be used to hold soil to create a level parking area.

Pros:

- Gabions use "gravity and their own mass to resist lateral earth pressure" (Lane-Enterprise 2000).
- Gabions come in many different styles and sizes to allow for flexibility of uses throughout the site.
- One type of gabion is made from wielded wire making it sturdy and easy to assemble (Hilfiker Retaining Walls 2001).
- According to lane-enterprises this cuts the labor costs by 50% (Lane-Enterprise 2000).
- Don't have to worry about water because the water can move through the Gabions.
- Gabions will eventually blend in with the natural surroundings because plants and dirt will cover them.
- Gabions are considered permanent structures. For more information see the e-mail from Suzanne C. Blackburn in the Appendix 4b.

- "PVC coating is used in places where the soil pH is less than 5.5 (acidic) or more than 11.0(basic) to promote the longevity of the Gabion" (TerraAqua 2001).
- Companies exist locally in Humboldt County that produces Gabions and constructs retaining walls. See Appendix 4c for contact information for Hilfiker Retaining Walls.
- Since Gabions use gravity to stabilized them and are flexible to ground movement they will withstand small earthquakes without much damage or repair needed.

Cons:

- The materials are more expensive then concrete.
- It takes a lot of energy to produce the wire and the PVC for the Gabions.

Recommendation:

I recommend building a retaining wall and using Gabions. Gabions are utilized by many federal and state agencies for erosion projects, which mean they have been tested and used often making them a reliable material for retaining structures. Since Gabions use their own mass to hold themselves in place they will work well for creating retaining structures in an area with high tectonic movement such as Humboldt County. Gabions are much more aesthetically pleasing than concrete because they can blend in with the surrounding vegetation over time. They also come in many different styles that can be used for the different purposes of the retaining wall. For example, ArtWeld Gabions can be used in places where the wall will be highly visible. See appendix for pictures of Artweld Gabions. Gabions are cheaper in labor cost than concrete and are considered to be permanent structures. Gabions can also be used to hold up a parking structure by using a Gabion Faced Concrete wall (see Figure 10).

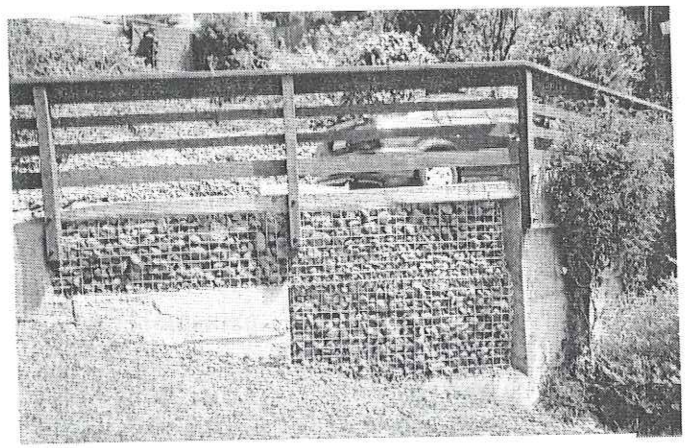

Figure 10: Concrete Faced Gabion Retaining and Parking Structure.

Alternative 4: Use gabions to build 2.5-foot walls for terraces.

Brief Description:

Stack Gabions that are filled with 4 to 12 inch rocks on top of each other 2.5 feet tall to create a terraced hillside on the property.

Pros:

- Gabions use "gravity and their own mass to resist lateral earth pressure" (Lane-Enterprise 2000).
- Gabions come in many different styles and sizes to allow for flexibility of uses throughout the site.
- One type of gabion is made from wielded wire making it sturdy and easy to assemble (Hilfiker Retaining Walls 2001).
- According to lane-enterprises this cuts the labor costs by 50% (Lane-Enterprise 2000).

- Don't have to worry about water because the water can move through the Gabions.
- Gabions will eventually blend in with the natural surroundings because plants and dirt will cover them.
- Gabions are considered permanent structures. For more information see the E-mail from Suzanne C. Blackburn in the Appendix 4b.
- "PVC coating is used in places where the soil pH is less than 5.5 (acidic) or more than 11.0(basic) to promote the longevity of the Gabion" (TerraAqua 2001).
- Companies exist locally in Humboldt County that produces Gabions and constructs retaining walls. See Appendix 4c for Hilfiker Retaining Walls information.
- Since Gabions use gravity to stabilized them and are flexible to ground movement they will withstand small earthquakes without much damage or repair needed.

Cons:

- The materials are more expensive then concrete.
- It takes a lot of energy to produce the wire and the PVC for the Gabions.

Alternative 5: Use pieces of old sidewalks to construct 2.5-foot terrace walls.

Brief Description:

This is a great way to re-use the concrete from dug up sidewalks. The pieces need to be of a uniform size –4 by 4 feet depending on the thickness of the walls- and are stacked on top of each other. A drainage system will be needed for this kind of wall so the water does not break the wall and can be caught for irrigation within the property. Figure 11 shows a de-paved wall keeping soil from running into a creek on I Street in Arcata.

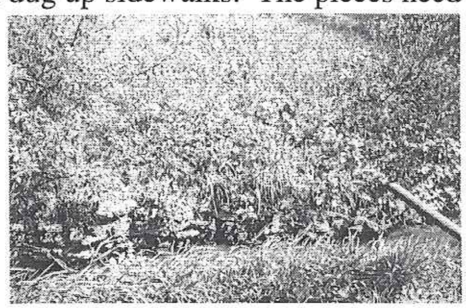

Figure 11: De-paved Sidewalk Retaining Wall.

Pros:

- This method of constructing terrace walls reuses materials that have already been created.
- A community of people exists in Arcata - Jan Lundberg at www.culturechange.org - that do De-paving as a living.
- The pieces of sidewalk can blend in with surrounding vegetation over time.

Cons:

- The pieces of jagged sidewalk may be dangerous for children to fall on.
- May have to ship the pieces of sidewalk to Arcata from all over the state.

Alternative 6: Use locally used tires to build 2.5 feet walls for the terraces on the south side of the property.

Brief Description:

Technology has been created for building terraces using tires on slopes. Since tires do not biodegrade easily other uses must be created for them. Using old tires to create terraced walls for a garden space on this property is an effective way to reuse the rubber.

Pros:

- The tires can be purchased locally from wrecking lots.
- This method of constructing terraces is a great way to reuse old tires that would otherwise sit for centuries. For more information on using tires for building materials refer to Appendix 4a.
- Some type of covering can be put over them to make them more aesthetically pleasing. Adobe is an example of a covering but it does not work well in the rainy environment of Humboldt County.
- These materials are found locally in Humboldt County and are relatively cheap to purchase.
- The wall does not have to be in perfect 90-degree angles.
- The wall can be built in a variety of ways.
  - For example the tires can be staggered on top of each other so that plants may be planted between the tires. No covering would be needed because plants could grow over the tires and cover the walls. This would take at least 5 years before the wall would become covered. For this approach steel rods would be needed so the tires could be fill with soil or aggregate material would be used for filling most of the tires except the ones plants will be planted in. In that case the steel would be use to reinforce tires with no aggregate material.
  - Tires can be stacked on top of one another and filled with aggregate material. Some sort of covering would help the cover the color of the tires if this style were used.
- If earthquakes break the wall it will be cheap to fix.
- The roundness of the tires is more appealing then boxed cages or harsh edges of De-paved concrete.
- An irrigation system can be used to gather water running through the hill. That water can be used to water the garden.

Cons:

- Aggregate material is needed to hold the tires in place. The material recommended in Goal 2 Alternative 3 would work well for the tire terraces.
- Finding enough of the same size tires might be hard.
- Some sort of steel I may be needed to help anchor the tires into the hillside.
- Steel isn't cheap and uses a lot of energy to create.
- Some sort of irrigation system is needed to allow the water to flow through the tire terraces.

Recommendation:

Using the tires to create a terraced hillside would be the best for meeting the objectives of this goal. Tires have been used all over the world to build walls, such as in Australia where they help the country meet their reduction of waste disposal (Australian 2002). It reuses local materials, is aesthetically appealing once finished, inexpensive, and a good building material.

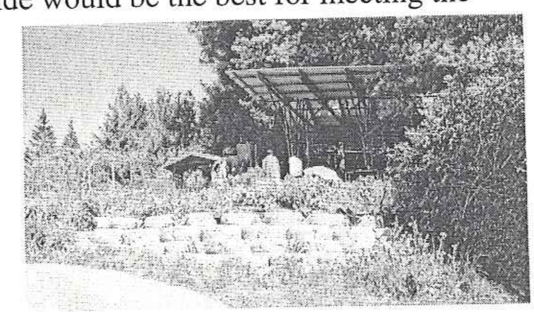

Figure 12: Tire Terrace at CCAT

Since aggregate material that was recommended for the paths is so cheap it would be easy to use it for the tire terraces as well. Using gravity and the slope of the hill an irrigation system could be designed to allow water to pass through the wall and into a storage tank were it can be used to water the garden. One 100-gallon tank on each level of the terrace would ensure there was enough water for each terraced level. This would also prevent the need to pump water up hill. Figure 12 is a picture of the tire terrace at Campus Center for Appropriate Technology at Humboldt State University.

Implementation Plan

See Appendix 5a for a Timeline.

Kate - She is in charge of researching the housing design, which includes active and passive solar heating, insulation, and ventilation. This is part of Goal 1 of the project. She has been brainstorming ideas for each of these aspects. Each idea is then researched comprehensively. Her research methods include: extensive Internet research and books on the subjects. After ideas are researched, she then communicates with her peers through e-mail and in person to bounce ideas off one another. She is also involved in the group meetings with the developers Nick and Nina and has spent time typing and formatting draft documents.

AJ - He is researching the portion of housing design which includes framing and sheathing lumber alternatives, masonry and concrete alternatives, housing accessories, and unit layout. This is part of Goal 1 of the project. He has been creatively forming ideas for each of these aspects. Each idea is then researched extensively. His research methods are as follows: Internet, books, and communication with engineering professionals and professors. After ideas are researched, he then communicates with his peers through e-mail and in person to reflect on the thoughts. AJ is building a 3-dimensional model of a housing unit. He is also involved in the group meetings with the developers Nick and Nina, and has spent time typing group documents.

Rooz - He is studying pathways, which is Goal 2. He has looked into materials such as recycled-glass pavers, plastic lumber, and aggregate materials for the use of the walking surface. Each material is researched using the Internet and personal contacts with professionals. He communicates with the group about his findings for feedback. He is also involved in the group meetings with the developers Nick and Nina, and spends time typing and formatting draft documents.

Ellen - She is researching garden design, which is Goal 3. She has been examining alternatives for terraced, flat, and wetland garden spaces within the property. She has looked into ideas for the garden that include composting systems, native plant species, and horticultural species. Surveying of the property has been done to delineate the proper areas within the property for specific plant species. Her research has included Internet, books, student reports, and personal gardening experience. She is also involved in the group meetings with the developers Nick and Nina, and has spent time typing group documents.

Holly - She is researching retaining walls and terracing materials, which is Goal 4. She has researched materials that are used for such things and chosen those that fit the projects goals and objectives. The materials chosen for further research are as follows: concrete, gabions, tires, and de-paved sidewalk pieces. Her research has included: Internet, books, personal contacts with construction companies, CCAT, and contacting professionals with information pertinent to the project. After researching she has met with the group to receive feedback about her ideas. She is also involved in the group meetings with the developers Nick and Nina, and has spent time typing and formatting documents for the project.

Monitoring and Evaluation

Each goal will be monitored and evaluated on a periodical basis using various indicators to determine if each goal's objectives have been met. Only recommended alternatives are discussed in this section.

Goal 1: Providing sustainable options for housing design.

Heating the home with "solar".

The alternatives for house design, specifically heating the home, will be surveyed over time in a series of two-five year blocks by the members of the covenants and Nick (the property owner). The process of monitoring will be done with the guidance of professionals, engineers, and project consultants as the most effective avenue for evaluation. This will allow for the owners and renters of the houses to describe any problems they may be having with the individual aspects of the materials, products, and design of the home to these specialists so that they may analyze the situations and direct their concerns to the property owner. This process will ideally reveal the majority of problems any of the tenants may have so that another analysis can begin for rectifying these situations.

The specific aspects, which need to be monitored for the house design, will include the effectiveness of the solar panels and their ability to provide the household with adequate energy for every day use. The effectiveness of the solar hot water heaters to provide (the family with) adequate amounts of hot water for domestic use will be evaluated. Monitoring will also include the competence the sunspace has offered the home. Has the sunspace been able to warm the home? Have there been other uses for the sunspace, such as a greenhouse, living space, etc? Are the radiant slabs effective and efficient? All of the questions will be answered and assessed through the surveying process and the visits from the consultants.

Ventilation using "alternative design".

There will be an evaluation, through survey, of the entire "alternative design" of the home. Has the design of the house, including the south facing windows and the bedroom placement on the top floor, yielded a comfortable temperature in the home? Has the helical design of the house allowed for proper ventilation, constant circulation of air, and even heating of the home? Are the tenants satisfied with the temperatures in their homes as a result of the original design of the house?

Insulation using "bio-insulation"

This category will allow the homeowners to describe any problems they may have had with the insulation of the home. Have the materials been degraded or disintegrated? Are there any problems with mold, decay, or fire? Have they been satisfied with the ability the bio-insulation has provided in their home, especially during the winter months? Has the house been unusually cold or drafty? Would you recommend the materials used in this design for other homes in the area?

Framing Lumber, Masonry and Concrete

It is best to evaluate the choices for lumber and concrete before construction in order to minimize monetary investment losses. A licensed engineer will evaluate the lumber alternatives and concrete designs and designate potential applications. For example, a large piece of felled lumber milled on the property must be graded for load bearing capabilities. In order to keep track of pieces of unconventional lumber and construction techniques it would be helpful to keep a database of what piece went in what house and how. This will simplify future monitoring and evaluation of the project giving inspectors an accessible history of construction of the houses.

When using recycled/naturally felled lumber ensure each piece of lumber used is applied according to specifications recommended by the manufacturer before construction begins. In order to monitor the quality of materials, sound construction techniques, and overall sustainability; the following is suggested:

1) Allow a licensed carpenter to survey the houses for poor workmanship and unusual degradation of wood materials. Recommended every three years for the first decade or after an earthquake.
2) Allow a licensed geologist to survey the foundation of the property looking for any cracking or movement of concrete. Recommended every 4 months for the first two years or after an earthquake.
3) Allow a licensed pest management specialist to survey the property for pests. Recommended every three months the first year and then every four years thereafter.
4) Survey the residents of the houses for a better understanding of what it is like to live in the houses. Creaking? Poor ventilation? Earthquake experience? Leaks? Moisture? Recommended right after moving in and every year thereafter for four years.

Goal 2: Provide sustainable options for paths throughout the property.

Plastic lumber

A licensed carpenter will carry out the monitoring and evaluation of pathways by determining the following on a yearly basis:

- Structural stability of the pathways.
- Integrity of walking surface.
- Signs of rotting and decay within the boards
- Signs of cracks and splinters within the boards
- Life expectancy of plastic boards based on wear and tear at time of inspection.

Goal 3. Provide design for the integration of gardens throughout the community.

Terraced gardens

Communal composting system: It will be up to the residents of the community to monitor the composting system. Major guidelines for ensuring its proper function follow:

- Aeration of pile, ensured by ample air passages, such as straw and weeds.
- Proper moisture content, moist but not wet. For the weather in Humboldt County, the pile should be protected from the rain, especially during the wet season.
- Proper particle size of ingredients, the smaller the better.
- Proper temperature of pile, ensured by a relatively sunny location, preferably near the houses in the flatter area of the property.
- Proper ingredients contained in pile, such as any vegetative matter other than weeds, diseased plants and chemically treated wood products. No animal products or human wastes.
- Proper size of the pile, no larger than 5 feet cubed and no smaller than 3 feet cubed.

Incorporation of native flora: Native plants will initially be planted in the garden spaces (see Appendix 3a). Once they are established, it will be up to the residents of the community to monitor their growth and ensure their persistence. Guidelines for maintenance of the native vegetation in garden spaces follow:

- Irrigate garden spaces during first dry season.
- Compost garden spaces prior to planting and in planted areas periodically as needed.
- Trim and replace plants as needed.
- Removal of any exotic species that invade the garden

Vegetable and herb garden areas: Plants used for consumption will initially be planted in the garden spaces, though some may need to be replaced seasonally to ensure continued production. It will be up to the residents of the community to ensure the persistence of herbs, fruits and vegetables in garden spaces. Guidelines for the vegetable and herb garden areas follow:

- Rotate crops seasonally, replacing spent plants as needed.
- Remain within climatic limitations when planting new productive plants. Extra composting and irrigation to ensure survivorship of productive plants should be kept at a minimum.
- Irrigate garden spaces during dry season.
- Compost garden spaces prior to planting and in planted areas periodically as needed.
- Adjust soil with organic mineral and nutrient amendments as needed.

Goal 4: Provide options for retaining walls and terraces using alternative materials.

Build 6-8-foot retaining walls out of gabions.

In order to monitor the effectiveness of the gabions as retaining walls yearly inspections will be carried out by licensed engineers. Inspections will require the following:

- The structural integrity of the wire meshes
- The quality of the PVC on the wire if used.
- Check for movement of the gabions.
- Check for hazardous materials such as rocks, wires, and soils that may be exposed or shifted within the year period.
- Check the state of the vegetation around the wall.
    - Are soils and plants starting to cover the gabions helping with aesthetics?
    - A survey of the residents regarding the wall will be used to assess the aesthetic value of using gabions.

It is important to note that the wall's stability must be evaluated after significant earthquakes that occur. If this does occur the following must happen:

- Residence must call the developer if the earthquake is felt on the property.
- The developer must ensure the builder of the wall performs a safety check.

Incorporate locally used tires in building two and a half foot walls for the terraces on the south side of the property.

Monitoring of the tire terraces will occur twice a year and include the following:

- Inspecting the adobe covering for cracks and breaks caused by plants or otherwise.
- Monitoring for movement of tires due to earthquakes or sliding.
- Keeping the irrigation pathways open so water can get through the wall. This will have to be monitored weekly by local residence to ensure the stability of the terrace walls.
- In the event of an earthquake all monitoring and evaluation requirements for the gabions will be carried out for the retaining walls.

All monitoring for both alternatives will be documented and filed with other community documents within the community's council chambers. The documents will be available for everyone in the community to read at any time. The council members will review the documents and request any repair that is needed to the developer. All repairs needed will also be documented and included in the monitoring documents.

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Appendices

Appendix 1: Goal 1 – To provide sustainable options for housing design.

Appendix 2: Goal 2 – To provide sustainable options for paths throughout the property.

Appendix 3: Goal 3 – Provide design for the integration of gardens throughout the community.

Appendix 4: Goal 4 – To provide options for retaining walls using alternatives materials.

Appendix 5: Time sheets and Time line

Appendix 1: Goal 1 – To provide sustainable options for housing design.

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Appendix 1g: Industrial Hemp

Appendix 1h: Faswall

Appendix 1i: Rainwater Catchment System

AAC PRECAST MASONRY PRODUCTS

MATERIAL HANDLING PROCEDURES

BABB International

GENERAL:

Please read the following instructions to insure proper handling and installation of Autoclaved Aerated Concrete (AAC). Damage may occur if AAC is moved or handled several times. If damage should occur, damaged block should be trimmed and installed to reduce job site waste.

For All AAC Construction Products:

- Deliver only an amount of material that can readily be installed.
- Unload pallets using pallet forks (either forklift or pallet fork on a crane cable). Consult your OSHA safety manual for "Rigging" for other safety considerations. It is not advisable to use crane straps and slings.
- Storage areas should be accessible to delivery trucks and convenient to material staging areas. If possible, drop-deliver the material right to the material staging areas.
- Storage material should always be stored away from other construction activities on a flat-graded area that is not susceptible to standing water, erosion or settling.
- Keep the material covered and banded until ready for installation.

BABB PAAC

6600 Highlands Pkwy
Smyrna, GA 30082

800-994-3235
770-308-1500 770-308-1515 fax

Interior and Exterior Finishes:

Elite Cement
P.O. Box 48823
Atlanta, GA 30362

888-403-5483

Sider-Oxydro, Inc.
3945 Regur Road
Hawkinsville, GA 31036

888-743-3750

W.R. Bonsal Company
P.O. Box 241148
Charlotte, NC 28224-1148

800-738-1621

Installation Equipment

PAACE
112 Gordon Commercial Drive
LaGrange, GA 30240

706-884-7600

Installation Tools

Wind-Lock Corp.
1055 Leisz's Bridge Road
Leesport, PA 19533

800-872-5625

Anchors and Fasteners

Fischer Fasteners
250 Barber Avenue
Worcester, MA 01606-2435

800-631-7131

Hilti
P.O. Box 21148
Tulsa, OK 74121

800-879-8000

Tox Fasteners
The Candler Building
127 Peachtree Street
Suite 1105
Atlanta, GA 30303

800-890-1006

U.S. Anchor
450 E. Copans Rd.
Pompano Beach, FL 33064

800-872-3330

TOOLS REQUIRED FOR INSTALLATION

BABB International

Hebel Block

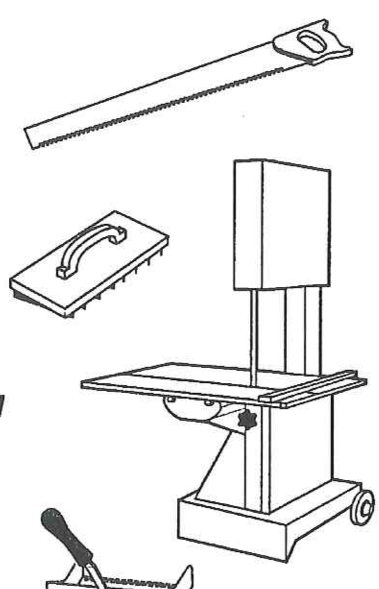
There are a full range of tools that are specially designed to assist the block layer in installing AAC masonry products and increase productivity at the job site.

Hand Saw

Rasp

Electric Bandsaw

Notched Trowel



AAC masonry installation will also will require the following standard masonry tools.

Margin Trowel

Small Hand Brush

Builder's Level

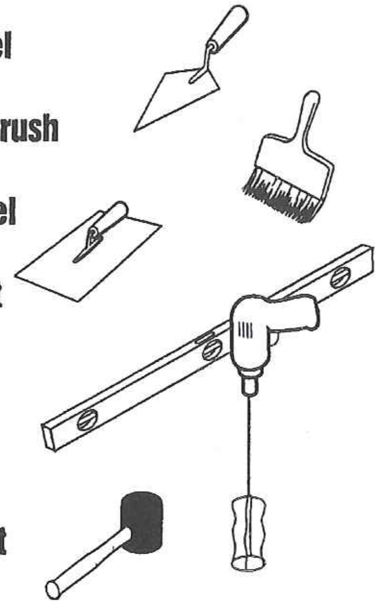
Sanding Float

4' Level

String Line

Rubber Mallet

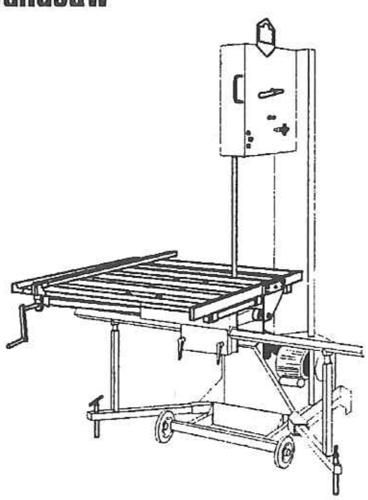
Low Speed Drill with Mixing Paddle



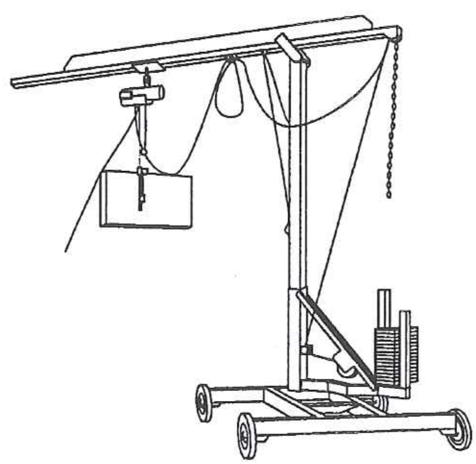
Hebel Jumbo® Block

Additional tools required for installing AAC Jumbo® Masonry Units.

Electric Jumbo Bandsaw

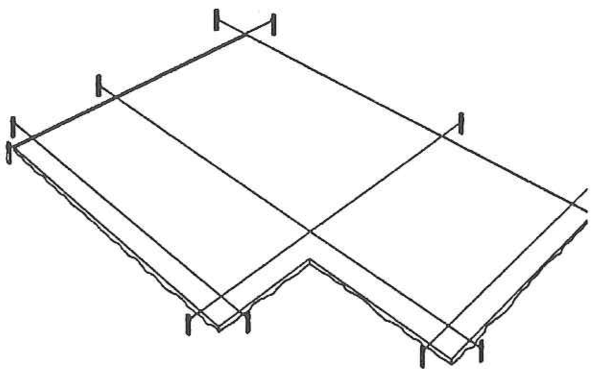


Electric Minicrane



Step 1 - Layout wall lines.

Lay out wall lines on building slab by control lines.

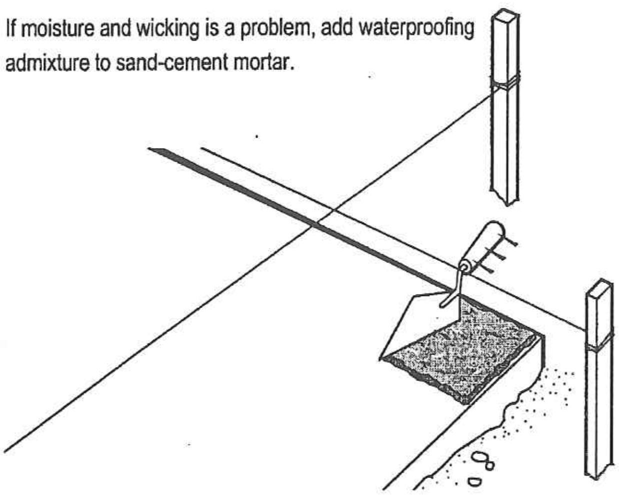


Step 2 - Start the leveling bed.

At the highest corner of the slab place a full width ½" deep sand-cement mortar joint using a masonry trowel (Mortar to be either Ready-Mix or 3:1 Sand: Portland Cement ratio).

Salvage additional mortar. Do not use thin-bed mortar for the leveling bed joint.

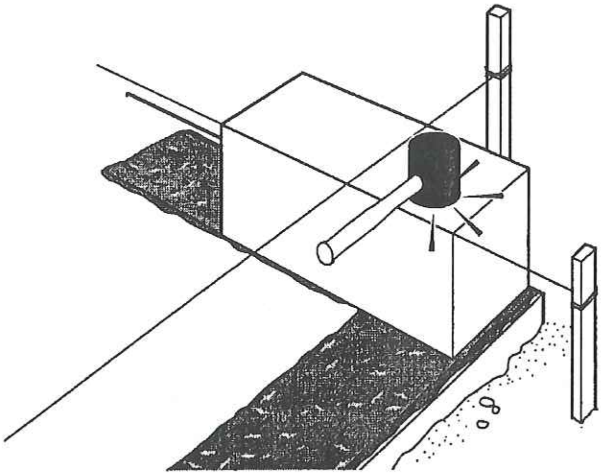
If moisture and wicking is a problem, add waterproofing admixture to sand-cement mortar.



Step 3 - Set the first corner block.

Set the first corner block in the sand-cement mortar and adjust the joint as needed.

To achieve the required height, lower or raise the block by tapping down with a rubber mallet or by adding additional mortar beneath.

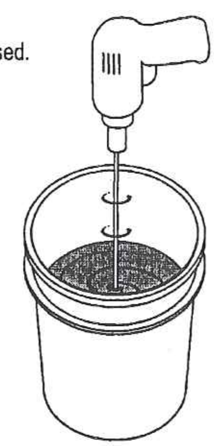


Step 4 - Mix thin-bed mortar.

Mix approved Hebel thin-bed mortar in a clean mixing container (5 gallon bucket or pail) per manufacturer's directions.

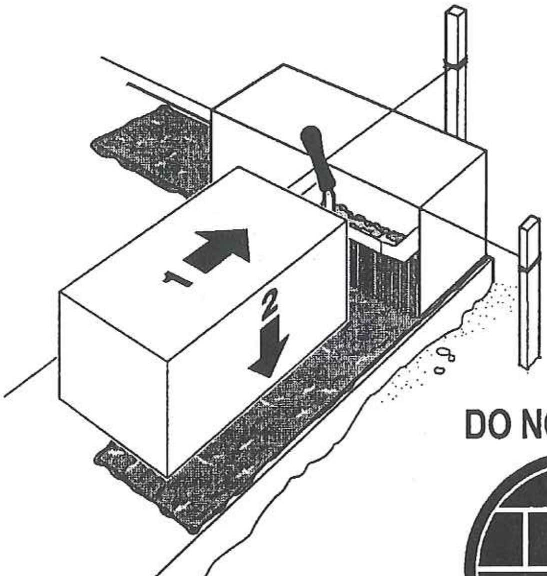
The consistency of the mixed thin-bed mortar should be such that it flows easily through the teeth of the notched trowel leaving the shape of the teeth in the mortar bed.

Thin-bed mortar droppings should not be used.



Step 5 - Set second corner block.

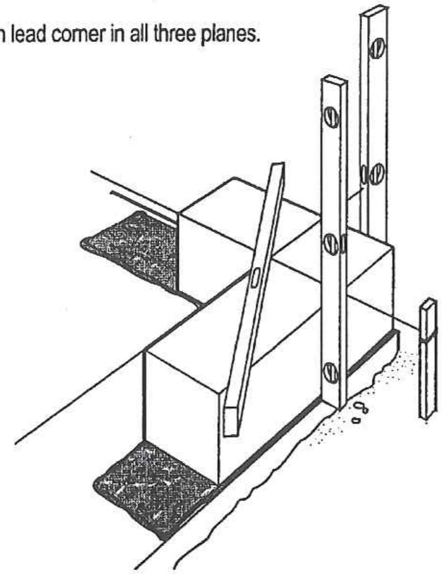
Set the second corner block adding thin-bed mortar to the head joint with the notched trowel.



Step 6 - Repeat for additional corners

Repeat subsequent steps for each corner using a builder's level to maintain an equal elevation.

Triple check each lead corner in all three planes.

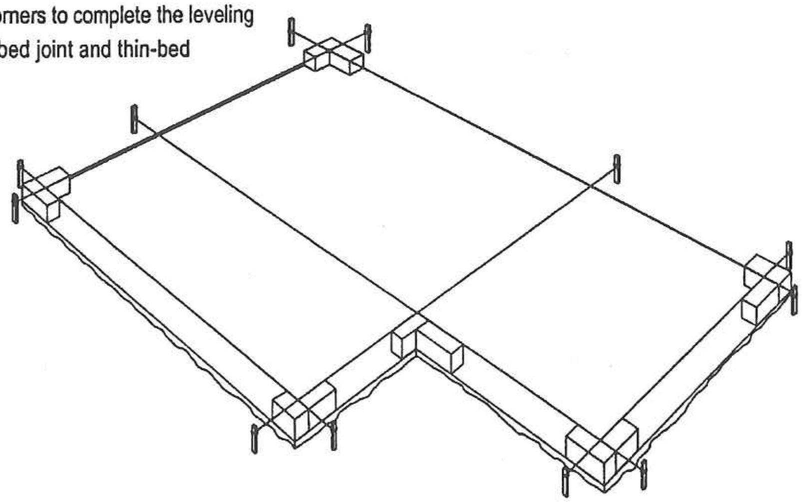


DO NOT TOOTH

Step 7 - Fill-in completion of leveling course.

After building the lead corners, pull a string between corners to complete the leveling course. Sand-cement mortar should be used for the bed joint and thin-bed mortar for each head joint.

Level across each block to insure a plumb wall.



DO NOT PROCEED TO SUBSEQUENT COURSES UNTIL LEVELING COURSE HAS SET SUFFICIENTLY.

BABB International

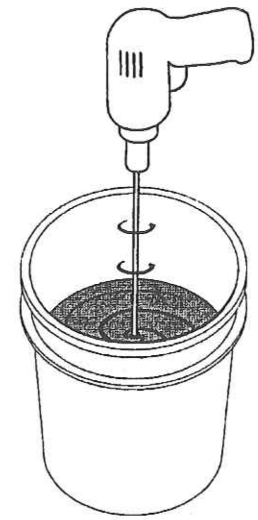
TYPICAL COURSING

DO NOT USE SAND-CEMENT MORTAR FOR COURSES OTHER THAN THE LEVELING COURSE.

Step 1 - Mix thin-bed mortar.

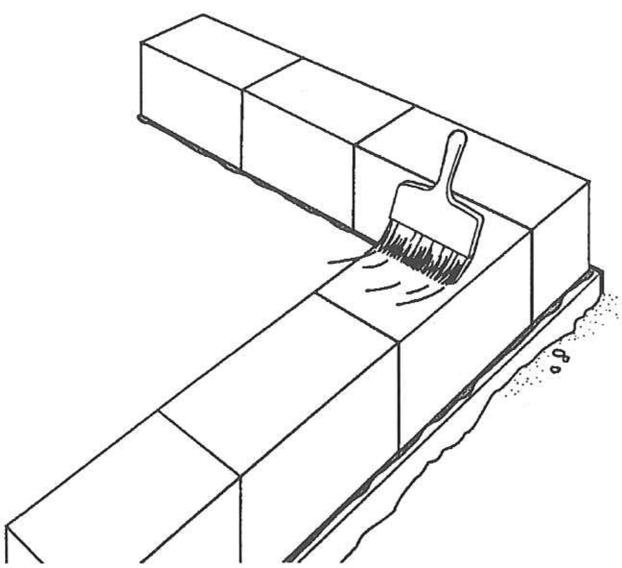
Mix thin-bed mortar.

Before mixing new batch, wash out the bucket or pail to prevent any old thin-bed from accelerating the drying time of the new mix.



Step 2 - Clean bed joint surface.

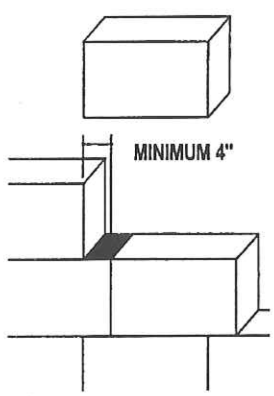
With a brush, sweep off all dust and loose particles to insure adhesion of thin-bed mortar.



Step 3 - Apply thin-bed mortar to head and bed joints.

Using a clean, notched trowel the same width as the block spread thin-bed mortar up the head joint of the adjoining block and then along the bed joint.

Spread only enough thin-bed mortar to lay one block at a time. The thin-bed mortar must cover the full width of the joints.

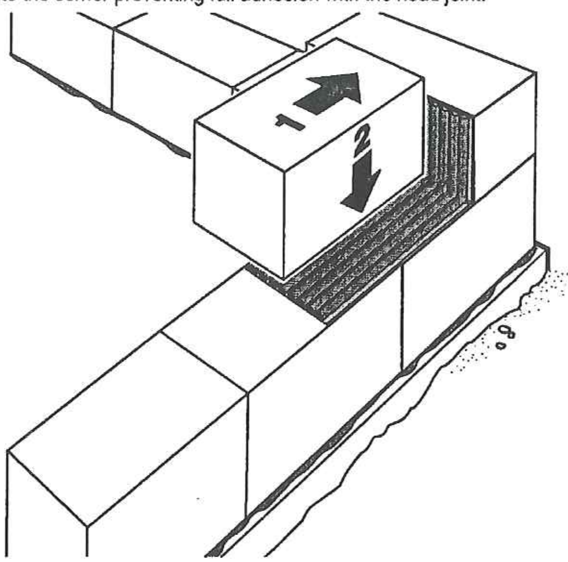


Install block in a running bond with a minimum 4" bearing (overlap) or 40% of the block's height (whichever is greater).

Step 4 - Set block.

Pick up each block and move it as close to the head joint as possible before lowering the block onto the bed joint.

Excessive movement along the bed joint will force the thin-bed mortar into the corner preventing full adhesion with the head joint.

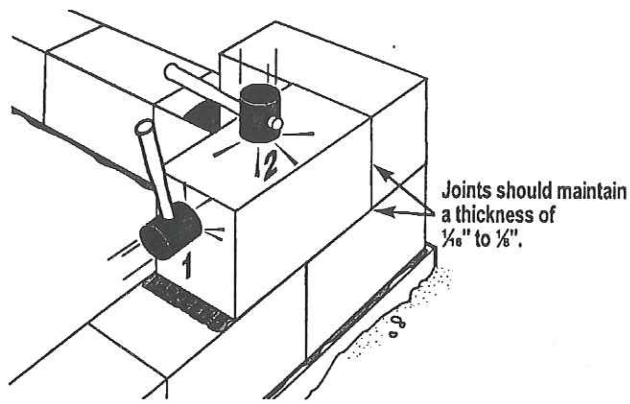


Step 5 - Tap the end of the block.

Tap the end of the block to insure a full surface coverage of thin-bed mortar at the head joint and align with string line.

Clean off spilled or dripped thin-bed mortar from face of wall as work proceeds.

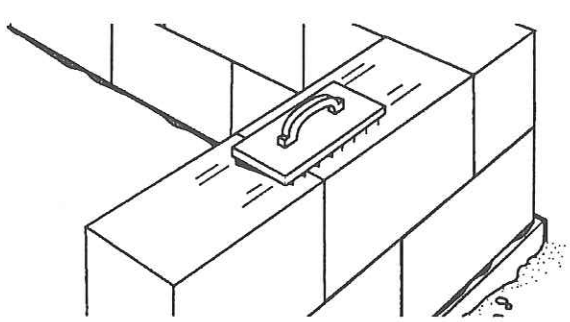
Repeat installation for subsequent courses.



Step 6 - Rasp as needed.

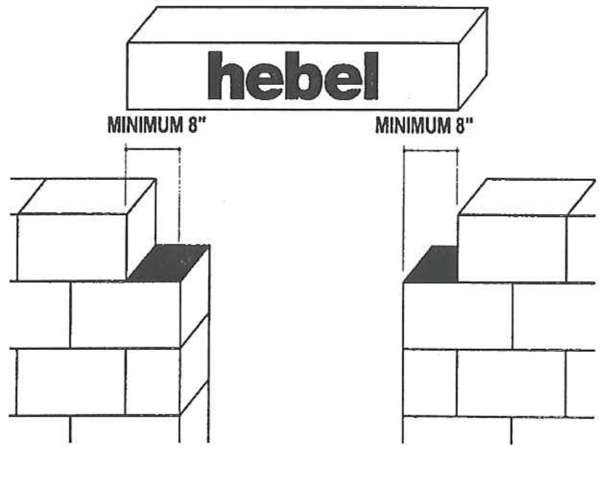
As needed, rasp (sand) the topside of the wall to ensure a level bed-joint for the next course.

This is required less often if block is installed within tolerances.



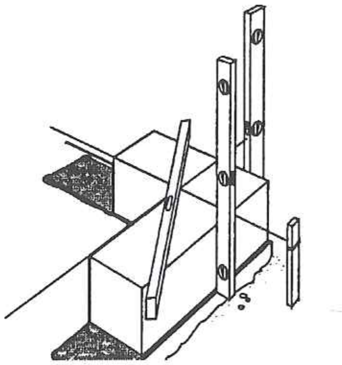
Step 7 - Install lintels as required.

Install lintels with a minimum 8" bearing (overlap) where required.



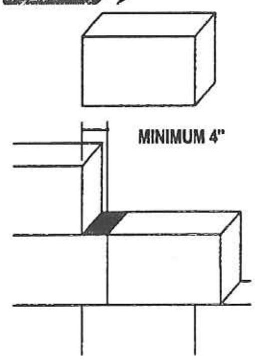
BABB International

POINTS TO CHECK



Point 1

Leveling course must be level and plumb. Do not proceed to subsequent courses until leveling course has set sufficiently.



Point 2

Blocks must be installed in a running bond with a minimum 4" bearing (overlap) or 40% of the block's height (whichever is greater). Lintels must be installed with a minimum 8" bearing (overlap).

Point 3

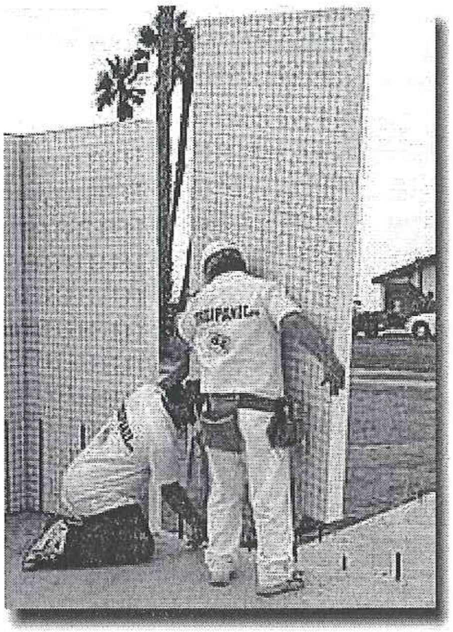
All Head and bed joints must be solid with approved Hebel thin-bed mortar for full adhesion. Do not tooth.

FAILURE TO ADHERE TO THESE PROPER INSTALLATION PROCEDURES WILL RENDER WARRANTY NULL AND VOID

Appendix 16

THE TRIDI PANEL IS A PREFABRICATED PANEL

This extremely strong structural product consists of a super-insulated core of rigid expanded polystyrene sandwiched between two-engineered sheets of eleven-gauge steel welded wire fabric mesh. To complete the panel form process a nine-gauge steel truss wire is pierced completely through the polystyrene core at off set angles for superior strength, then welded to each of the outer layer sheets of eleven-gauge steel welded wire fabric mesh. These three elements are joined by EVG state of the art manufacturing equipment producing a THREE-DIMENSIONAL lightweight panel that due to its characteristics makes it one of the strongest building materials you can find.



TRIDIPANEL CORE DENSITY AND STEEL MESH STYLES

Dimensions of the panels are manufactured from a starting width of 4' x 8' lengths. The panels can be prefabricated up to (40' in length) in (8" increments). Wire gauges available are 11,12.5 and 14 and may be ordered in bright or galvanized metal.

POLYSTYRENE **CORE THICKNESS**	**OUTER LAYER Wire MESH TO MESH**
1.5"	**2.5"**
2.0"	**3.0"**
2.5"	**3.5"**
3.0"	**4.0"**
3.5"	**4.5"**
4.0"	**5.0"**
4.5"	**5.5"**
5.0"	**6.0"**

"Hadrian Tridi-Systems"
Assembly Manuel

Index page

1. Materials used in the "Hadrian Tridi-Systems"
2. Tools recommended for assembling and safty
3. Foundations preparation
4. Panel preparations and assembly for, walls, doors, electrical, plumbing, columns, beams, and arches.
5. Panel preparation and assembly for roof, and floor
6. Application of concrete and finish to panels.

Materials used in the Hadrian Tridi-systems

1. Tridi panels 4'x8' through 40 ft.
2. Out side corner mesh
3. Inside corner mesh
4. Flat supplies mesh
5. End cap mesh
6. Rebar
7. Concrete
8. Pressure treated lumber

Tools recommended for assembling

1. Tape measure
2. Level
3. Skill saw and diamond blade, reciprocating saw
4. Pneumatic wire fastening tool
5. Bold cutters
6. Braces
7. Cement and Stucco tools

Foundations preparation

1. Setting rebar in concrete foundation
2. Setting key way in concrete foundation

Panel preparations and assembly

1. Walls,
2. Doors,
3. Electrical,
4. Plumbing,
5. Columns,
6. Beams,
7. Arches.
8. Roofs and second floors

Application of concrete and finish

1. Hand application
2. Machine applications

TRIDIPANEL PRICE LIST

TRIDIPANEL 3-D/EVG

JAN. 03

HADRIAN TRIDIPANEL SYSTEMS

DIRECT DISTRIBUTOR

		PRICE LIST		COST PER SQFT
Product Reg Or Brite Steel		Gauge	Product Type	
TRIDIPANEL	2"	14GA.	Expanded Polystyrene	$1.54
TRIDIPANEL	2"	12.5GA.	Expanded Polystyrene	$1.71
TRIDIPANEL	2"	11GA.	Expanded Polystyrene	$1.94
TRIDIPANEL	2.5"	14GA.	Expanded Polystyrene	$1.65
TRIDIPANEL	2.5"	12.5GA.	Expanded Polystyrene	$1.81
TRIDIPANEL	2.5"	11GA.	Expanded Polystyrene	$2.05
TRIDIPANEL	4"	14GA.	Expanded Polystyrene	$1.94
TRIDIPANEL	4"	12.5GA.	Expanded Polystyrene	$2.11
TRIDIPANEL	4"	11GA.	Expanded Polystyrene	$2.34
TRIDIPANEL	5"	14GA.	Expanded Polystyrene	$2.14
TRIDIPANEL	5"	12.5GA.	Expanded Polystyrene	$2.31
TRIDIPANEL	5"	11GA.	Expanded Polystyrene	$2.55
			ACCESSORY MESH	
Flat, Corner Or "U" Mesh		11GA.		$0.43
Flat, Corner Or "U' Mesh		12.5GA.		$0.31
Flat, Corner Or "U" Mesh		14GA		$0.26

GALVANIZED: Galvanized mesh and its additional cost per material is $0.10 per Sqft. Of panel and $0.05 per Sqft. of cover mesh. Additional cost is

FREIGHT: Freight prices to be quoted on a per shipment basis.

HADRIAN TRIDIPANEL SYSTEM
P.O. BOX 1747
VISTA, CA. 92083
TO ORDER PLEASE CALL
PHONE 760-643-2307
FAX 760-643-2305

Appendix 1c

THE PROPERTIES OF LUMBER AND TIMBER RECYCLED FROM DECONSTRUCTED BUILDINGS

Robert H. Falk, Research Engineer
USDA Forest Service, Forest Products Laboratory
Madison, Wisconsin, USA

SUMMARY

This paper overviews recent efforts by the Forest Products Laboratory of the USDA Forest service, in cooperation with the U.S. Army and the West Coast Lumber Inspection Bureau (WCLIB), to develop information on the grade yield and engineering properties of lumber and timber recycled from deconstructed buildings. More than 1,700 pieces of lumber and timber have been collected to date, ranging in size from 38 by 90 mm (2 by 4 in.) to 220 by 445 mm (10 by 18 in.). This material has been gathered from two military bases. This paper presents the effects of splits on timber beam and column strength and the effects of damage on lumber grade yield.

INTRODUCTION

Building demolition is often a wasteful process, with potentially valuable wood materials ending up as broken-up waste destined for the landfill. In the United States, the practice of building deconstruction (or reverse construction) is being evaluated as an environmentally attractive alternative to demolition. An important aspect of deconstruction is reusing the salvaged materials. Because the reclaimed lumber is often damaged in both the construction and deconstruction processes, it needs to be evaluated in terms of options for reuse.

While larger timbers command a high price and are regularly recycled, dimensional lumber is not often reused. However, recent studies suggest the feasibility of deconstructing buildings and salvaging and reusing dimensional lumber stock [1-3]. Ongoing research at the Forest Products Laboratory (FPL) is characterizing the grade distributions and engineering properties of lumber and timber recycled from deconstructed buildings [4-7]. To date, more than 1,700 pieces of lumber and timber have been collected from the U.S. Army's Twin Cities Army Ammunition Plant (TCAAP) in Minnesota and Fort Ord in California This paper highlights results of tests on timbers in bending and columns in compression, and the grading of dimension lumber

TCAAP PROJECT

working cooperatively with the FPL, the U.S. Army Successfully recycled more than 4,700 m^3 (2 million board feet) of lumber and timber from two large military industrial buildings at the TCAAP [8,9]. In 1995, research staff at the FPL worked cooperatively with U.S. Army facilities engineers and demolition contractors at the TCAAP to select a sample of lumber and timber members from Building 503 for testing. This 59,000-m^2 (548,000-ft^2) heavy timber building contained approximately 4,400 m^3 (1,875,000 board feet) of softwood timber, primarily Douglas Fir. Approximately 82.6 m^3 (35,000 board feet) of lumber and timber were collected, ranging in size from 140 by 190 mm (6 by 8 in.) to 240 by 445 mm (10 by 18 in.). Details have been reported [5-7].

FORT ORD PROJECT

The 1994 closure of the Fort Ord U.S. Army Military Reservation in Marina, California, left more than 1,200 buildings that either did not meet current building code requirements or that contained remnant hazardous materials requiring abatement. The Fort Ord Reuse Authority (FORA) developed a deconstruction project focused on distinct building types and monitored the cost, timing, and job creation involved in building disassembly, material collection, and material reuse [3]. The FPL developed a cooperative research agreement with FORA and the West Coast Lumber Inspection Bureau (WCLIB) to develop information on the grades of lumber reclaimed from deconstructed buildings.

GRADING METHODOLOGY

The lumber and timber collected from the two bases was primarily Douglas Fir and was visually assessed for structural grade by a WCLIB grading supervisor according to standard No. 17 in *Grading Rules for West Coast Lumber* [10]. The WCLIB is one of six rules-writing agencies recognized by the American Lumber Standard Committee. Particular attention was paid to damage, defined as holes resulting from nails or bolts, splits resulting from factors other than drying, saw cuts, notches, decay, and mechanical damage (such as gouges, broken ends, missing sections resulting from splits).

If a bolt and/or nail hole or holes were present in the piece, the grader estimated an equivalent knot size for determining the grade.

RESULTS

Beam Strength

Ninety 140- by 190-mm (6- by 8-in.) timbers were collected from the TCAAP and shipped to the FPL for testing [7]. Thirty timbers with heart checks (boxheart splits), characteristic of old timbers installed in dry locations, and 60 "unchecked" timbers were selected for testing. Most beams were Select Structural Beams and Stringers grade by current grading rules. Bending tests were performed according to ASTM D198 procedures [11]. Analyses of the bending strength data indicated that the mean modulus of rupture of beams with heart checks was about 15% lower than that of beams without heart checks.

Column Strength

Nominal 190- by 190-mm (8- by 8-in.) Douglas Fir columns were collected at TCAAP and sent to FPL for testing [5]. Columns were tested in direct compression with no intermediate lateral support [11]. The ends were laterally supported to prevent slippage, although no attempt was made to secure the ends. An inspection of the building indicated that the timber had been installed green and many members had developed significant drying checks and/or splits. In spite of the fact that the wood had been in service for 55 years and contained many in-service defects, 75% of the columns were graded as No. 2 or higher and 40% as Select Structural. In-service defects, such as checks, splits, and mechanical damage, resulted in downgrading of approximately one-third of the columns. To study the effect of defects on column strength, "checked" and "unchecked" members were selected on site. The selection criteria were rather qualitative; Figure 1 indicates a typical "checked" member. Checks had little effect on column compressive strength (Fig. 2). All columns were found to be higher in strength than expected by current design procedures (Fig. 3).

Lumber Grading

More than 900 pieces of nominal 2 by 4, 2 by 6, 2 by 8, and 2 by 10 lumber (standard 38 by 90, 38 by 140, 38 by 190, and 38 by 235 mm lumber) were collected from four deconstructed buildings at Fort Ord [4]. Most pieces graded as Structural Joists and Planks qualified for the No. 2 grade (47%); most of the 2 by 4 pieces were graded as Standard (68%). As expected, Douglas Fir was the predominant species (92%). although Hem–

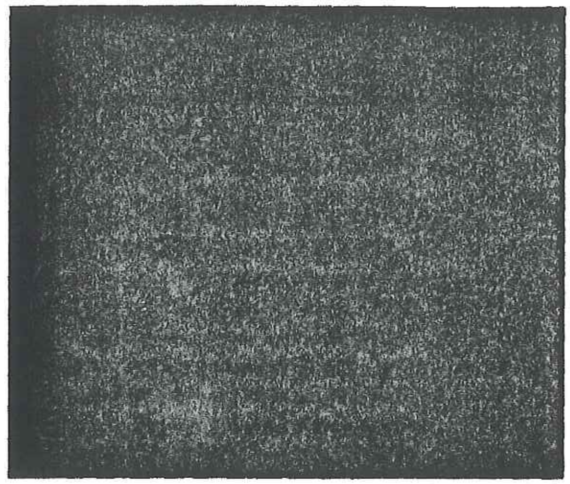


Figure 1—Typical "checked" column.

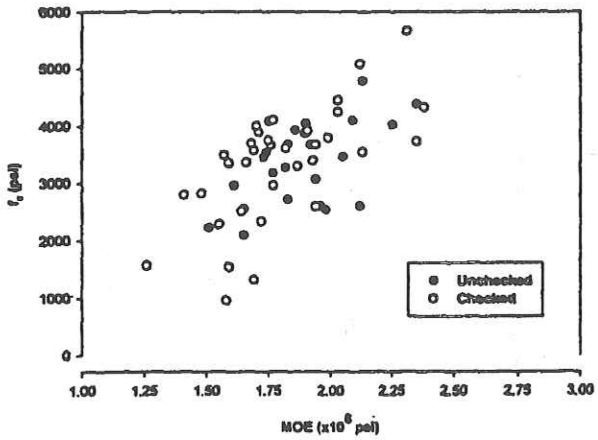


Figure 2—Effect of checks on 8 by 8 column strength. 1,000 lb/m^2 = 6.9 MPa.

Figure 3—Comparison of tested 8 by 8 column strength to design equation. 1,000 lb/in^2 = 6.9 MPa

Fir (6%) and sugar pine (2%) were also present. From the standpoint of structural use, the most distinguishing feature of recycled lumber compared to freshly sawn lumber is the presence of damage, which may be a result of the original construction process (for example, nail holes, bolt holes, saw cuts, notches), building use (drying defects, decay and termite damage), and/or the deconstruction process (edge damage, end splitting, gouges). Damage reduced the average grade of the lumber (Fig. 4).

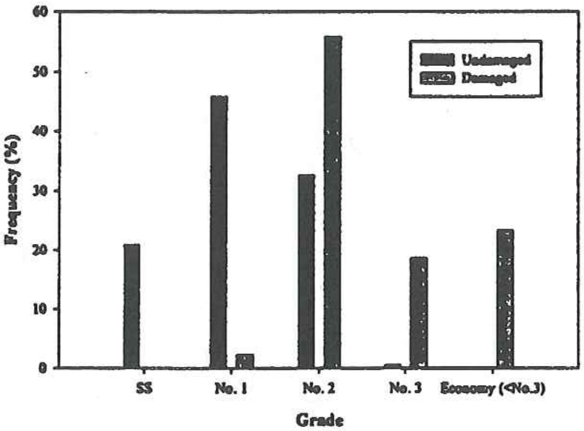


Figure 4—Grade reduction of 2 by 8 lumber resulting from damage. $n = 504$.

CONCLUSIONS

Results to date indicate that heart checks lower the modulus of rupture of recycled timber beams but have little effect on the strength of recycled timber columns. As a result of damage, the quality of dimensional lumber from non-industrial military buildings is on average one grade lower than that of freshly sawn lumber. Because the value of lumber is tied directly to its quality, evaluation of the grades of lumber from these buildings will help determine reuse options and market value.

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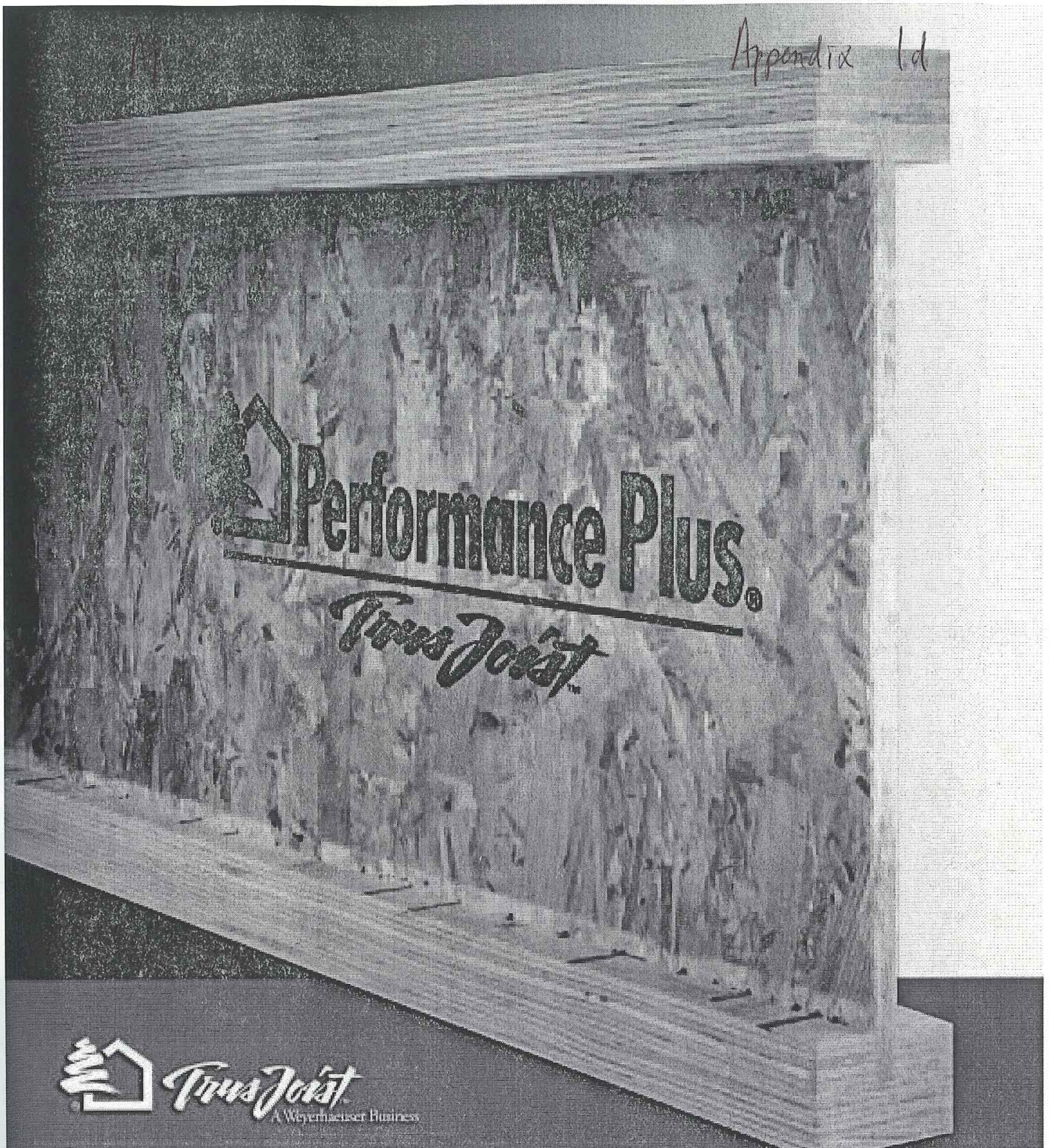
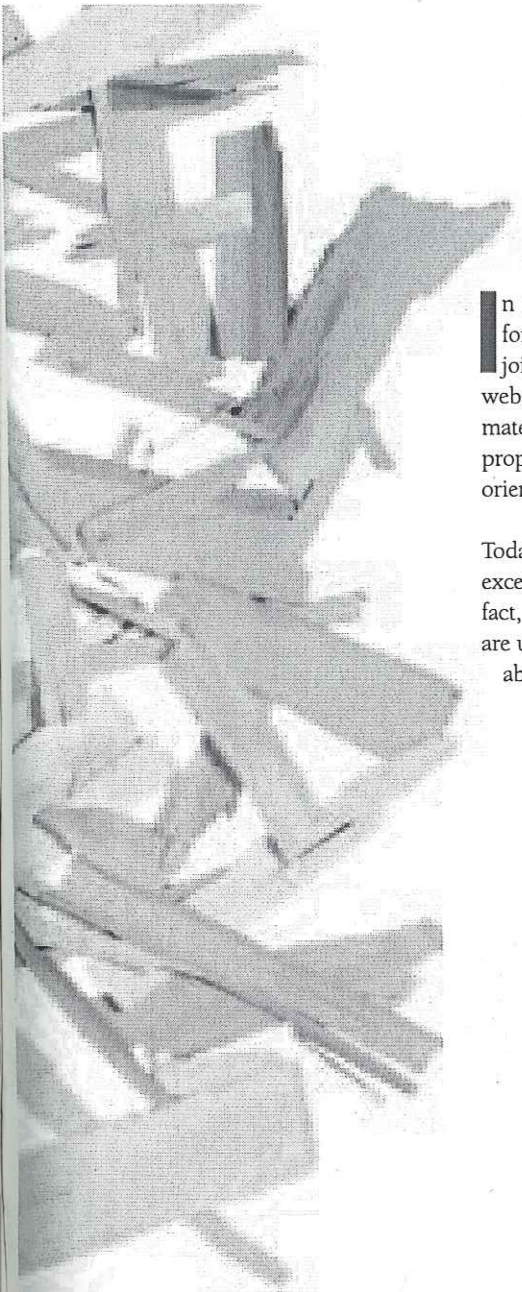
Appendix 1d



The Performance Plus® Web from Trus Joist — Strong, Consistent and Durable.



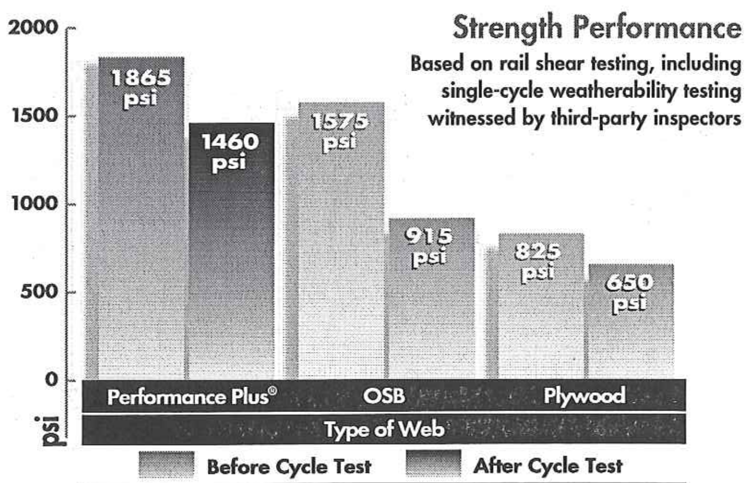
The Performance Plus® Web: Defining Excellence and Quality

In 1992, we established the benchmark for performance in our Silent Floor® joists. We added the Performance Plus® web, a high-density, structural composite material that has excellent moisture-resistant properties — far superior in all measures to oriented strand board (OSB).

Today, the Performance Plus® web still defines excellence and quality in a web material. In fact, our specifications for web performance are unmatched, with only a few manufacturers able to meet the demanding criteria required to produce Performance Plus® web material.

The quality and consistency of Performance Plus® web material is upheld through continuous monitoring. Quality assurance inspections and testing occur at both the Performance Plus® manufacturer and our Silent Floor® joist manufacturing facilities across North America.

Moisture and weatherability testing proves that our Performance Plus® web swells less than OSB. And even after it has been saturated with water and allowed to dry, the Performance Plus® web is comparable in strength to unexposed OSB and nearly double the strength of unexposed plywood.



1969–1970...

The first commercially produced, all-wood I-joist features **machine stress-rated (MSR) solid-sawn flanges and a plywood web.**

1971–1986...

The next generation of TJI® joists features **flanges made from Microllam® LVL** (the first commercially produced laminated veneer lumber) and a **plywood web.**

1987–1991...

The evolution continues with **Microllam® LVL flanges** and an **oriented strand board (OSB) web,** offered in Trus Joist's commercial line of TJI® joists.

The Builder's Choice

On the job site, where it counts, the durability and consistency of the Performance Plus® web has gained the confidence of home builders in markets where the weather wreaks havoc on materials.

With so many choices and new products on the market, these builders trust the proven quality of our Silent Floor® joists and the reliability of Performance Plus® webs.

"We've been using the Performance Plus® Silent Floor® joists since 1992 and feel very positive about the product. We switched because we had experienced shrinkage with other products. We're glad we made the change."

— Bill Hinchcliff, president, Hinchcliff Homes, Ltd., Coquitlam, British Columbia, Canada.

"We've used the Silent Floor® joists in floor applications for 10 years. We've never had any problem with swelling and I'm very happy with the product. We're also very happy with the quality of service we've received from Trus Joist tech reps."

— Tom Busick, owner, Busick Construction, builder of custom homes, Portland, Oregon.

"Trus Joist's Silent Floor® joists have always worked well for us. We've been using your product for five years and our customers love it. The end result in the homes we build is a nice level floor without any squeaks."

— Steve Dunn, president, Deluxe Homes, Columbus, Ohio, and a builder of more than 200 homes a year.

"We use Silent Floor® joists with the Performance Plus® web in every home we build. We've tried the products of Trus Joist's competitors, but we've learned our lesson. My carpenters want the best, so I supply them with Silent Floor® joists with the Performance Plus® web."

— Charles Whitfield, owner, Whitfield Carpentry, Deltona, Florida, three-time winner of Florida State Carpentry Award at Southeastern Builders' Conference.

Resource Efficiency

The Performance Plus® web also makes efficient use of timber. Abundant, fast-growing tree species are used in its production, reducing the need to harvest less plentiful forest resources.

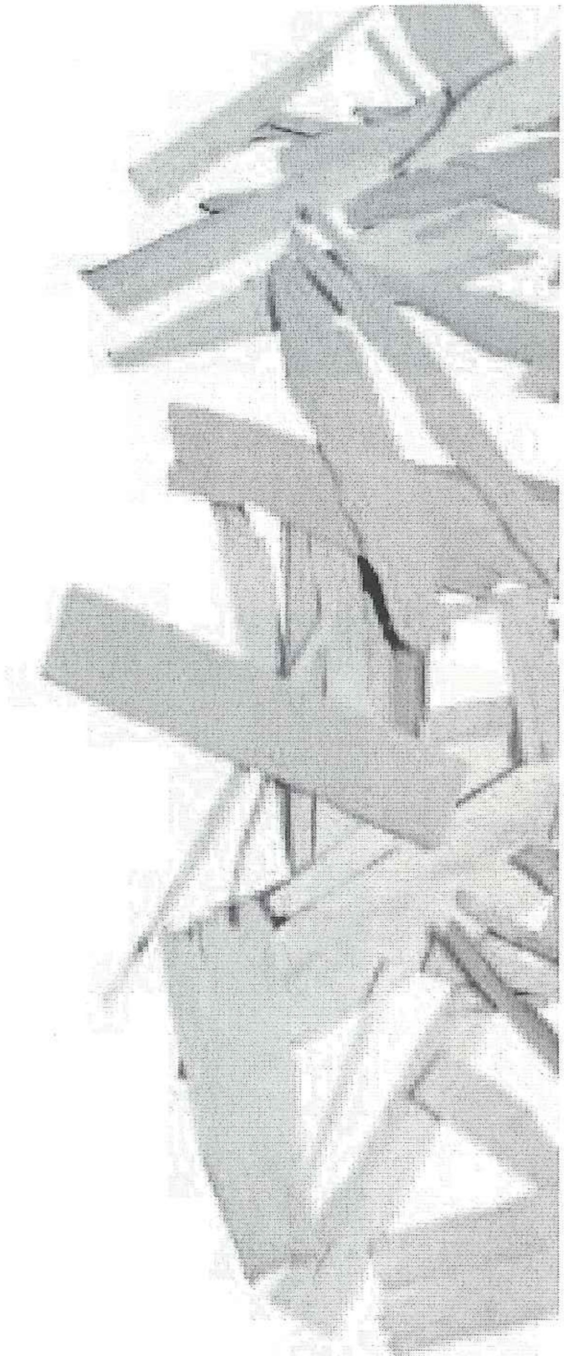
In addition, manufacturing processes convert a high percentage of each log harvested into Performance Plus® web material, extending the forest base even further.

1992...

Looking Toward the Future

Our Performance Plus® web and Silent Floor® joists define the standard for quality, value and resource efficiency. And we'll continue to listen to our customers and respond to their needs by raising technology and the use of resources to new levels, testing our materials beyond the status quo and striving to provide superior building products and systems. By doing so, Trus Joist will continue to lead the pack.

So keep watching. We're not finished yet!



Silent Floor®

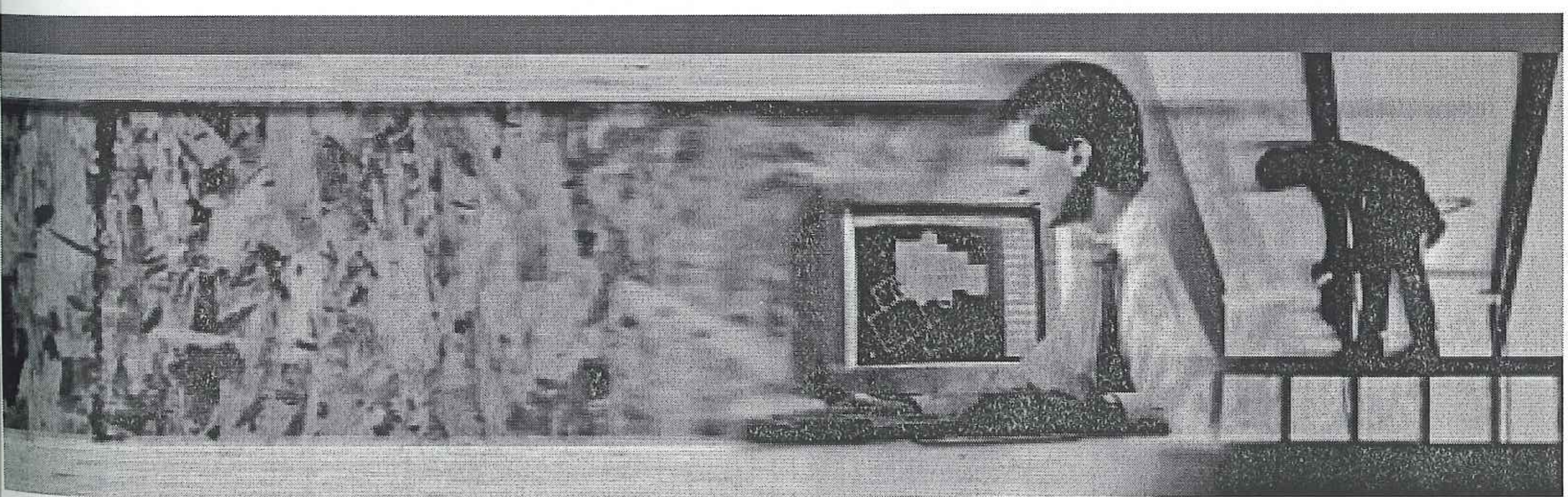
Trus Joist™

Part of the FrameWorks® Building System

Trus Joist
200 E. Mallard Drive
Boise, Idaho 83706
(208) 364-1200

1-800-628-3997

www.trusjoist.com

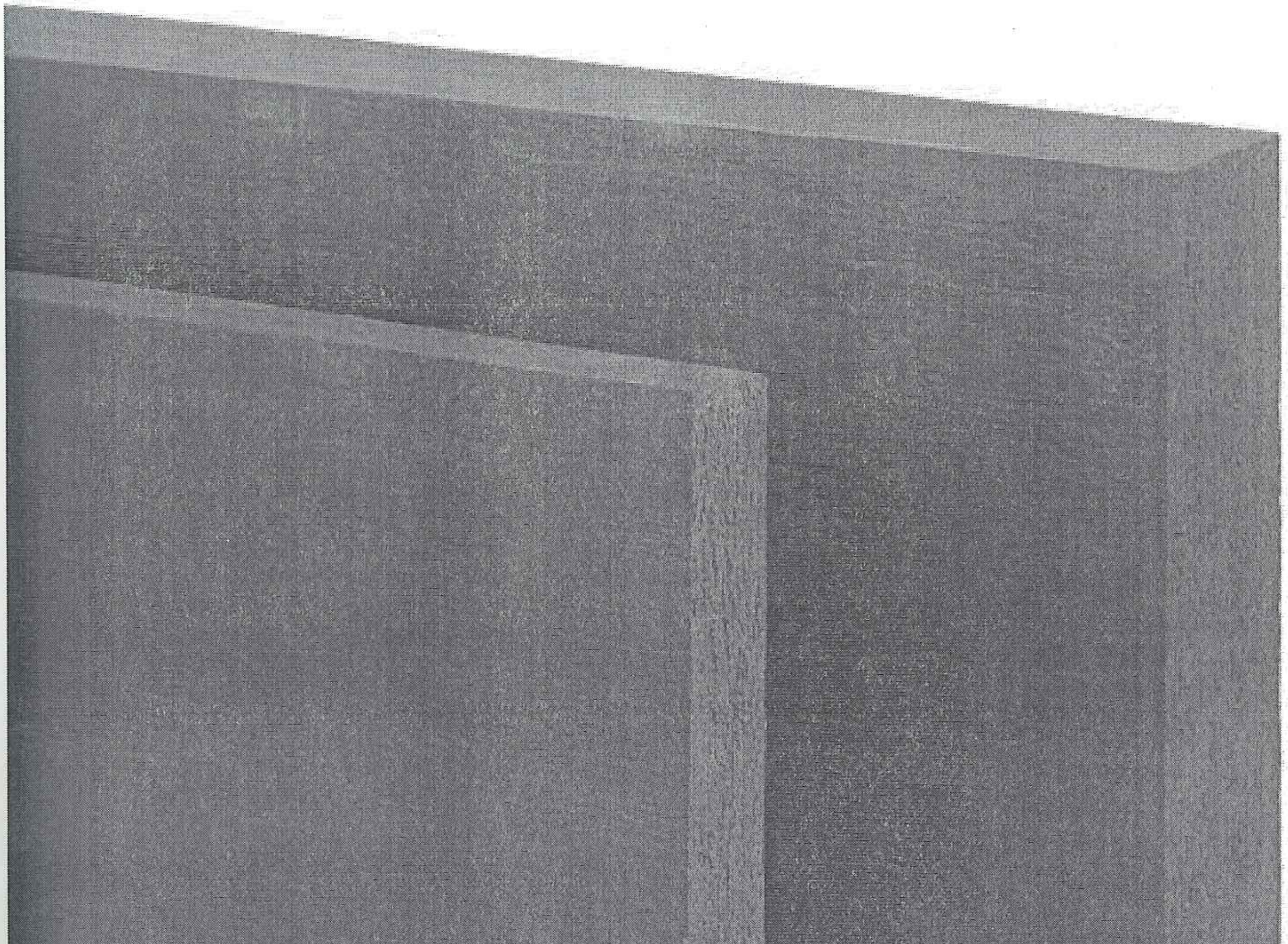


April 2002 J&M/20M

Reorder 2102

G-P Lam® LVL

Appendix 1e



G-P LAM®
with FiberGuard™

Depths:
9¼″ 9½″
11¼″ 11⅞″
14″ 16″ 18″

Thicknesses:
1¾″ or 3½″

Lengths:
Available in lengths up to 60 feet.

LIMITED LIFETIME WARRANTY

Structural Support for Today's Homes

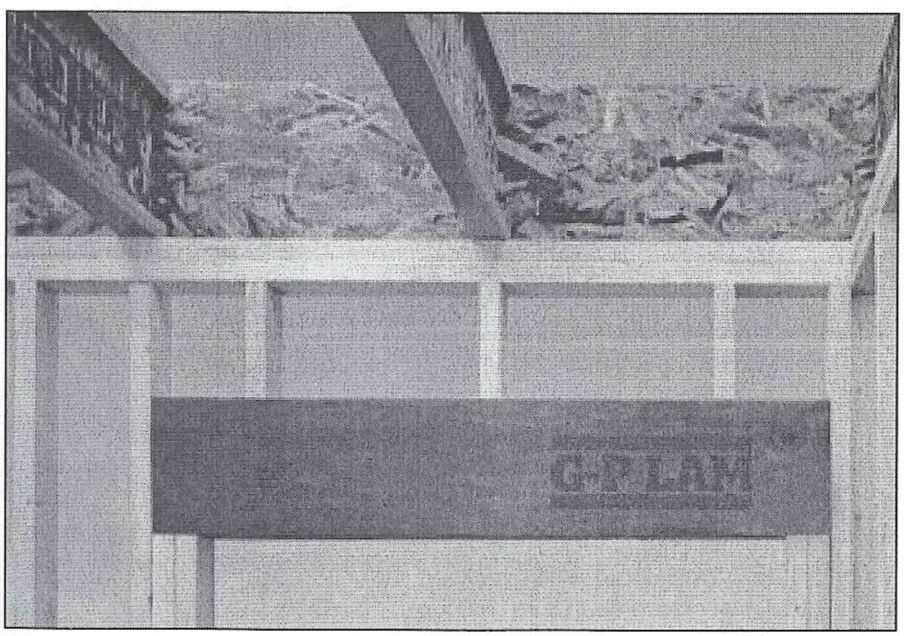
Today, home designs often include grand entrances, wider doorways between rooms, and dramatic window configurations. G-P Lam® LVL is designed for use as floor beams, headers for garage doors, windows and door, and ridge and hip beams.

Multiple pieces of G-P Lam LVL can be assembled easily to obtain greater thicknesses, providing additional strength to carry heavier loads. Greater load capacity means longer, uninterrupted spans.

For better performance, G-P Lam® LVL features FiberGuard™ sealant to provide protection from moisture damage that can cause splits, cupping and warping. The LVL is evenly coated on all four sides and both ends with a wood-tone modified acrylic emulsion film, helping to reduce the moisture absorption rate and to reduce the damage that an unprotected product may sustain. FiberGuard™ sealant also includes UV inhibitors to minimize color change caused by the sun's ultraviolet rays.

G-P Lam LVL Features & Benefits

- Thicknesses of 1-3/4" and 3-1/2"
- Standard depths of 9-1/4", 9-1/2", 11-1/4", 11-7/8", 14", 16", & 18" (20", 22", & 24" by special order)
- Value Lengths of 24', 28', 32', 36', 40', 44' and 48' (lengths to 60' by special order)
- High design values for bending, stiffness and shear strength
- High strength-to-weight ratio, more than 50% stronger than solid sawn products
- Consistent manufacturing minimizes defects and reduces waste on the job
- Installs as easily as ordinary lumber
- FiberGuard™ sealant offers jobsite protection from moisture
- Backed by a Limited Lifetime Warranty*



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Appendix 1f

GREEN SEAL'S Choose GREEN REPORT

OCTOBER 2001

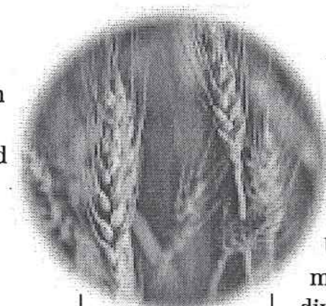
PARTICLEBOARD AND MEDIUM-DENSITY FIBERBOARD

Since U.S. production of particleboard began after World War II, this practical and inexpensive alternative to solid wood has become one of the nation's leading building materials. The floor you walk on, your workstation at the office, your household cabinets, and the walls and doors of your home may well contain particleboard (PB) or medium-density fiberboard (MDF), a similar product whose manufacture began in the United States in the mid-1960s.

Production and use of PB and MDF have grown dramatically in the past decade, replacing more and more solid wood lumber and plywood products. In fact, the combined production of PB and MDF in North America during 1999 was approximately 10.7 million cubic meters (over 12 billion square feet of 3/8-inch thick panel).

Though easy to produce and well-suited for a host of uses, most PB and MDF, as currently manufactured, use formaldehyde-based resins, which emit formaldehyde gas from factories, into the workplace, and into the home. Formaldehyde is considered a probable human carcinogen, and inhalation of even small amounts of the gas can increase risks of cancer. Some manufacturers are now turning to more benign resins to bind the wood products.

Meanwhile, though PB and MDF are currently manufactured primarily from wood residues from production of lumber and plywood, there is the opportunity to utilize post-consumer waste wood and waste paper and agricultural residues as raw materials. Use of these materials can divert wastes from landfilling or burning.



The amount of agricultural waste fiber far exceeds present and future fiber requirements for production of PB and MDF.

These alternative materials include straw residue, which is the stem of a grain crop, such as rice or wheat, and bagasse, the residue from sugar cane processing. The amount of agricultural waste fiber far exceeds present and future fiber requirements for production of PB and MDF. Most residual straw and bagasse is now burned, which contributes to air pollution and global warming.

From an environmental standpoint it is also important to make sure that the recycled content of wood-fiber-based PB and MDF is as high as possible and that little, if any, virgin wood is used. Recycled content saves trees.

This report evaluates various methods of producing PB and MDF and the associated environmental and health impacts. It also makes recommendations that will inform consumers and guide them to environmentally preferable—and safer—PB and MDF products.

WHAT'S WHAT: SOME KEY DEFINITIONS

Post-consumer Materials: Materials or finished products that have served their intended use, been diverted or recovered from waste destined for disposal, and formed into useful consumer items. Post-consumer materials are part of the broader category of *recovered materials.*

Pre-consumer Materials: Materials generated by manufacturing and converting processes, such as manufacturing scrap and trimmings/cuttings. Also called post-industrial materials.

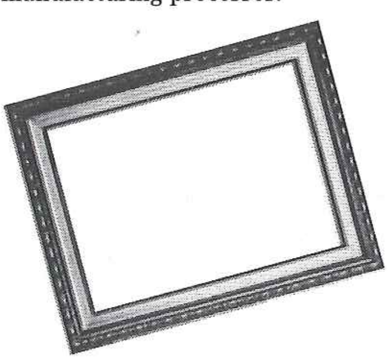
Recovered Materials: Waste materials and byproducts that have been recovered or diverted from solid-waste streams; this category does not include materials and byproducts generated from, and commonly reused within, an original manufacturing process.

Resin: The chemical material that binds the fibers together to produce particleboard or medium density fiberboard. Also called "binder."

PB and MDF: Hard-Pressed and Bonded for Life

Particleboard (PB) is a panel product made of sawdust and wood shavings bonded together by urea formaldehyde or other synthetic resin and pressed into sheets. Used primarily as core material for doors, furniture, and cabinets, particleboard often is covered on one or both sides with veneer or another surface finish. In housing construction, particleboard is used under carpet or other finished surfaces as floor underlayment and stair treads; it is also used as floor decking in mobile homes.

Medium-density fiberboard (MDF), a composite board made of wood fibers bonded with urea formaldehyde or other synthetic resin, has a smooth surface and good machinability. MDF is used as a replacement for wood boards in furniture, cabinets, moldings, and picture frames. Like PB, the wood residues used to manufacture MDF come from sawdust and shavings from lumber and plywood manufacturing processes.



The manufacture of PB in the United States began on a large scale after World War II as a low-cost replacement for lumber and plywood in furniture and cabinetry. Some twenty years later, in 1966, the first North American MDF plant began production in New York. Demand for PB and MDF has grown dramatically in the past decade, replacing more and more solid wood lumber and plywood products.

While demand for PB and MDF is increasing, there are concerns that the availability of wood residues is not keeping pace with this demand and that the price is increasing. This has led some producers to look toward alternative sources of fiber, such as agricultural waste products and wood and paper waste. Aside from any economic advantage, these alternatives also present environmental benefits such as diversion of waste from landfills or burning.

The ***Choose Green Report*** is published for Green Seal Environmental Partners. To become an Environmental Partner, or to receive a copy of this report, contact Green Seal at (202) 872-6400 or greenseal@ greenseal.org.

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GREEN SEAL
Environmental Partner

If These Walls Could Talk

Environmental Impacts of PB and MDF

A portion of the trees cut for lumber and plywood production become sawdust and trimmings that are used in PB and MDF. If trees are harvested for direct use in these products, then the impacts from growing and harvesting these trees must be considered as part of the environmental profile of PB and MDF. Information obtained from industry sources shows that approximately 25% of the production capacity in the U.S. and Canada uses some virgin wood in their products, ranging from 1 to 80% virgin content, averaging 34%.

The wood residues are either ground into particles (for PB) or steam heated to break down the residues into fibers (for MDF), then dried to lower moisture content. Many dryers are directly heated by combustion of a portion of the wood residues; others are heated by burning oil or natural gas. Dryers release wood dust, carbon monoxide, carbon dioxide, nitrogen oxides, fly ash, volatile organic compounds—such as terpenes, resin, and fatty acids—that evaporate from the wood, and combustion and pyrolysis products, such as methanol, acetic acid, ethanol, formaldehyde, and furfural.

After the fiber is dried, it is blended with wax, a synthetic resin such as urea formaldehyde, and other additives and formed into mats. The mats are processed in large presses that use heat and pressure to cure the resin and form the product into sheets or boards. Presses are usually heated by steam, which is generated by a boiler that burns wood residues.

The type of resin used to bind the wood fibers determines the type of air emissions released during the pressing process; typically these emissions include formaldehyde compounds, such as urea formaldehyde. Primary finishing steps for PB and MDF include cooling or hot stacking, grading, trimming/cutting, and sanding. Secondary finishing steps include filling, painting, laminating, and edge finishing.

When used in the home in furniture, subflooring, or stair treads, PB and MDF made with formaldehyde-based resins continue to release small amounts of formaldehyde gas. Producers have generally met industry standards and have reduced formaldehyde emissions from PB an average of 80 percent below 1980 levels, primarily by reducing the ratio of formaldehyde to urea in resin formulations.

Because no threshold has been determined below which exposures do not increase the risk of cancer, formaldehyde remains a health concern even at lower levels.

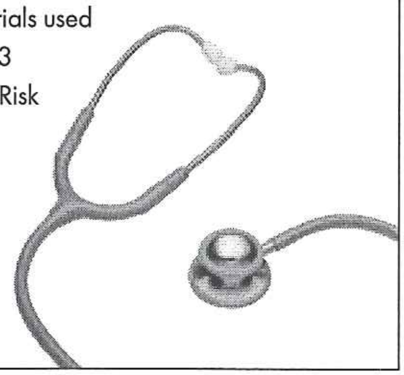
FORMALDEHYDE TOXICITY

According to the EPA, formaldehyde is a probable human carcinogen when inhaled or ingested. In fact:

- Breathing even small amounts of formaldehyde may increase the risk of contracting lung and nasal cancer.
- Chronic formaldehyde exposure can cause menstrual disorders and pregnancy problems in women workers exposed to higher levels.
- Short-term inhalation exposure can result in eye, nose, and throat irritation and respiratory symptoms.

Standards have been set by industry for formaldehyde emissions from all wood products and by the U.S. Department of Housing and Urban Development for wood products in manufactured homes.

American National Standards Institute (ANSI) standards for particleboard flooring products restrict formaldehyde gas emissions to 0.2 parts per million (ppm) as measured in the American Society for Testing and Materials (ASTM) large chamber test. All other materials must emit less than 0.3 ppm to meet the ANSI standard. HUD regulations for materials used in mobile homes limit emissions to 0.3 ppm. According to EPA's Integrated Risk Information System, if these levels were to occur in indoor air, and an individual had lifetime exposure, the risk of cancer would be higher than generally considered acceptable.



However, because formaldehyde is believed to cause cancer, and because no threshold has been determined below which exposures do not increase the risk of cancer, formaldehyde remains a health concern even at these lower levels.

Greener Choices

Alternative Fiber Sources

Clear the Air, Clear the Fields by Using Agricultural Waste Fiber

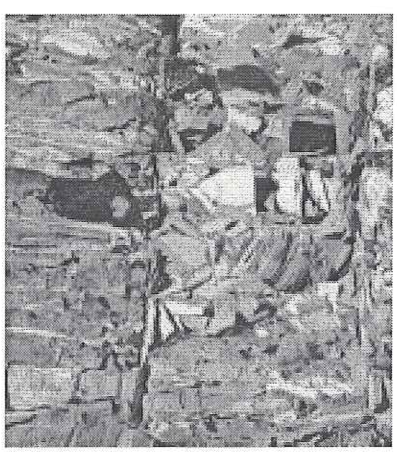
Straw is the stem of a small-grain cereal plant, such as wheat or rice, or the shaft left after the growing of grass for grass seed. While some straw is left to condition the soil, in many places it is cleared from fields after grain harvest by burning, which has caused serious air pollution problems. For example, some 500,000 acres of rice fields in California's Sacramento Valley produce about 1.5 million tons of rice straw that traditionally was burned in the field each year. Such burning was creating 56,000 tons of carbon monoxide annually in California alone, along with particulate matter, carbon dioxide, and other air pollutants.

Some 500,000 acres of rice fields in California's Sacramento Valley produce about 1.5 million tons of rice straw that traditionally was burned in the field each year.

Because of adverse health effects associated with such pollution, California is phasing out straw burning and is requiring rice growers to find alternative means of straw disposal. Meanwhile, wheat production in the Midwest and the cultivation of bluegrass for grass seed in the Northwest are producing large amounts of straw. For PB and MDF manufacturers, this is a case of one industry's trash being another industry's treasure. In fact, the amount of residual straw generated by U.S. agriculture (estimated at over 100 million metric tons) far exceeds present and future fiber requirements for PB and MDF manufacture.

Bagasse, another source of fiber for PB and MDF, is the residue from the processing of sugar cane for sugar production. This waste product is currently disposed of in large quantities in Louisiana, Florida, and Hawaii. In fact, more than 4.5 million tons of bagasse generated each year in the United States is typically burned in steam boilers, which creates more air emissions than other energy sources, such as natural gas.

Using straw or bagasse as the fiber for PB and MDF provides an alternative to burning straw in fields or disposing of bagasse by burning it in steam boilers. Although processing straw into PB and MDF is similar to processing wood residues, breaking straw into fibers requires less processing and less drying, therefore less energy use.



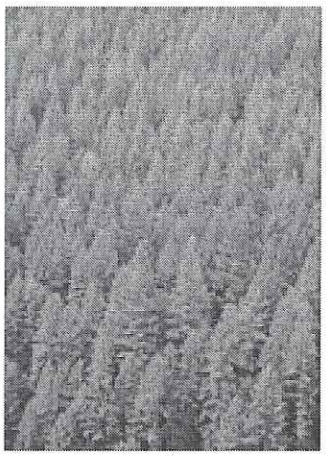
In addition, the properties of strawboard, such as internal bond strength, resistance to rupture, moisture resistance, and screw-holding strength (as measured by tests developed by the American National Standards Institute or the American Society for Testing and Materials), are equal to or better than wood-based PB and MDF. And, because formaldehyde-based resins are not used with board made from straw and bagasse, the resulting product does not carry the health risks associated with formaldehyde.

Currently, six plants in the United States produce PB and MDF from straw and bagasse. These include strawboard plants in North Dakota (Primeboard, Inc.), Minnesota (Isoboard Enterprises), California (Fiber Tech), and Idaho (Pacific Northwest Fiber) and sugar cane bagasse plants in Louisiana (Acadia Board) and Hawaii (Hawaiian DuraGreen). Another strawboard plant, which will use rice straw, is under construction in California. These plants are located near the sources of the straw or bagasse to keep transportation to a minimum.

Reduce the Waste Stream through Use of Post-Consumer Wood and Paper

The solid-waste stream in the United States contains approximately 16 million tons of recoverable solid wood waste from the municipal, construction, and demolition solid-waste streams. In addition, 79 million tons of waste paper disposed of each year could provide another source of fiber for PB and MDF. Using post-consumer wood and paper waste for PB and MDF could potentially divert some 95 million tons from landfills and decrease the harvesting of trees. Locating PB and MDF plants near urban areas would provide access to wood and paper wastes and place the finished product in proximity to users.

One company, Homasote, produces an MDF-like board from post-consumer recycled waste paper, recycling approximately 80,000 tons per year. Homasote uses a formaldehyde-free wax emulsion as the binder and a closed-loop manufacturing process that recycles all water used. Unfortunately, while there are PB products available that are made from recycled wood products, such as waste pallets, they use formaldehyde-based resins.



Reduce the Waste Stream by Using Pre-consumer Recycled and Recovered Wood Residues

Most PB and MDF contains wood residues from lumber and plywood production. The PB and MDF industries, along with other panel industries, consume approximately 10 million metric tons of these wood residues per year. Depending on the plant and the process, these raw materials may be considered pre-consumer recycled content or recovered materials.

Pre-consumer and recovered materials are those that otherwise would end up in the solid waste stream. PB and MDF with high content of pre-consumer and recovered materials divert wood waste from disposal and is an indication that little or no wood fiber was produced and harvested for direct use in the product. Some manufacturers have had the pre-consumer and recovered material content of their PB and MDF certified by independent certification organizations. Most producers of PB and MDF with pre-consumer recycled wood content, however, use formaldehyde resins in the board.

Promote Sustainable Forest Practices by Using Sustainably Managed Wood Sources

Even if the wood fiber for PB and MDF is pre-consumer recycled and recovered material, by demanding that this wood fiber be from trees grown and harvested in a sustainable manner, builders can reduce the overall impacts of forestry practices for lumber and plywood products. There are organizations that certify wood products that have been produced with wood from sustainably managed forests. For instance, the Forest Stewardship Council and its independent certifiers apply criteria to certify that the source of wood for products is a "well-managed" forest: one that maintains the essential characteristics of a natural forest before and after a timber harvest. FSC standards of well-managed forestry carefully balance ecosystem health with the amount of timber harvested from the forest. Invasive management techniques, like clear-cutting and biocide use are minimized. Non-invasive management practices such as riparian buffer zones, balanced-age distribution, and integrated pest management are always preferred over invasive techniques. PB is available containing wood fiber derived from sustainable forestry, but these products currently use formaldehyde-based resins.

Alternative Resins

Methylenediphenyl Isocyanate (MDI)

The most widely used alternative to urea formaldehyde for PB and MDF is methylene-diphenyl isocyanate (MDI). Unlike most wood-based PB and MDF products that are made with formaldehyde-based adhesives, products made with MDI do not emit a toxic gas during use. While MDI has other advantages, such as the ability to bond to wood particles with higher moisture content and requiring less dryer energy and lower press temperatures (which may lower air emissions), there are concerns about MDI toxicity for workers exposed during PB and MDF manufacturing. MDI can be used

MDI TOXICITY

MDI is a hazard for workers in PB and MDF plants, although controls to prevent exposure are generally in place. MDI can cause dermatitis and respiratory diseases in workers and may alter the immune system, resulting in sensitization of the respiratory system and asthma-like reactions. It is not considered a carcinogen in humans, but there is limited evidence of tumors in animals. While OSHA's Permissible Exposure Limit for MDI in the workplace is less than that for formaldehyde (0.02 ppm versus 0.75 ppm), MDI does not present an exposure risk in the finished PB and MDF products.

for wood-based PB and MDF and for products made with agricultural residues, for which formaldehyde-based adhesives are generally not suitable.

Naturally Derived Adhesives

Environmental and human health concerns have prompted researchers to develop naturally derived adhesives and resins for wood products. While alternatives, such as resins manufactured from furfuryl alcohol or lignin chemicals, have been demonstrated in the laboratory, they have not been embraced by manufacturers of PB and MDF. A strawboard, available in the United Kingdom under the name Stramit, uses the natural lignin in straw, together with high temperatures and pressures, to bind the straw fiber; this type of strawboard is not currently manufactured in the United States.

Market Survey: What's Available

There are three categories of greener PB and MDF available on the market:

1. **Agricultural Waste Fiber, Formaldehyde-Free:** agricultural residues that would have been burned, bonded with a formaldehyde-free resin;

2. **Post-Consumer Waste Fiber, Formaldehyde-Free:** post-consumer paper waste, bonded with a formaldehyde-free resin;

3. **Recovered Wood Fiber and Formaldehyde-Free:** pre-consumer wood residues, bonded with a formaldehyde-free resin.

Recommended Particleboard and Fiberboard Products

AGRICULTURAL WASTE FIBER, FORMALDEHYDE-FREE

MANUFACTURER (BRAND)	PRODUCT DESCRIPTION	FIBER SOURCE	RENEWABLE/ SUSTAINABLY HARVESTED	PRODUCT AVAILABILITY	PERFORMANCE STANDARDS
Isoboard (Isoboard, StorageBord, ShelfBord and IsoUnderlay)	Strawboard	Wheat Straw	Annually renewable	Home Depot, Lowe's, Isobord's Global Sales Office	Meets ANSI-M3 (particleboard) standards at Guaranteed Property Performance Levels
PrimeBoard	Strawboard	Wheat Straw	Annually renewable	Multiple distributors	Meets ANSI-M3 standards
Pacific Northwest Fiber (PacificBoard)	Strawboard	Bluegrass Straw	Anually renewable	Available for immediate shipment	Moisture-resistant; laboratory tests conducted by company show superior strength, campared to wood-based particleboard
FiberTech	Agrifiber composite panel (Mainly door cores; also some industrial board and underlayments)	Rice Straw	Annually renewable	Door cores sold to door manufacturers	Meets ANSI standards for particleboard and fiberboard
Acadia (DuraCane)	Particleboard	Bagasse	Annually renewable	Available directly from the company	Excellent moisture resistance, high hardness and moduli of rupture (MOR) and elasticity (MOE); exceeds MDF standards
Hawaiian DuraGreen	Particleboard	Bagasse	Annually renewable	Panel Source International is the exclusive sales agent	Highly moisture-resistant; internal bond values greater than 200 psi; tight screw holding (contact company for details)

Recommended Particleboard and Fiberboard Products

POST-CONSUMER WASTE FIBER, FORMALDEHYDE-FREE

MANUFACTURER (BRAND)	PRODUCT DESCRIPTION	FIBER SOURCE	RENEWABLE/ SUSTAINABLY HARVESTED	PRODUCT AVAILABILITY	PERFORMANCE STANDARDS
Homasote	Fiberboard	100% post-consumer recycled newsprint	Post-consumer newsprint supply exceeds current demand	Most lumber and home center locations; network of dealers	Products comply with building codes for various applications (contact comapny for details)

RECOVERED WOOD FIBER, FORMALDEHYDE-FREE

MANUFACTURER (BRAND)	PRODUCT DESCRIPTION	FIBER SOURCE	RENEWABLE/ SUSTAINABLY HARVESTED	PRODUCT AVAILABILITY	PERFORMANCE STANDARDS
SierraPine (Medex, Medite II and Medite-FR)	Medium-density Fiberboard	100% recovered and preconsumer recycled wood fiber	N.A.	Multiple distributors	Meets ANSI 208.2-1994 standards for MDF

MANUFACTURER CONTACT INFORMATION

Isoboard. .... http://www.isoboardenterprises.com 503-242-7345

Primeboard. .... http://www.primeboard.com 701-642-1152

PacificBoard .... http://www.pacificfiber.com 208-686-6800

FiberTech 530-458-4547

Acadia 727-393-9668

Hawaiian DuraGreen .... http://www.hawaiianduragreen.com 808-877-2942

Homasote .... http://www.homasote.com 800-257-9491

SierraPine .... http://www.sierrapine.com 800-334-2250

GREEN SEAL
1001 CONNECTICUT AVE., NW
SUITE 827
WASHINGTON, D.C. 20036

IN THIS ISSUE

— ***Recommended Particleboard & Medium-Density Fiberboard***
— *Environmental Impacts*
— *Greener Choices*
  — *Alternative Fibers*
  — *Alternative Resins*
— *Market Survey*

Guidelines and Standards

EPA Comprehensive Procurement Guideline for Fiberboard

EPA has adopted a Comprehensive Procurement Guideline for Structural Fiberboard containing recovered materials (80–100% recovered material required). Structural fiberboard is a panel made from wood, cane, or paper fibers matted together which is used for sheathing, structural, and insulating purposes. Examples of these products include building board, insulating formboard, and sheathing. Any Federal agency, or any state agency that is using appropriated Federal funds for procurement, is required to purchase products meeting this guideline. See http://www.epa.gov/cpg/products/fiberbrd.htm.

U.S. Department of Agriculture Biobased Products List

A 1998 Executive Order directs the U.S. Department of Agriculture to develop a list of biobased products that can guide agencies in their purchasing policies. Once the list is published, it may also be a useful reference. See http://www.usda-biobasedproducts.net.

Performance Standards

The American National Standards Institute (ANSI) and the American Society for Testing and Materials (ASTM) have adopted several performance standards for PB and MDF. If you are purchasing PB and MDF, you should determine the level of performance you need (a waterproof product, for example) and inquire as to whether the product meets those performance standards. For PB and MDF made from agricultural fiber, specifying the performance characteristics required may yield more eligible products than just referencing test methods, since many of the test methods for PB and MDF were developed with wood fiber products in mind. The recommended products table provides available information about performance standards met by the individual products.

hemp oil could be a very successful replacement for diesel oil

American farmers look across the border in Canada, which export hemp fiber to the U.S. and ask why can't we grow it. Jeffrey W. Gain, Blue Ridge Company, Hardin, Illinois; NAIHC Director and former CEO of both the National Corn Growers and American Soybean Association.

Industrial hemp might also be a profitable alternative crop to tobacco. A University of Kentucky study found that with the exception of tobacco, industrial hemp would be more profitable than any other Kentucky crop. *I first became interested in industrial hemp as an alternative to tobacco. United States farmers need a new crop, which would have a consistent industrial market. I've talked to many older Kentucky farmers who remember profitably growing industrial hemp.* Gale Glenn, Durham, North Carolina; NAIHC Vice-Chair and former Kentucky tobacco and cattle farmer.

We are growing, processing and supplying hemp fiber on an increasing basis to replace glass fiber for composites in the automotive sector. Geof Kime, Hempline, Delaware, Ontario, NAIHC Director who runs a hemp fiber separation facility that in 1994 brought in the first crop of industrial hemp in North America since the 1950s after being instrumental in persuading the Canadian government to change its policy.

The largest maker of industrial carpet in the world is focused on producing carpet that is biodegradable and result in full-life cycle sustainability: *Research proves that carpet made from industrial hemp is both biodegradable and recyclable.* Dr. Raymond A. Berard, Senior Vice President of Technology, Interface Research Corporation, Kennesaw, Georgia and NAIHC Director.

Over half the states have enacted or are considering laws to either allow industrial hemp cultivation and/or petitioning the federal government to reclassify industrial hemp as no longer being legally defined as a drug. *North Dakota has changed its laws to again allow for the growing of industrial hemp. My friend across the border in Manitoba, Canada, is making money raising industrial hemp. I am losing money by raising wheat.* State Representative David Monson, (R- Osnabrock), Assistant majority leader, ND House of Representatives, NAIHC Director, farmer, full-time school superintendent, and a part-time insurance agent.

allow farmers to grow industrial hemp

action needed:

Encourage the DEA to remove industrial hemp from its classification as a drug. In meetings with the NAIHC, DEA officials have stated that it does not consider industrial hemp a drug or an enforcement problem. DEA has proposed new regulations that would allow industrial hemp to be grown. The new regulations have gotten sidetracked. These regulations need to be reviewed and an executive order issued to implement changes that will allow farmers to grow industrial hemp.

NAIHC
NORTH AMERICAN
INDUSTRIAL HEMP COUNCIL, INC.

KENAN INSTITUTE
ENGINEERING, TECHNOLOGY & SCIENCE

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(Printed on hemp blend paper • 40% Hemp, 40% Fax and 20% Cotton)

tree free

Appendix 1g

40% Hemp

THIS PAPER IS 20% COTTON 40% FLAX AND

THOMAS JEFFERSON DRAFTED THE DECLARATION OF INDEPENDENCE ON HEMP PAPER

INDUSTRIAL HEMP

INDUSTRIAL HEMP

George Washington and Thomas Jefferson both grew hemp. Ben Franklin owned a mill that made hemp paper. Thomas Jefferson drafted the Declaration of Independence on hemp paper. Industrial hemp (Cannabis sativa) was grown in the United States from the beginning of our nation's history up to the early 1950s. At that point, industrial hemp's legal status was changed when it was classified a dangerous drug. Subsequently, the growing and manufacture of industrial hemp products ended in the United States. Over 30 countries are currently developing a hemp industry to meet international fiber demands. The United States is not one of them.

Why not give back American agriculture an old crop for which new technologies are creating a large market so that our farmers can take a step towards profitability and sustainability? Erwin A. "Bud" Sholts, Chairman, North American Industrial Hemp Council (NAIHC); Principal, CTL Group, retired after 35 years with the Wisconsin Department of Agriculture, Trade and Consumer Protection.

Industrial hemp is not a drug crop. The international standard is that hemp of Cannabis with less than 1% THC is not marijuana. Strains that would likely be grown in the U.S. would be 0.3%, or less THC as is the case in Canada and the European Union.

Planting marijuana anywhere near industrial hemp would be ill conceived. When hemp pollinates marijuana it transfers the genes for low drug content to developing seeds of the marijuana. The drug potency in the new marijuana plants will be about half that of the original marijuana. When hemp repeatedly crosses with new marijuana plants obtained each year, the drug content is repeatedly reduced in the plants. Thus, the drug content will become so low and uncertain that the derived marijuana will be useless as a drug plant. Dr. Paul G. Mahlberg, Professor, Department of Biology, Indiana University; NAIHC Director who has held a Drug Enforcement Administration research license for cannabis research for 32 years.

The U.S. needs to become more sustainable in terms of fibers, fuels, and energy. A strong and viable agriculture is important to the national security. Current trade deficits and near depression conditions in agriculture are not a good recipe for long term national economic security.

Industrial hemp is a non-drug, earth-friendly, industrial crop that can help reduce greenhouse gas emissions and achieve a greater level of U.S. energy independence. R. James Woolsey, Shea & Gardner, Washington, D.C.; Legal counsel to NAIHC and former Director of the Central Intelligence Agency, 1993-1996.

The widespread use of industrial hemp could result in numerous environmental benefits, including but not limited to: (1) Less reliance on fossil fuels, (2) more efficient use of energy, (3) less long-term atmospheric build-up of carbon dioxide, (4) soil redemption, (5) forest conservation, (6) agricultural pesticide use reduction, (7) dioxin and other pollution reduction, and (8) landfill use reduction. Hemp is superior to many other plants for a variety of uses.

Industrial hemp is being grown in Canada, just a few miles from the United States border. Raw hemp is being imported into the United States for manufacture of products. A growing market exists for Omega-3 rich hemp seed and oil products including snack foods, body care and supplements. Several thousand businesses, including Fortune 1000 firms, are participating in this market. With raw materials for these products being imported, U.S. farmers are deprived of the economic benefits stemming from these new markets.

The demand for building material is also growing at a rapid rate. A United Nations Study conducted in the mid-1990s predicts a world fiber shortage by 2006. *Industrial hemp can be a major raw material for construction products and the machinery and technology are already available. Hemp oil could be a major player in reducing the fuel crisis. Hemp oil could be a very successful replacement for diesel oil.* William C. "Bill" Miller, President, Miller Consulting Group, Jackson, Mississippi; NAIHC Director and retired from Union Camp Corporation.

Industrial hemp can be utilized quite effectively in paper manufacture. Curtis P. Koster, Principal, Technology Evaluation & Economic Analysis, Malcolm Associates Investment Consultants, Mahwah, New Jersey; NAIHC Director and retired from International Paper with his last job as Interdivisional Business Development Manager-Technology, still consults for International Paper.

Industrial hemp, with its long natural fiber length, would be valuable in a composite with other fibers making the end product more flexible facilitating a broader range of uses. Dr. Shelby F. Thames, Distinguished University Research Professor, University of Southern Mississippi and former NAIHC Director.

A limiting factor in sustainable agriculture is the lack of profitable rotation crops. Hemp could be quite profitable as it fits well into the corn-soybean rotation. The University of Minnesota has suggested that the corn-soybean rotation is unsustainable. Farmers are losing money and equity on the corn-soybean rotation. In North Dakota, farmers have been making more by selling wheat straw to particleboard plants than from the wheat itself. Due to the bulkiness of hemp fiber, processing facilities will have to be built near the production areas. This will provide new jobs and investment in rural America.

Major markets have opened up for hemp fiber in the United States. We are importing Canadian and European hemp, since it is illegal to grow hemp here in the United States. Hugh S. McKee, President, Flaxcraft, Inc., Cresskill, New Jersey; NAIHC Director.

Appendix 1h

GENERAL INFORMATION

The following technical notes are recommended instructions for the practical use of FASWALL Building Systems. Jobsite conditions, worker experience, or other factors may sometimes make it necassary to deviate from these instructions, but under no circumstances should applicable building codes or standard construction practices be ignored.

WALLFORM DEFINITION

Wallforms (WF or form blocks) are cast from wood-concrete, a mixture of K-X® Aggregate (mineralized wood chips) and portland cement. The wallforms are designed as stay-in-place wallforming units which become part of a load-bearing wall only after being filled with reinforced concrete **(See Figure 1)**.

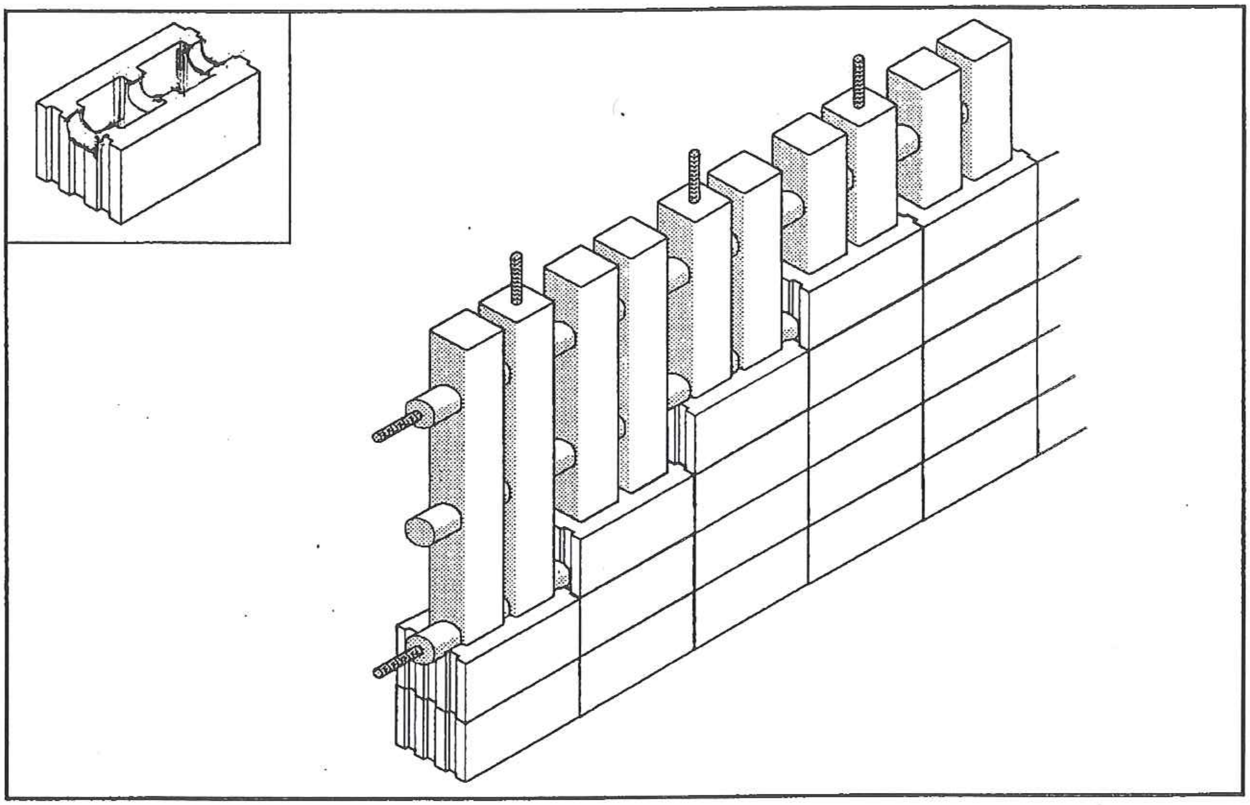


FIGURE 1

It is important to note that FASWALL wallforms are not designed as load bearing concrete masonary units, and mortar should be used only as a bed for leveling the first course of wallforms on a footing or slab that is uneven.

UNLOADING AND CONTROL OF WALLFORMS ON PALLETS

Carefully unload the wallform pallets, placing them on level ground close to the jobsite where they will be used. When unloading by hand, use caution and avoid reckless handling of the wallforms.

Check each pallet for wallforms that have been damaged in shipment. After examination of the shipment, set aside on a separate pallet any wallforms that have been cracked or broken and are not safe for use. It is important to notify the distributor or manufacturer so that arrangements can be made for the replacement of the defective wallforms. All damages should be noted on the trucking company's delivery ticket and the driver should verify the damage and sign the papers before the truck leaves the jobsite. Claims for damaged products should be made promptly and the distributor of the FASWALL should be made aware of the claim

LAYOUT OF THE JOBSITE (FIGURE 2)

Thoroughly study the building plans and make note of all details that must be given special consideration throughout the project.

The footing or slab should be checked with a level to assure accuracy. Areas of the footing/slab that are uneven should be marked with a black marker.

Starting with the perimeter walls, determine the best wallform layout using combinations of the 8" and 16" modular wallform sizes (8" high). Use a red marker to layout on the footing/slab the placement of vertical rebars.

Use an orange marker to layout on the footing/slab the locations of door and window openings.

Use a blue marker to layout on the footing/slab the positions of electrical conduits or pipes.

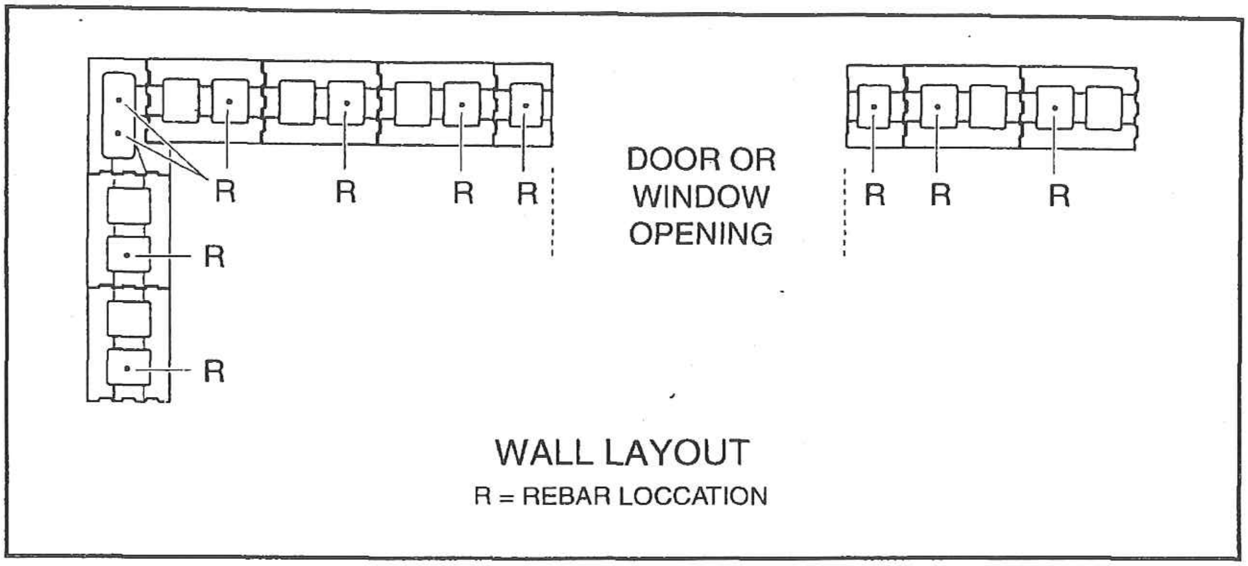


FIGURE 2

WALLFORM ERECTION

Before workers begin to lay the wallforms, they must understand that the forms are not conventional concrete blocks. FASWALL wallforms must be handled with more care and placed more carefully in order to make proper use of the precise sizing and interlocking design.

If there are any questions about the proper use of FASWALL building systems, do not hesitate to contact the FASWALL distributor or manufacturer. In order to realize all the benefits and advantages of the system, it is vitally important that the system be used correctly.

NOTE:

- FASWAll wallforms have a rough surface and are cut with carpenter's tools (carbide tipped saw blades, etc.). Workers should wear eye protection and gloves when cutting and handling the wallforms.
- Wallforms must be layed tight with no spaces between adjoining forms. adjust the positions of the wall-forms with a fist, the heel of the hand, or by striking a piece of wood placed firmly against the form. never strike the wallform with a hammer.

1. FOUNDATION/SLAB DESIGN

1.1. Foundations/slabs shall be designed/engineered and constructed in accordance with all applicable building codes and ordinances. The design professional can use the following information in the calculation of the dead weight of the completed FASWALL wall assemblies. These weights should be considered in the foundation/slab design. **See Table at top of page 3.**

WALLFORM WIDTH/TYPE	8' WALL HEIGHT (12 ROWS WALLFORMS)	17' WALL HEIGHT (25 ROWS WALLFORMS)
(AVERAGE WET WEIGHT FIGURED PER LINEAL FOOT)		
11-1/2" HEAVY DUTY	1002 LBS/LF	2292 LBS/LF
11-1/2" DOUBLE	828 LBS/LF	1759 LBS/LF
11-1/2" HEAVY DUTY WITH INSULATION	942 LBS/LF	2001 LBS/LF

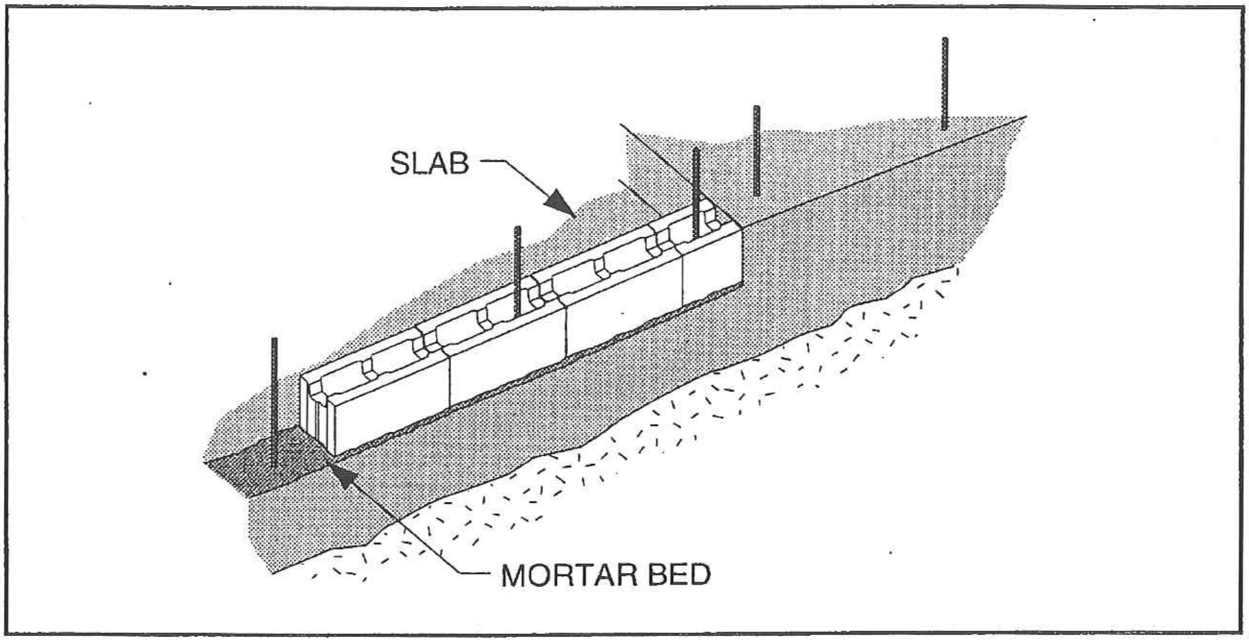


FIGURE 3

2. FIRST COURSE

2.1. One should have the necessary materials on hand for framing the rough window and door openings; using 2x8 or 2x10 lumber with 11-1/2" wide wallforms. Window and door framing can be left in place or removed after the concrete infill has been completed and cured.

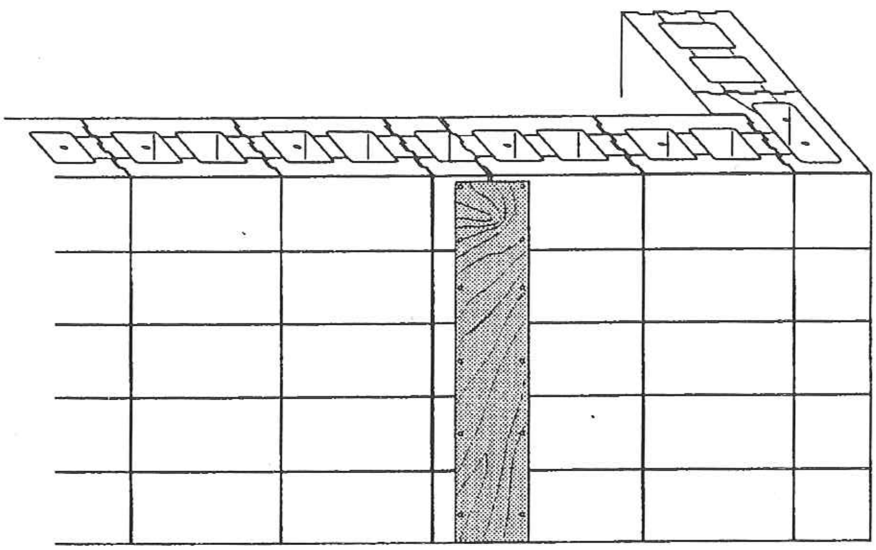
2.2. Layout windows and doors so that full modular wallform sizes are used to complete the walls. Cutting of wallforms should be avoided whenever possible. If it is necessary to cut wallforms, locate the cuts between windows and doors and maintain whole wallform units around the openings.

2.3. Setting the first course properly is absolutely essential for the construction of a level, plumb, and square structure. Because footings and slabs are never 100% level and true, the first course should be set in a 1/2" inch thick mortar bed which will allow for accurate leveling and squaring of the first course **(Figure 3)**. We suggest that the first course be layed as follows:

- In order to avoid working with a too dry mix, work 10' sections of wall at a time.
- Use a string and a 4' level to properly align and level the wallforms. Check positioning of wallforms frequently to assure control of all three planes. With FASWALL, "close" is not good enough. Proper construction requires accuracy.
- Some workers will benefit from the erection of 2x4 lumber bracing for the more rapid and more accurate (vertical) layup of corners. By erecting the corners first, stringlines can be pulled which will enable rapid positioning of the courses in-between.
- Always make certain that the male and female ends of the wallforms mate properly. They are designed to fit together tightly, assuring maximum insulation value and fire resistance. DO NOT use fasteners (nails, screws, etc.) to join wallforms.

First Course, Continued:

- When a wallform has been cut to a shorter length and placed within a course, fasten a piece of 1/2" plywood over the cut end and the joint with the next form before placing concrete within it. The plywood should be securely screwed into the solid webs of the wallforms adjacent to the cut. Proper attention to this detail will assure that the cut wallform will hold up when the forms are filled with wet concrete **(See Figure 4).**



SECURE SHORTENED WALLFORMS TO
ADJACENT FORMS WITH PLYWOOD PATCHES

FIGURE 4

3. PLACING SUBSEQUENT COURSES AND PREPARING FOR CONCRETE FILL.

3.1. As subsequent courses of wallforms are set, DO NOT stagger the vertical joints. Stack the forms one directly over the other so that the columns will be correctly and fully formed.

3.2. As the courses are layed up, use thin wooden shims to correct any irregularities of either level or plumb.

3.3. The proper placement of reinforcing (whether steel or fiberglass) is very important. Because the FASWALL system is an engineered wall assembly, both vertical and horizontal bars must be correctly located.

NOTE: It is not necessary to tie the minimum 12" overlapping rebars to assure a flexible, monolithic post and beam structure (which is best for earthquake and hurricane resistance).

3.4. After setting wallforms to a height of 4' to 5', make certain that all electrical conduit is in place and that all framing and bracing for windows and doors is in place. Also double-check to verify that all cut wallforms have been reinforced or braced with plywood.

3.5. Call the building inspector and/or the licensed engineer to examine and approve the progress of the installation.

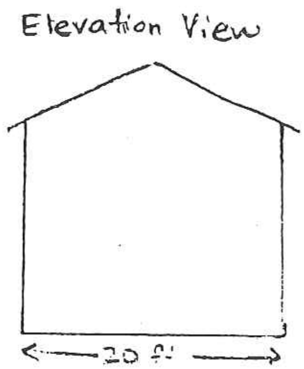
Appendix 1: Susan Ornelas
Arcata Comm. Farm
permaculture class

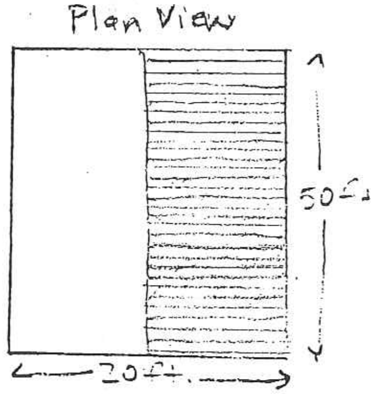
Rainwater Catchment System
Humboldt County

Assess the rainfall potential:

In Humboldt County it rains approximately 36 inches to 48 inches each year. We wil pick a number in the middle, 42 inches or 3.5 feet.

Next we look at our roof dimensions for catchment. Measure the roof from the plan view (birds eye view), ignoring any angle of the roof. If our house is 20 ft. x 50 ft., we have 20 ft. x 50 ft. = 1,000 sq. ft. We will anticipate an 80% efficiency in catching rain from the roof. This varies depending on the roof surface, but 80% is typical for shingled roof.





So how much rainwater could we catch from the roof in a year?

3.5 ft x 1,000 sq. ft x .80 = 2,800 cubic feet

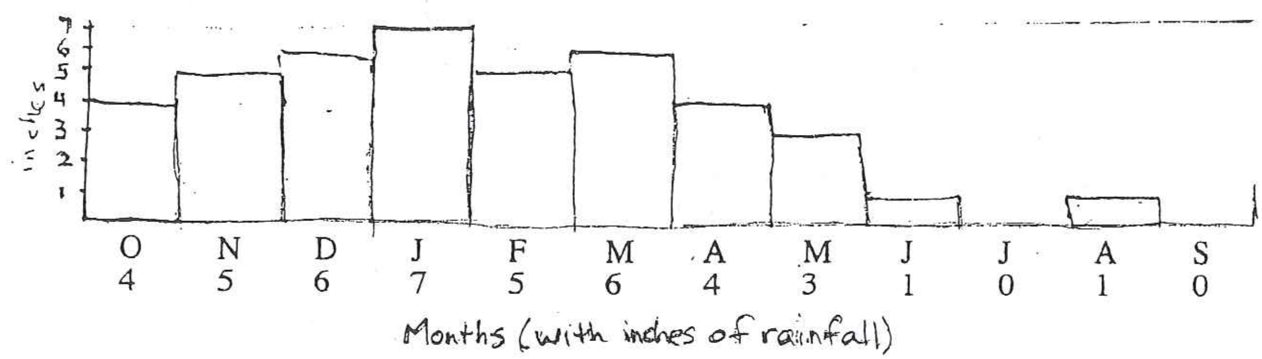
There are 7.5 gallons in a cubic foot:

2,800 ft^3 x 7.5 gals/ft^3 = 21,000 gallons

Now we have to understand how we wish to use this water. If this is to be the drinking water for the household we will analyze the use in one way. If it is to be irrigation water for summer production (through the dry season) we will analyze it in a different way. We will look at these two ways of analyzing this information.

Drinking Water for the Household:

For this situation we need to look at the rainfall pattern. Below is an approximate histogram of how rain falls in Humboldt County (in inches).



If we have a total of 21,000 gallons possible that could be collected in one year, and say we have 4 people in the household then how much water do we have available each day, per person?

21,000 gallons / 365 days = 57.5 gallons / day

57.5 gallons per day / 4 people = 14.4 gallons per day per person

The normal amount of water usage per person in America is between 100-150 gallons day. The minimum for survival is about 5 liters per day. It all depends on usage, washing machines, baths, dishwashing, etc. Lets say that there was no other method to get fresh drinking water and the people of this household will be happy to have 14 gallons day fresh water every day of the year. How big of a tank do we need?

One might consider that this family would need to build a tank to hold all 21,000 gallon. This is not necessary as the rain comes over a period of about 6 months, and the family uses some of the water along the way. What we do now is examine water use monthly and determine the amount of storage necessary when the largest amount of water will need to be stored. It goes like this:

Using the approximate month of 30 days: Each month the family of 4 uses 57.5 gallons per day or 1725 gallons/month.

Start at the beginning of the rainy season.

October: 4 inches rain

We have 4 inches of rainfall. Four inches is 4/12 or 1/3 of a foot.
[Remember 80% efficiency]

Running Total

1,000 ft^2 x 1/3 ft. x .80 = 266.6 ft^3
266.6 ft^3 x 7.5 gals/ft^3 = 2,000 gallons
Use - 1,725 gallons
Excess 275 gallons — **+275 g**

November: 5 inches rain

1,000 ft^2 x 5/12 ft. x .80 = 333.33 ft^3
333.33 ft^3 x 7.5 gals/ft^3 = 2,500 gallons
Use - 1,725 gallons
Excess 775 gals — **+ 1,050 g**

December: 6 inches rain

1,000 ft^2 x 1/2 ft. x .80 = 400 ft^3
400 ft^3 x 7.5 gals/ft^3 = 3,000 gallons
Use - 1,725 gallons
Excess 1,275 gals — **+ 2,325 g**

January: 7 inches rain

1,000 ft^2 x 7/12 ft. x .80 = 466.67 ft^3
466.67 ft^3 x 7.5 gals/ft^3 = 3,500 gallons
Use - 1,725 gallons
Excess 1,775 gals — **+ 4,100 g**

February: 5 inches rain

1,000 ft^2 x 5/12 ft. x .80 = 333.33 ft^3
333.33 ft^3 x 7.5 gals/ft^3 = 2,500 gallons
Use - 1,725 gallons
Excess 775 gals — **+ 4,875 g**

March: 6 inches rain

$1{,}000\ ft^2 \times 1/2\ ft. \times .80 = 400\ ft^3$

$400\ ft^3 \times 7.5\ gals/ft^3 =$ 3,000 gallons

Use - 1,725 gallons

Excess 1,275 gals — **+ 6,150 g**

April: 4 inches rain

$1{,}000\ ft^2 \times 1/3\ ft. \times .80 = 266.6\ ft^3$

$266.6\ ft^3 \times 7.5\ gals/ft^3 =$ 2,000 gallons

Use - 1,725 gallons

Excess 275 gallons — **+6,425 g**

May: 3 inches rain

$1{,}000\ ft^2 \times 1/4\ ft. \times .80 = 200\ ft^3$

$200\ ft^3 \times 7.5\ gals/ft^3 =$ 1,500 gallons

Use - 1,725 gallons

Excess Demand -225 gallons — **+6,200 g**

June: 1 inch rain

$1{,}000\ ft^2 \times 1/12\ ft. \times .80 = 66.67\ ft^3$

$66.67\ ft^3 \times 7.5\ gals/ft^3 =$ 500 gallons

Use - 1,725 gallons

Excess Demand -1,225 gallons — **+4,975 g**

July: no rain

Excess Demand -1,725 gallons — **+3,250 g**

August: 1 inch rain

$1{,}000\ ft^2 \times 1/12\ ft. \times .80 = 66.67\ ft^3$

$66.67\ ft^3 \times 7.5\ gals/ft^3 =$ 500 gallons

Use - 1,725 gallons

Excess Demand -1,225 gallons — **+2,025 g**

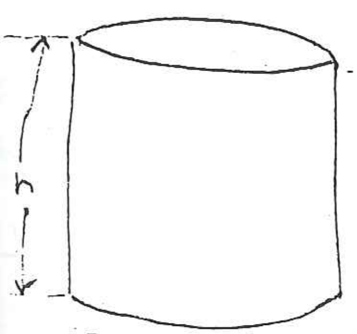
September: no rain

Excess Demand -1,725 gallons — **+ 300 g**

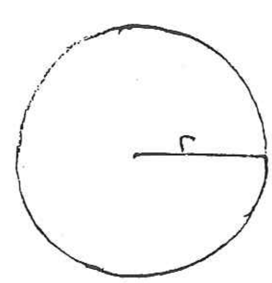
By our figuring have 300 gallons going into the next year. Actually we simplified each month to 30 days, thus the year actually has 5 more days than we accounted for. For all intents and purposes we have no water left in the cistern as we head into the new rainfall year.

So how big need we make the tank?

Look at the above storage needs for each month and pick the largest storage necessary. This is 6,425 gallons in April, towards the end of the rainy season. As this all is an approximation, and we want to assure adequate storage we will design our tank to hold 7,000 gallons. Note that this will be a much smaller (and less expensive) tank that one to hold all 21,000 gallons, the full years worth.



Elevation View



Plan View

r = radius

d = diameter = 2r

$Area = \pi r^2$

$\pi = 3.14$

$C = \pi d = 2\pi r$

(circumference)

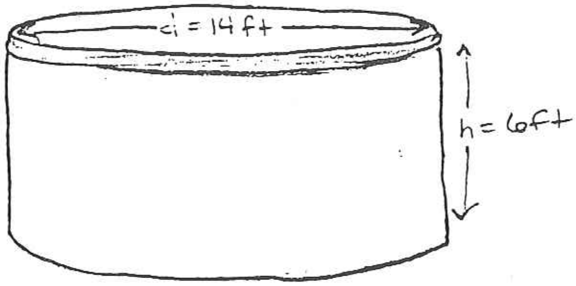
To figure the tank size, recall that the volume of a tank is described by:

V = Surface Area (A) x Height of tank (h)
$A = \pi r^2$ $\qquad \pi = 3.14$

We need a volume of 7,000 gallons or 933.33 ft^3 (7,000 gals / 7.5 gals per ft^3). Lets say we pick a cistern height of 6 ft.

$V = 933.33\ ft^3 = 3.14 \times r^2 \times 6$ ft.
$r^2 = 49.54\ ft^2$
$r = 7$ ft.

Thus we need a tank with a diameter of 14 feet.



Saving the water for summer irrigation:

To compare the cistern size necessary to provide this minimal amount of drinking water to this family, lets see how big of a tank we would need to hold the full amount of winter rainfall for summer irrigation:

Total rainfall caught by roof = 21,000 gallons or 2,800 ft^3
$V = 2,800\ ft^3 = 3.14 \times r^2 \times 6$ ft.
$r^2 = 148.6\ ft^2$
$r = 12.2$ ft.
Diameter of 24 .4 ft. - Are we talking about a pond?

How much ground could a person irrigate with this much water ?

Estimate crops need 1 inch (1/12 ft/) of water per week throughout the growing season. Lets talk in beds, 4 ft. x 100 ft. each. Thus each bed needs:

4 ft. x 100 ft. x 1/12 ft. of water each week

4 ft. x 100 ft. x 1/12 ft = 33.3 ft^3 each week

Say that through the months of June - September we will for sure need to water. This is 16 weeks.

33.3 ft^3 each week x 16 weeks = 533.3 ft^3 for each bed

We have 2,800 ft^3 so we can water about 5 such beds. This is approximately 1/10 of an acre.

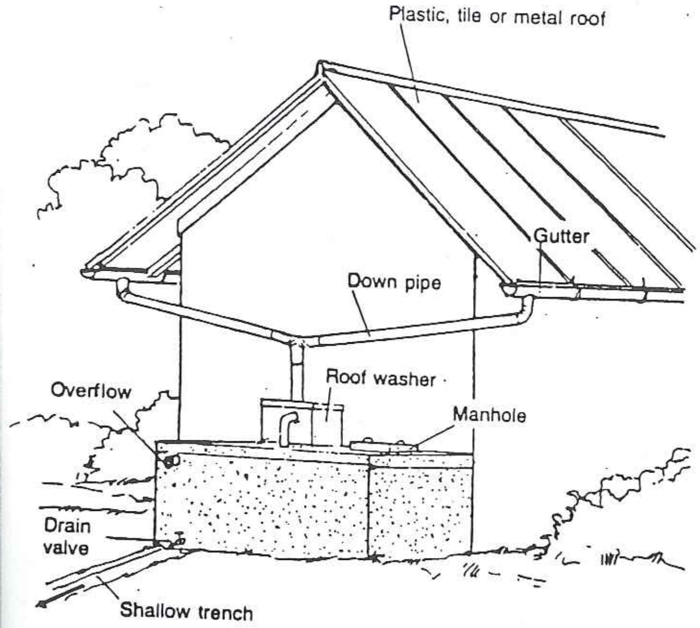


Figure 1a. Roof Catchment and Concrete Cistern

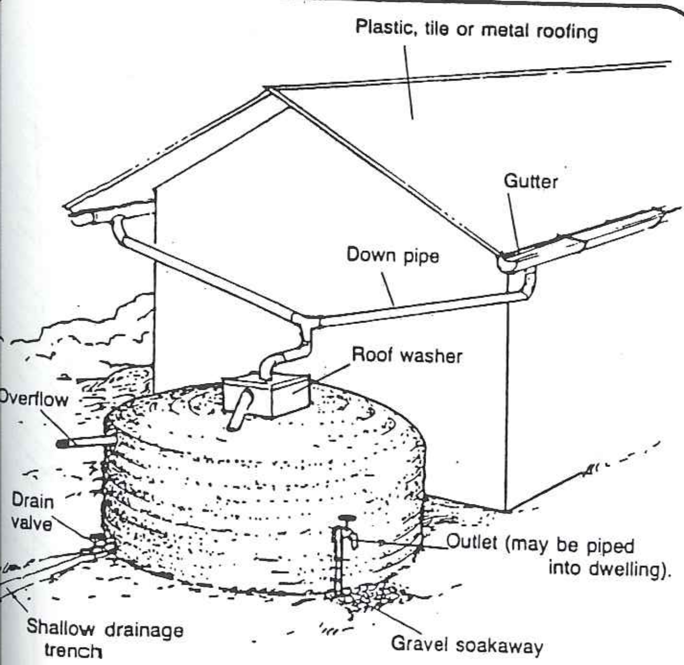


Figure 1b. Roof Catchment with Ferrocement Cistern

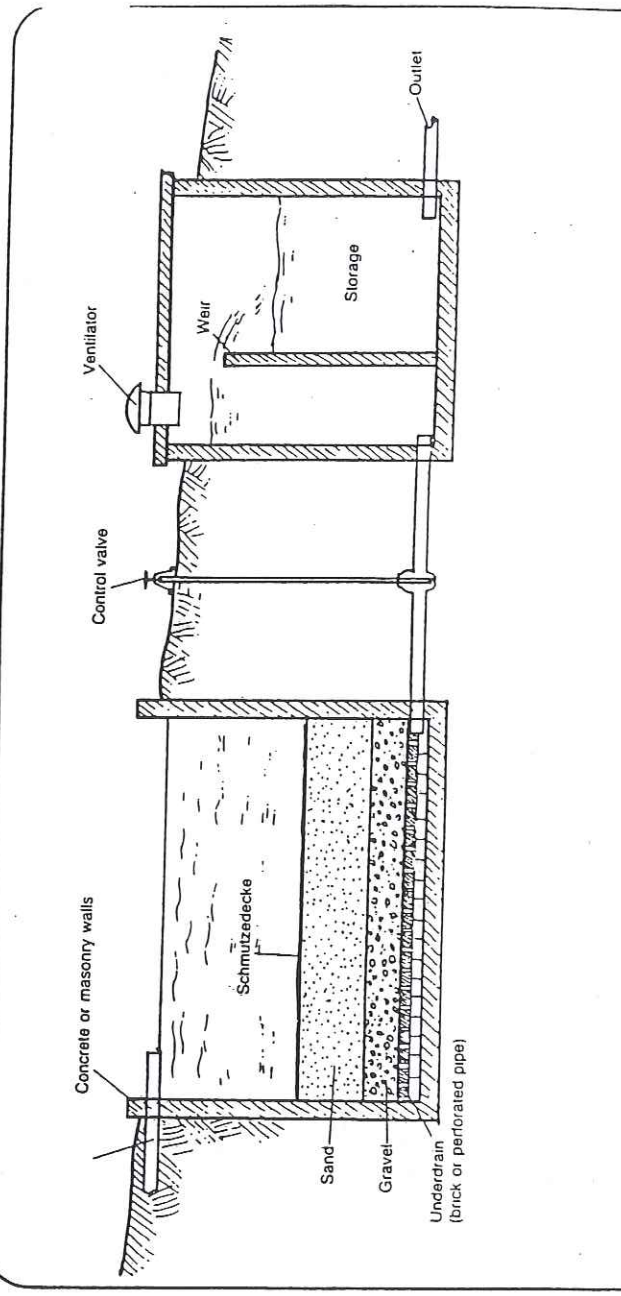


Figure 5. Slow Sand Filter and Storage Tank

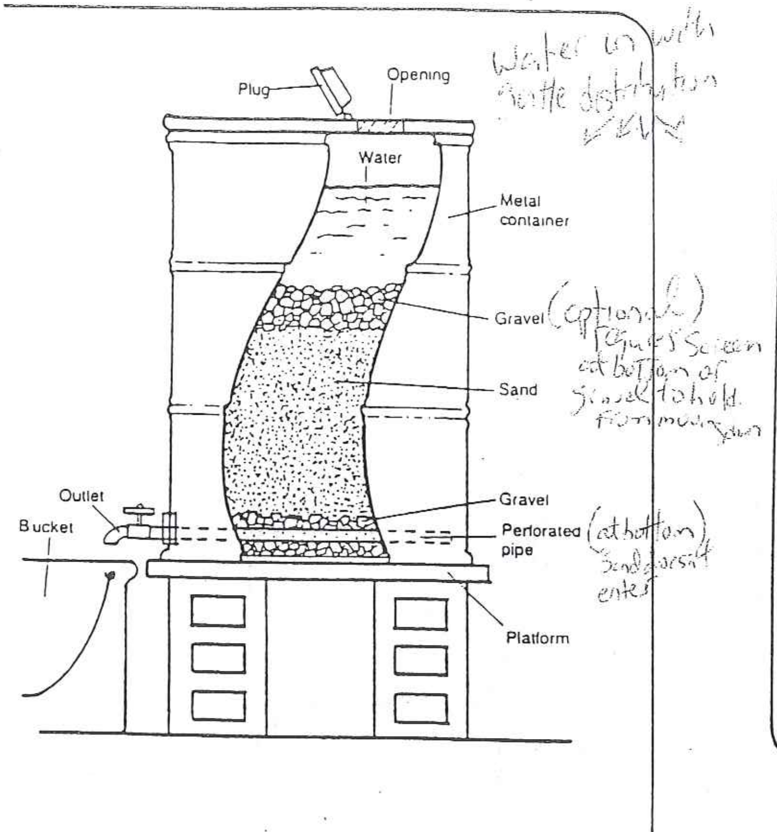


Figure 2b. Sand Filter

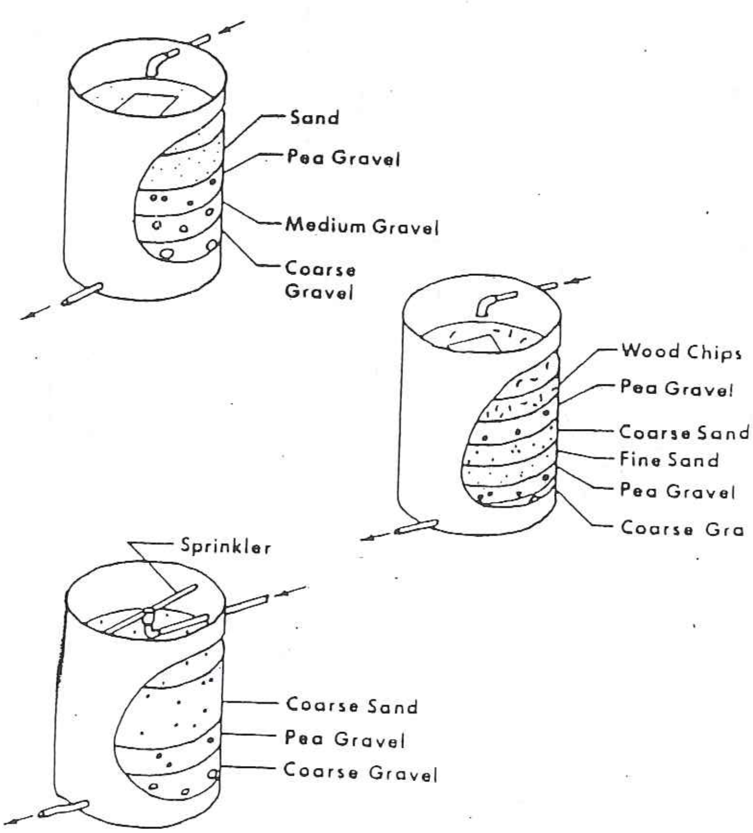


Figure 7.13 Simple sand filters.

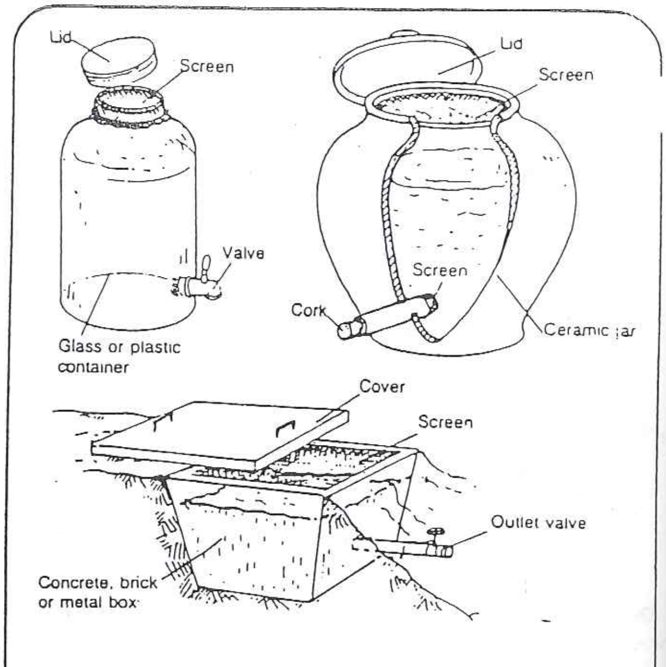


Figure 1. Methods of Household Storage

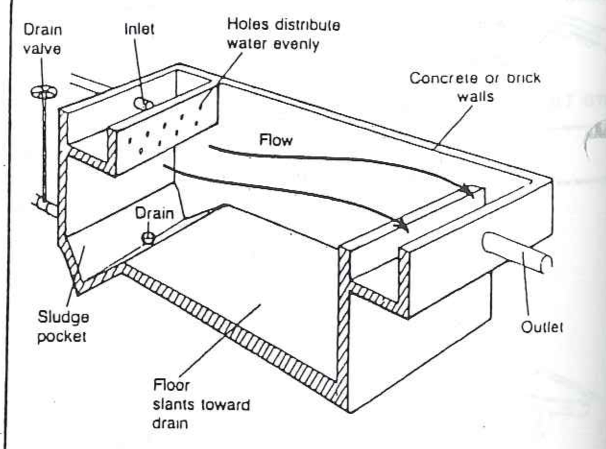


Figure 4. Sedimentation Basin

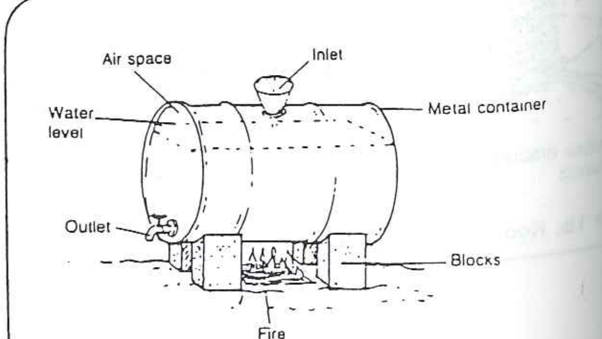
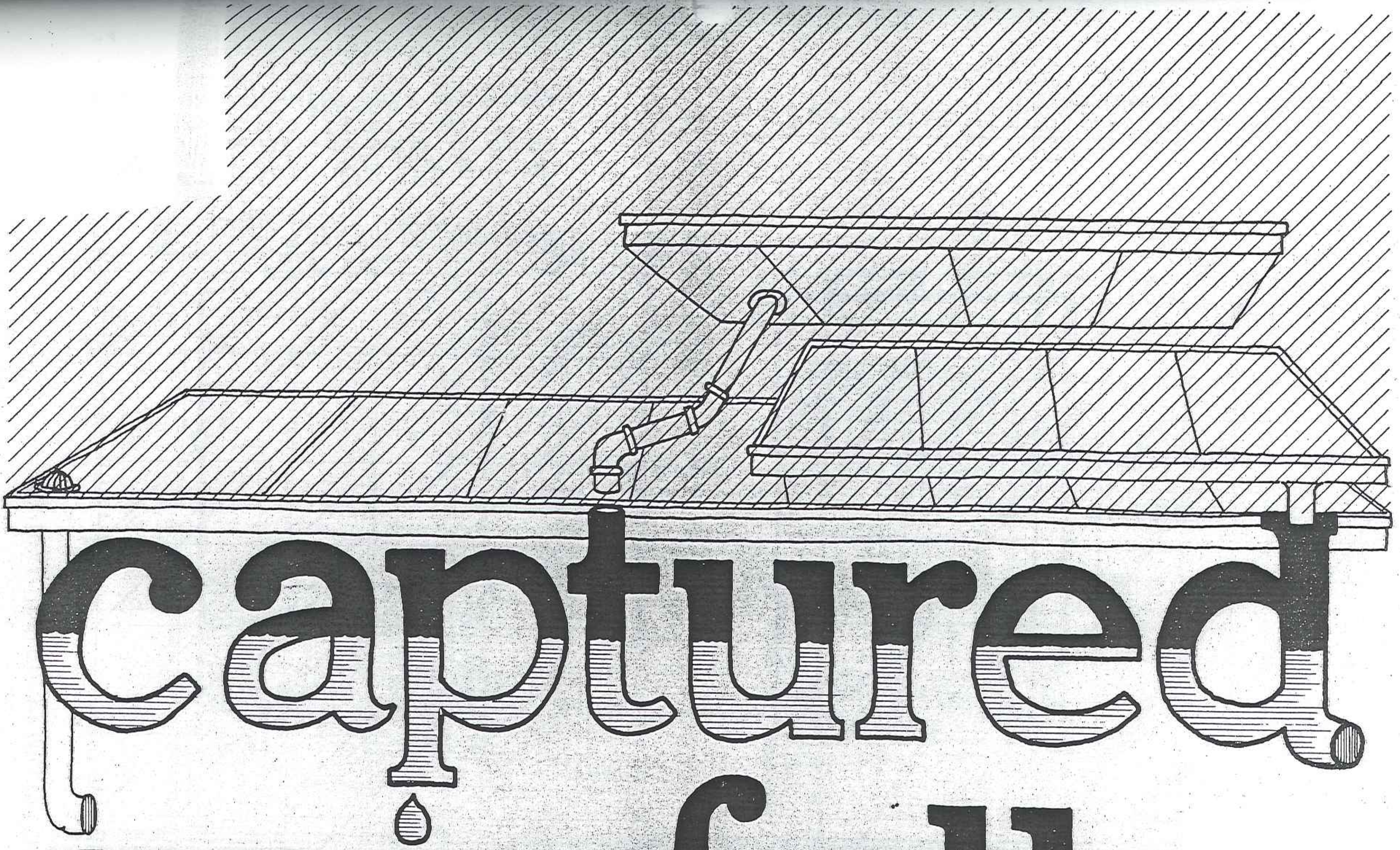


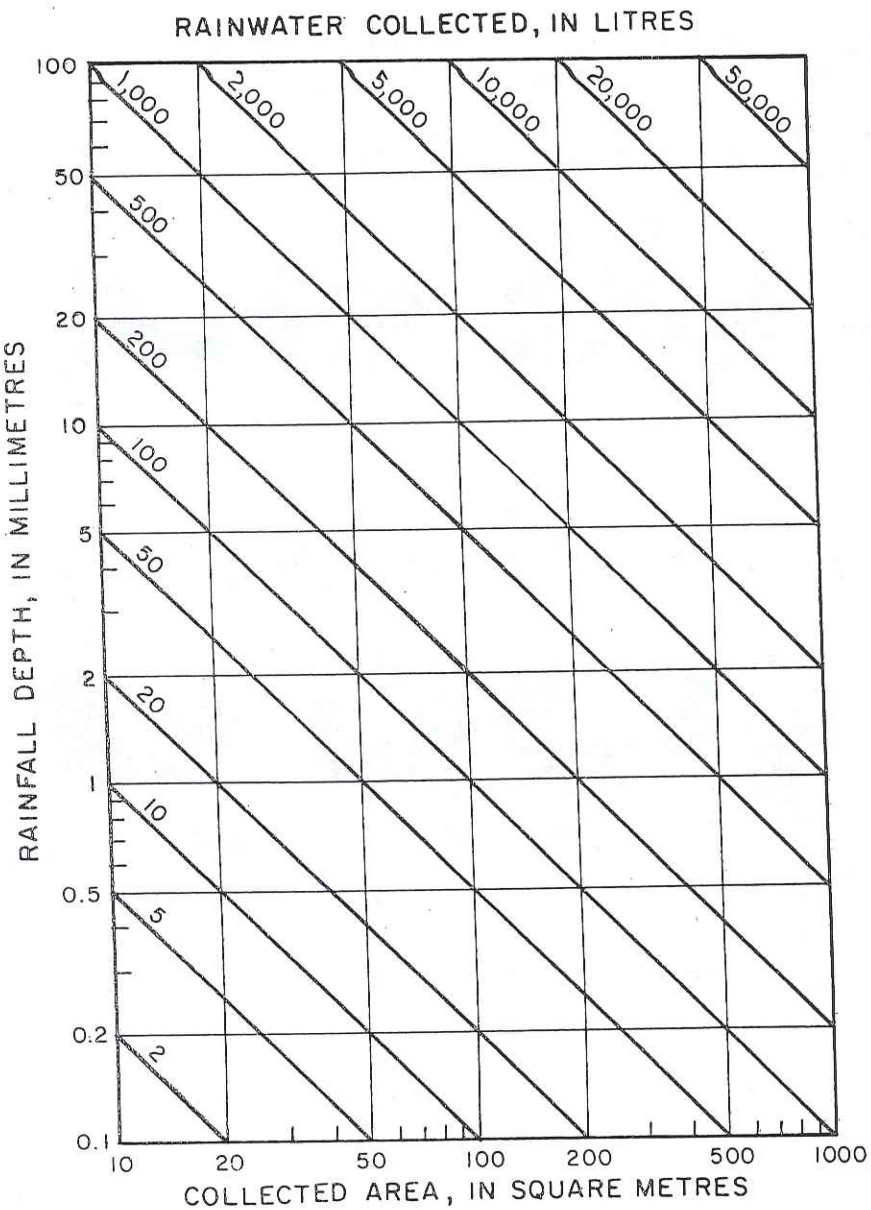
Figure 3. Method of Boiling Water

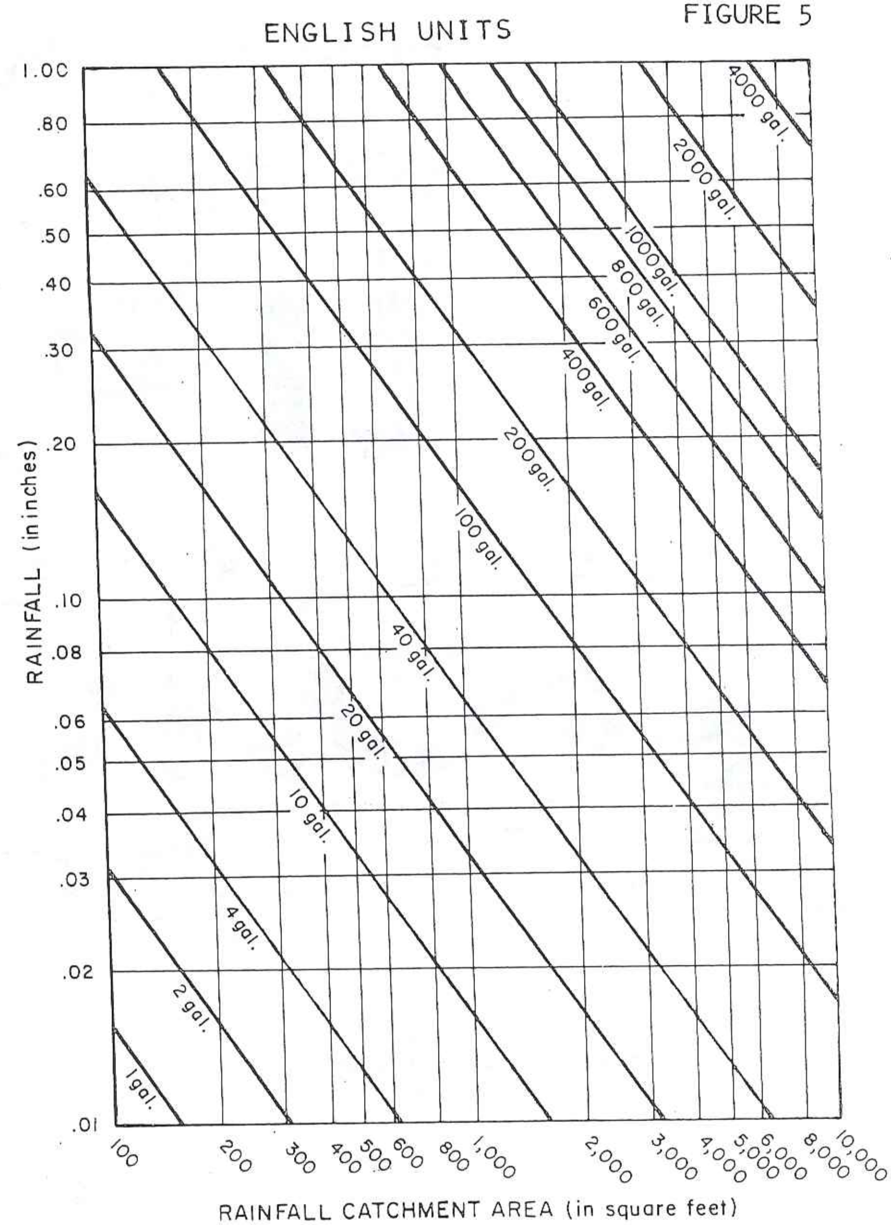


captured rainfall

Small-Scale Water Supply Systems

FIGURE 5



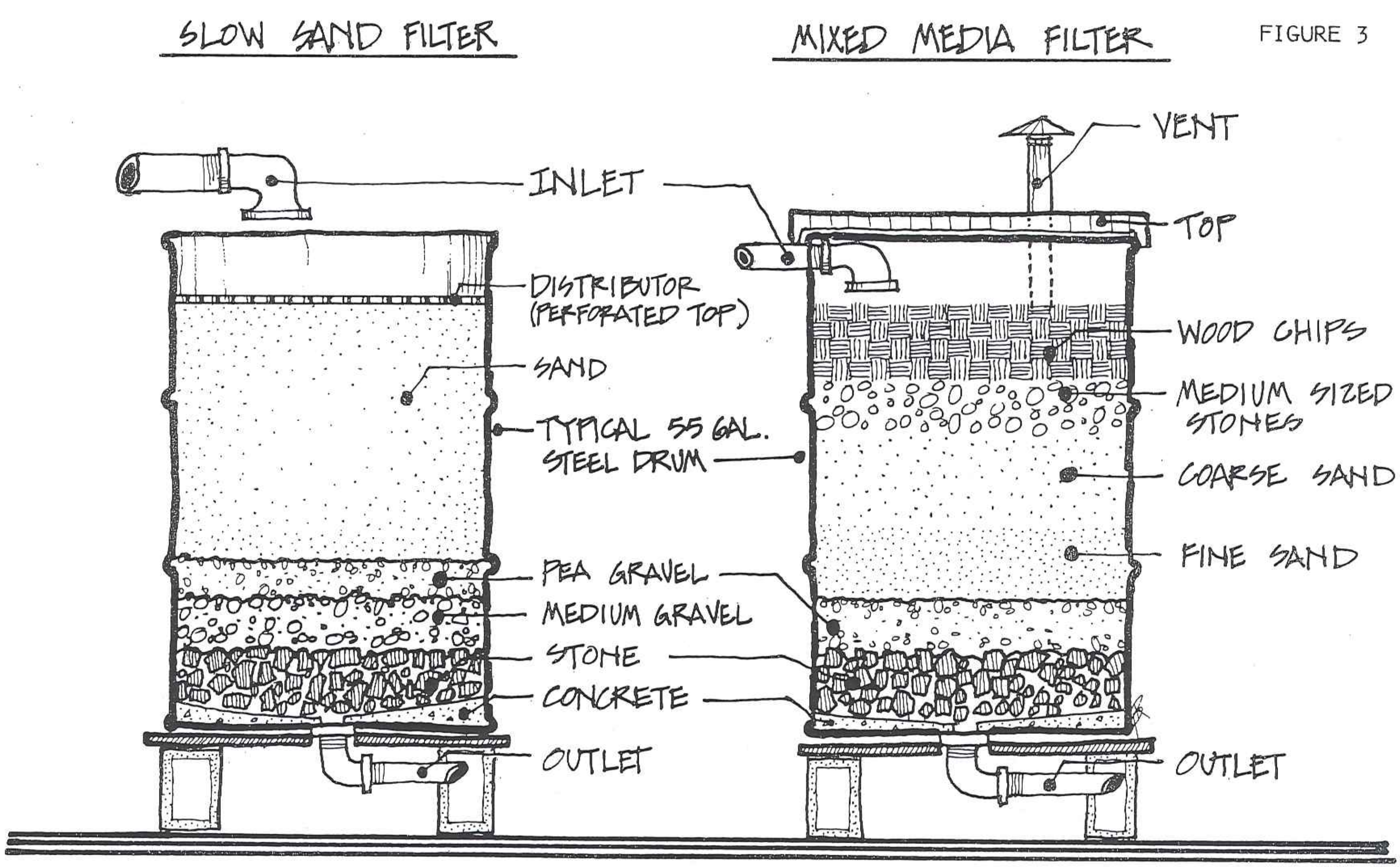


WATER SUPPLY

BASED ON CATCHMENT AREA AND RAINFALL

SOURCE: WENTWORTH (1959)
(1 in of RAIN PER SQUARE FOOT = 0.6 GAL.)
1mm of RAIN PER SQUARE METRE = 1 LITRE

FIGURE 3

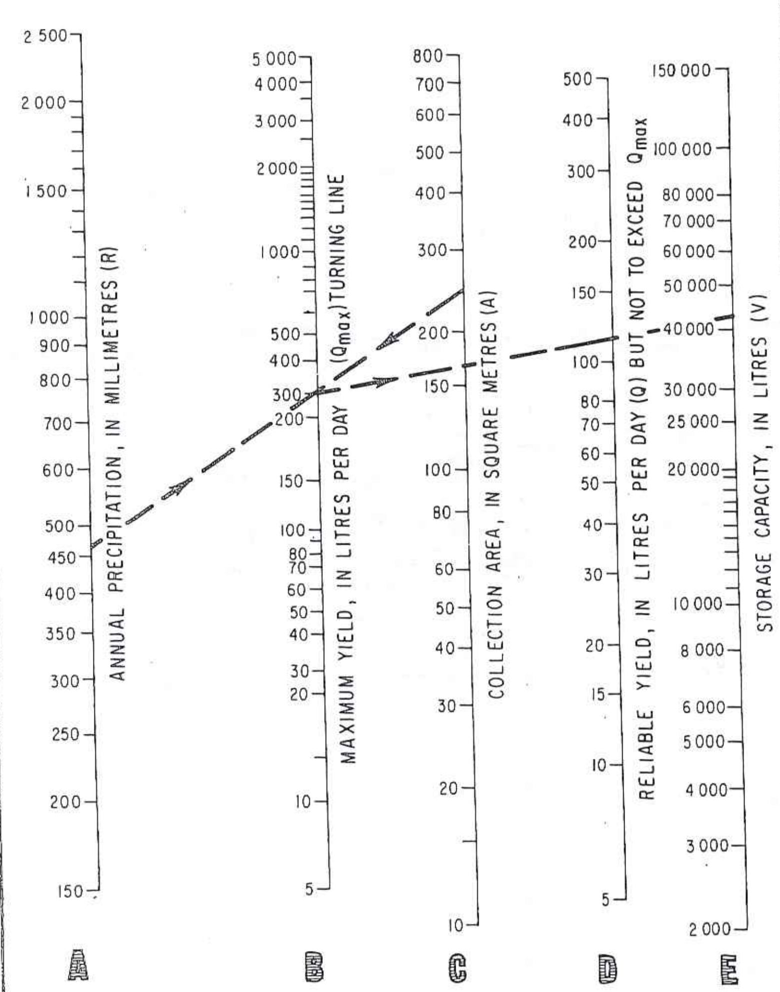


COLLECTION SYSTEM FILTERS

ADAPTED FROM AN ILLUSTRATION IN M. MILNE'S "RESIDENTIAL WATER USE."

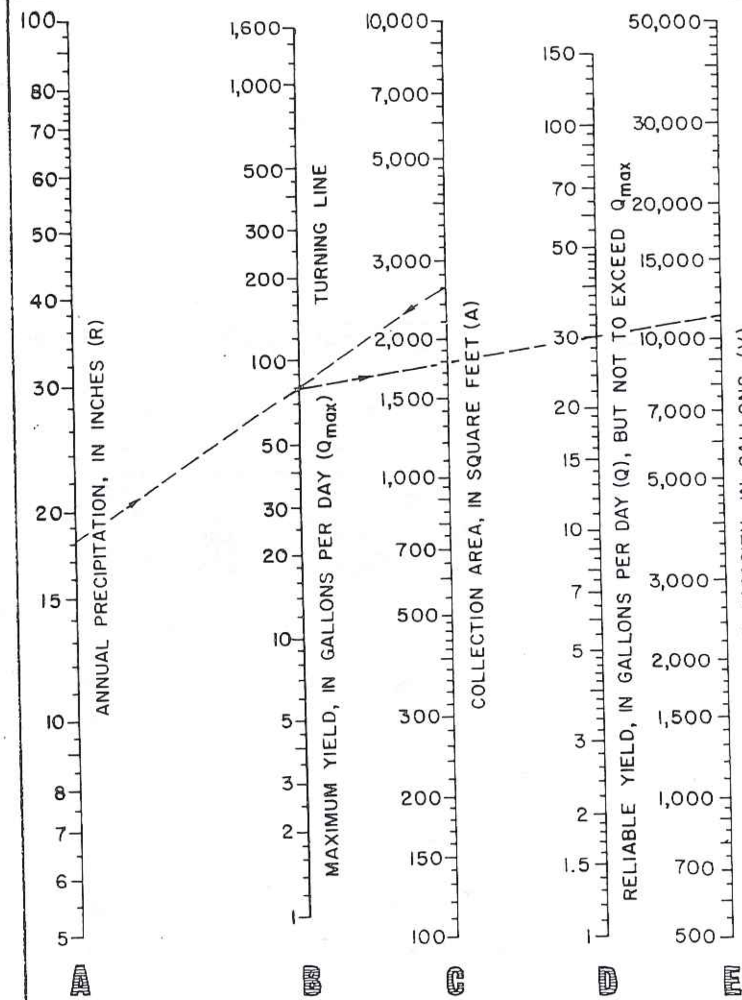
FIGURE 6

METRIC UNITS



EXAMPLE: SELECT ANNUAL PRECIPITATION, 457mm (SCALE A)
SELECT COLLECTION AREA, 242m (SCALE C)
READ MAXIMUM YIELD (SCALE B), 303 l
SELECT RELIABLE YIELD, (NOT TO EXCEED 303 l).
FROM (SCALE D) 114 l DRAW LINE FROM MAXIMUM YIELD 303 l (SCALE B) THRU 114 l (SCALE D). THIS WILL TELL YOU YOUR STORAGE CISTERN CAPACITY WILL HAVE TO BE 42 775 l.

ENGLISH UNITS



EXAMPLE: SELECT ANNUAL PRECIPITATON, 18 in. (SCALE A)
SELECT COLLECTION AREA 26,000 ft^2 (SCALE C)
READ MAXIMUM YIELD, 80 gal. (SCALE B)
SELECT RELIABLE YIELD (NOT TO EXCEED 80 gal.)
FROM (SCALE D) 30 gal., DRAW LINE FROM MAXIMUM YIELD 80 gal. THRU 30 gal. (SCALE D).
THIS WILL TELL YOU YOUR STORAGE CISTERN CAPACITY WILL HAVE TO BE 11,300 gal.,

NOMOGRAPH FOR DESIGN OF A RAINWATER COLLECTION SYSTEM

TABLE 1

1 FOOT=0.3048 METRE   1 GALLON=3.7854 LITRES

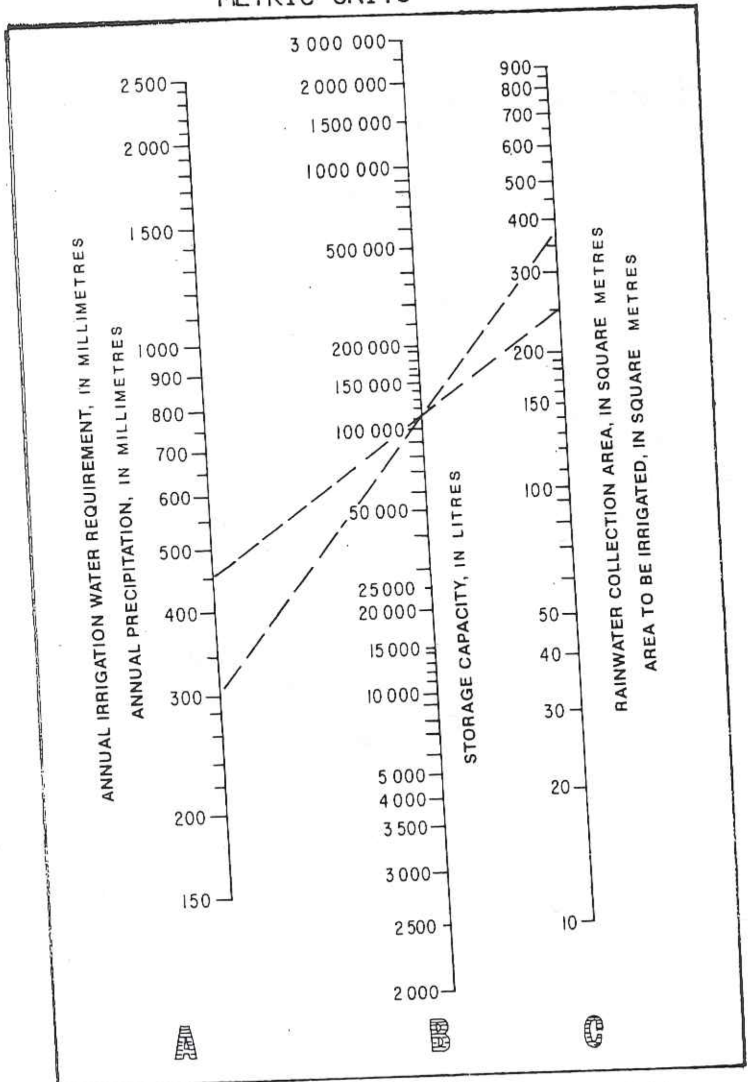
Depth in Feet	Diameter of Round Type — Length of Sides of Square Type (Feet)													
	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	ROUND TYPE (gallons)													
5	735	1055	1440	1880	2380	2935	3555	4230	4965	5755	6610	7515	8485	9510
6	882	1266	1728	2256	2856	3522	4266	5076	5958	6906	7932	9018	10182	11412
7	1029	1477	2016	2632	3332	4109	4977	5922	6951	8057	9254	10521	11879	13314
8	1176	1688	2304	3008	3808	4696	5688	6768	7944	9208	10576	12024	13576	15216
9	1323	1899	2592	3384	4284	5283	6399	7614	8937	10359	11898	13527	15273	17118
10	1470	2110	2880	3760	4760	5870	7110	8460	9930	11510	13220	15030	16970	19020
12	1764	2532	3456	4512	5712	7044	8532	10152	11916	13812	15864	18036	20364	22824
14	2058	2954	4032	5264	6664	8218	9954	11844	13902	16114	18508	21042	23758	26628
16	2342	3376	4608	6016	7616	9392	11376	13536	15888	18416	21152	24048	27152	30432
18	2646	3798	5184	6768	8568	10566	12798	15228	17874	20718	23796	27054	30546	24236
20	2940	4220	5760	7530	9520	11740	14220	16920	19860	23020	26440	30060	33940	38040
	SQUARE TYPE (gallons)													
5	935	1345	1835	2395	3030	3740	4525	5385	6320	7330	8415	9575	10810	12112
6	1122	1614	2202	2874	3636	4488	5430	6462	7584	8796	10098	11490	12974	14534
7	1309	1883	2569	3353	4242	5236	6335	7539	8848	10262	11781	13405	15134	16956
8	1496	2152	2936	3832	4848	5984	7240	8616	10112	11728	13464	15320	17296	19378
9	1683	2421	3303	4311	5454	6732	8145	9693	11376	13194	15147	17235	19458	21800
10	1870	2690	3670	4790	6060	7480	9050	10770	12640	14660	16830	19150	21620	24222
12	2244	3228	4404	5748	7272	8976	10860	12924	15168	17592	20196	22980	25944	29068
14	2618	3766	5138	6706	8484	10472	12670	15078	17696	20524	23562	26810	20268	33912
16	2992	4204	5872	7664	9696	11968	14480	17232	20224	23456	26928	30640	34592	38756
18	3366	4842	6606	8622	10908	13464	16290	19386	22752	26388	30294	34470	38916	42600
20	3740	5380	7340	9580	12120	14960	18100	21540	25280	29320	33660	38300	43240	48444

TAKEN FROM "PLANNING FOR AN INDIVIDUAL WATER SYSTEM"
AMERICAN ASSOCIATION FOR VOCATIONAL INSTRUCTIONAL MATERIALS, ATHENS, GA. MAY 1973

CAPACITIES OF VARIOUS SIZED CISTERNS

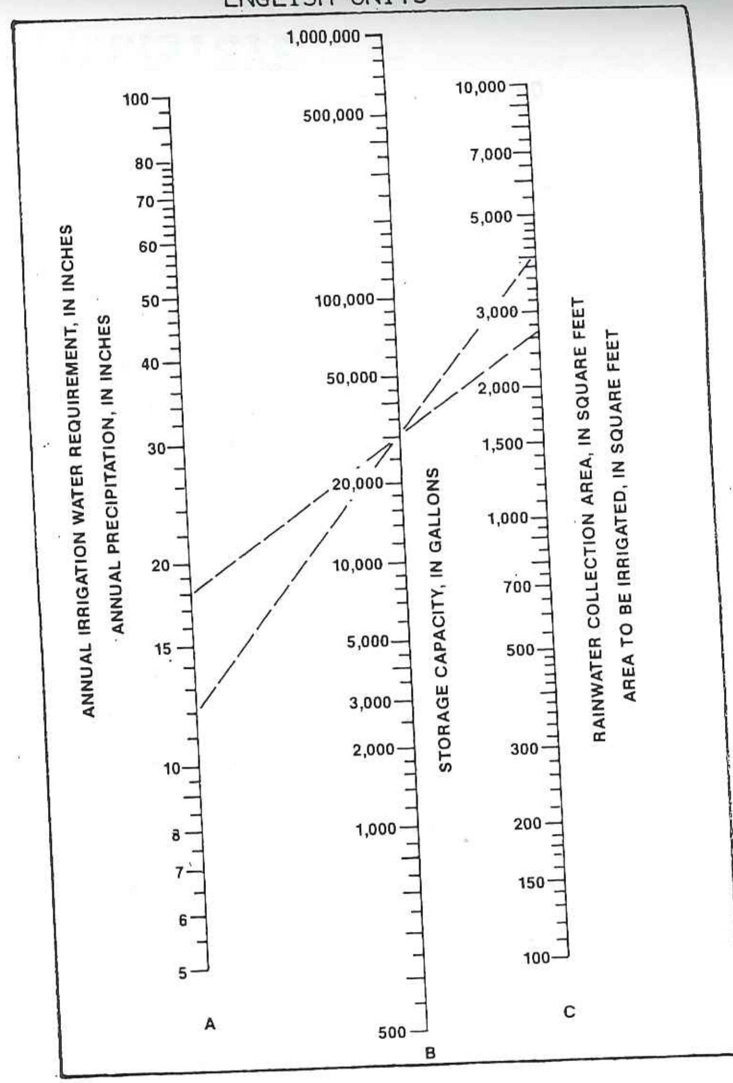
FIGURE 8

METRIC UNITS



EXAMPLE - SELECT ANNUAL PRECIPITATION = 457 mm (SCALE A)
SELECT RAINWATER COLLECTION AREA = 251 m^2 (SCALE C)
READ STORAGE CAPACITY = 113 562 l (SCALE B)
SELECT ANNUAL IRRIGATION WATER REQUIREMENT = 305 mm (SCALE A)
READ AREA TO BE IRRIGATED WITH RAIN WATER = 372 m (SCALE C)

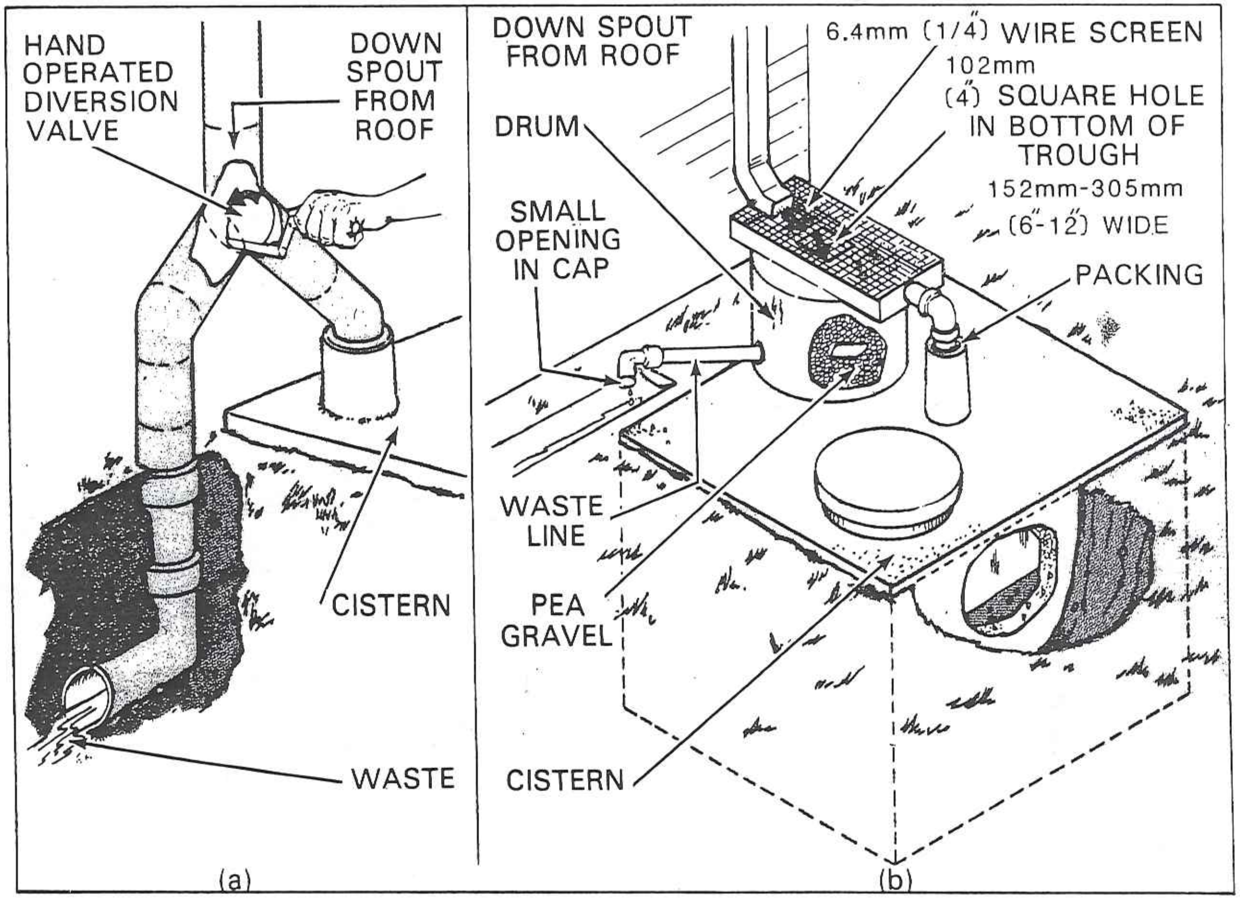
ENGLISH UNITS



EXAMPLE - SELECT ANNUAL PRECIPITATION = 18 IN. (SCALE A)
SELECT RAINWATER COLLECTION AREA = 2700 SQ FT (SCALE C)
READ STORAGE CAPACITY = 30,000 GAL (SCALE B)
SELECT ANNUAL IRRIGATION WATER REQUIREMENT = 12 IN. (SCALE A)
READ AREA TO BE IRRIGATED WITH RAIN WATER = 4000 SQ FT (SCALE C)

NOMOGRAPH FOR CISTERN SIZE BASED ON AREA REQUIRING IRRIGATION

FIGURE 10

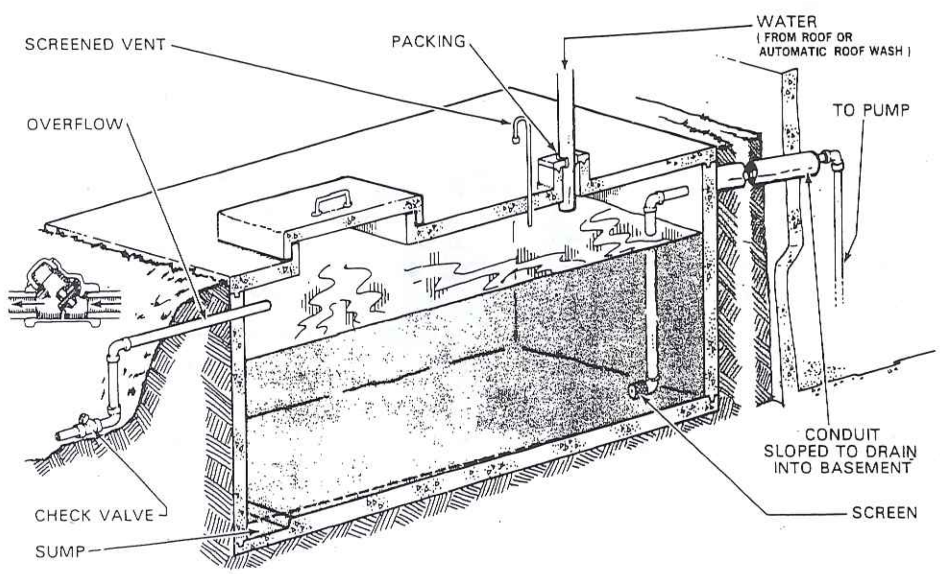


Methods of roof washing for cistern water. (a) Hand-operated diversion valve used to waste first rainfall. After roof is washed, the valve is changed so water will enter the cistern. (b) Automatic roofwash. The first rainfall flows into the drum. After the drum is filled, the remaining water flows into the cistern. During a period without rainfall, water dripping from the opening in the waste line empties the drum.

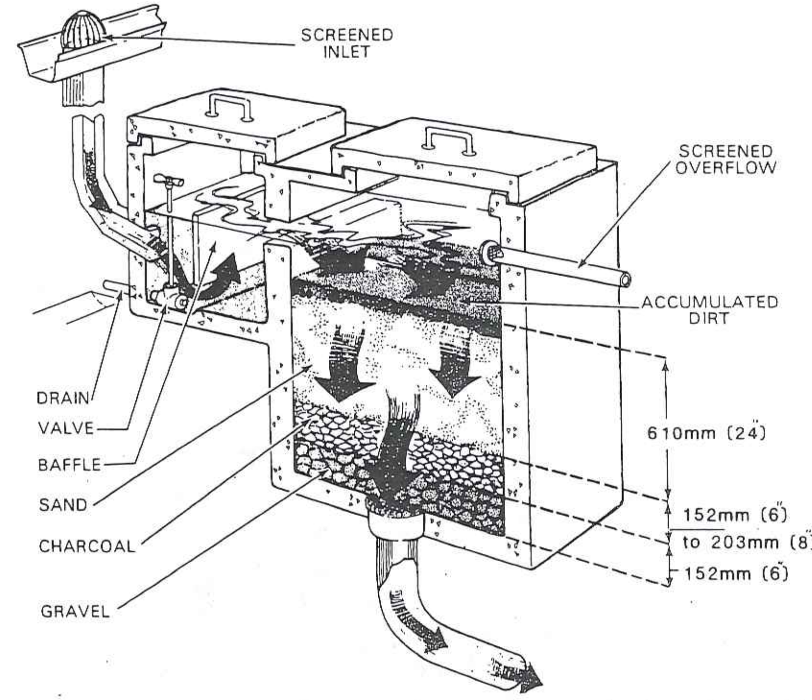
SOURCE: AAUIM, "PLANNING FOR AN INDIVIDUAL WATER SYSTEM", 1973

ROOF WASHERS

FIGURE 11



A CISTERN MUST BE WELL CONSTRUCTED TO KEEP SURFACE WATER FROM ENTERING AROUND THE POINTS WHERE PIPING ENTERS THE CISTERN, AND WHERE THE COVER FITS OVER THE ACCESS HOLE. THE CHECK VALVE KEEPS PESTS FROM ENTERING THE OVERFLOW.

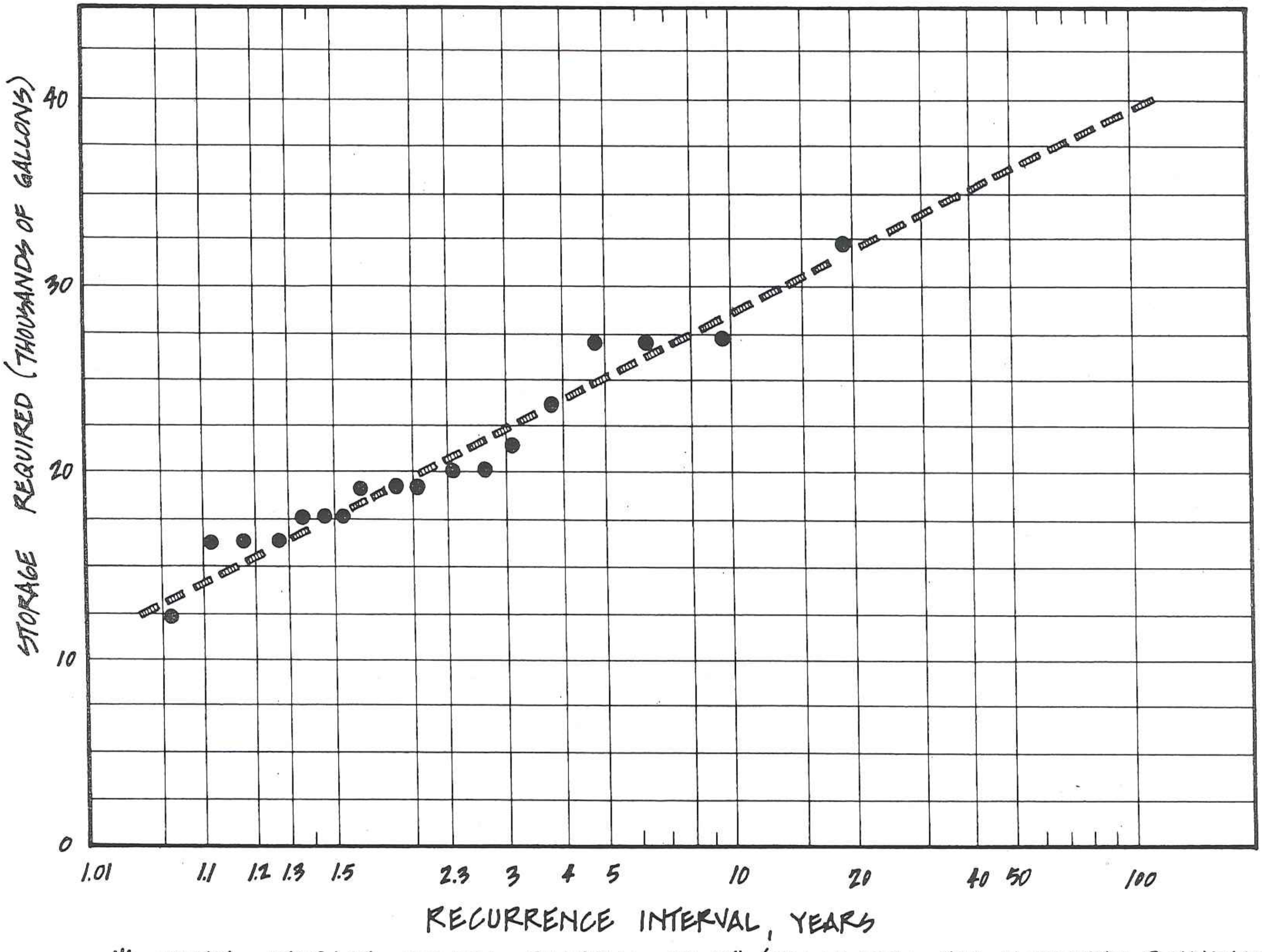


A SAND FILTER OF THIS TYPE CAN BE VERY EFFECTIVE IN REDUCING POLLUTION OF CISTERN WATER IF KEPT CLEAN. IF NOT CLEANED REGULARLY, IT CAN BE A SOURCE OF POLLUTION.

IDEAS FOR CISTERN DESIGN

SOURCE: AAUIM, "PLANNING FOR AN INDIVIDUAL WATER SYSTEM" 1973.

GRAPH A-2



* GIVEN AVERAGE ANNUAL RAINFALL OF 18" (CALCULATED FOR MONTEREY PENNINSULA)

STORAGE REQUIRED TO PROVIDE 100 GALLONS PER DAY WATER SUPPLY

BASED ON 2000 SQUARE FOOT CATCHMENT AREA

Table C-1. Daily and Seasonal ET Rates in California*

	Northeastern Mountain Valleys	North Coast-Coastal Valleys and Plains	North Coast-Interior Valleys	Sacramento Valley	San Joaquin Valley	Central Coast-Coastal Valleys and Plains	Central Coast-Interior Valleys	Sierra (Tahoe Basin)	South Coast-Coastal Valleys and Plains	South Coast-Interior Valleys	Southern California Desert
	inches per day										
January	0.02	0.02	0.03	0.04	0.03	0.06	0.05	--	0.06	0.06	0.09
February	0.04	0.04	0.04	0.06	0.06	0.08	0.08	--	0.09	0.09	0.13
March	0.07	0.06	0.08	0.1	0.1	0.1	0.11	--	0.1	0.11	0.19
April	0.12	0.08	0.11	0.15	0.15	0.13	0.14	0.10	0.13	0.14	0.25
May	0.16	0.11	0.16	0.19	0.21	0.15	0.18	0.13	0.14	0.16	0.33
June	0.19	0.12	0.20	0.24	0.25	0.16	0.21	0.16	0.17	0.20	0.38
July	0.26	0.11	0.23	0.26	0.25	0.17	0.22	0.20	0.18	0.22	0.37
August	0.23	0.11	0.20	0.22	0.21	0.16	0.19	0.17	0.18	0.22	0.31
September	0.16	0.09	0.15	0.17	0.16	0.13	0.16	0.13	0.15	0.17	0.28
October	0.09	0.06	0.09	0.11	0.11	0.1	0.12	0.09	0.11	0.12	0.2
November	0.03	0.04	0.04	0.05	0.05	0.07	0.08	--	0.09	0.08	0.12
December	0.02	0.02	0.02	0.03	0.02	0.05	0.05	--	0.07	0.06	0.06
Totals: inches											
November-March	5.1	5.3	6.3	8.5	7.9	10.7	10.8	--	12.1	11.5	17.7
April-October (growing season)	37.1	20.8	34.9	40.7	40.7	30.6	37.5	30.0	32.3	37.9	65.1
Annual	42.2	26.1	41.2	49.2	49.0	41.3	48.3	--	44.4	49.4	82.2

* From Dept. of Water Resources Bulletin 113-3, except for figures for Sierra (Tahoe Basin), which are UC observations for the growing season.

In the spring, make a "water budget" for the coming season. First, estimate the inches of water that will be available to your plants during the growing season by adding the amount already stored in the soil and the amount of irrigation water you expect to add. To estimate the amount of available moisture in the soil at the start of the growing season, determine the storage capacity of your soil reservoir (see Table C-2). Then use a hand-feel test to estimate how full the reservoir is.

Second, determine the expected inches of ET loss during the growing season in your area. Then estimate your minimum requirement. Remember, the ET rates given are close to maximum. Many plants can get by with less. For shallow-rooted water-spenders you are determined to save, figure on replacing almost all of the potential ET loss. For deeper-rooted woody plants on deep soil, you should be able to get by on one-half ET, or even as little as one-fourth.

Table C-2. WATER STORAGE CAPACITY OF SOILS

Soil Texture	Inches of Available Water per foot of soil depth	Gallons per Cubic foot of soil
Sand	1/2 - 1	1/3 - 2/3
Sandy loam	1 - 1-1/2	2/3 - 1
Clay loam	1-1/2 - 2	1 - 1-1/3
Clay	1-1/2 - 2-1/2	1 - 1-2/3

(An inch of water is the amount that would cover the surface 1 inch deep. 1-1/2 inches covering 1 square foot = 1 gallon.)

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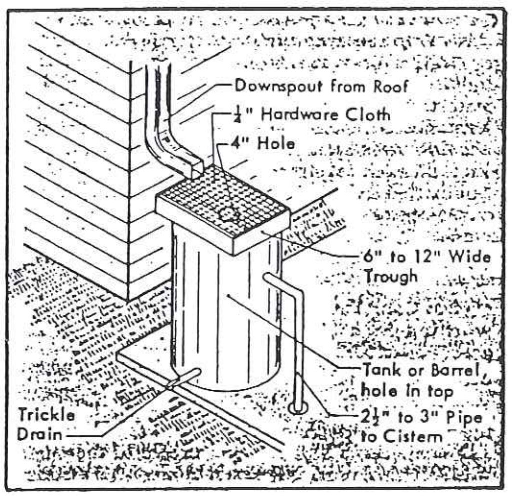
5.2 Automatic Systems

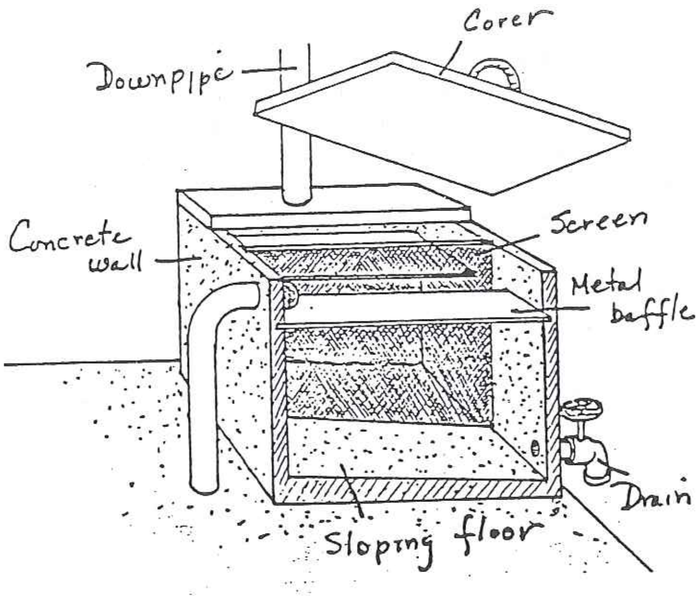
Automatic roof cleaning devices are available commercially only in a few areas, but they may be fabricated from local materials in some situations. One simple automatic device is a container or receptacle for dirty water called a "roofwasher" (Midwest Plan Service, 1979; see figure 8 below). After the roofwasher receptacle fills up with the foul flush, water begins to overflow into the storage tank. A screen is usually attached between the downpipe and the foul flush container as shown in the figure to keep out leaves and other large pieces of debris that would float on the water in the receptacle and clog the overflow pipe to the tank. Oil or fuel tins, used for hauling water in many areas, might be converted to roofwashers. Midwest Plan Service (1979) recommends about 10 liters of roofwasher receptacle capacity for every 30 m^2 of roof area. Other sources (e.g. Dooley, 1978) say a roofwasher should be big enough to hold the first 20 minutes of runoff.



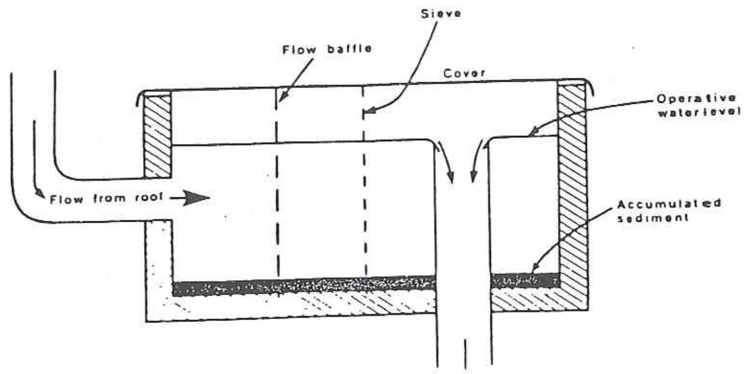
Midwest Plan Service (1979) by permission

Figure 8, Homemade Roof Washer.

A problem with such a simple device is that when the beginning of a rainstorm is torrential, water will pour vigorously into the roofwasher from the downpipe, stirring dirt and bird droppings so that they are carried through the overflow pipe into the tank instead of settling at the bottom of the receptacle. To inhibit this stirring action a baffle can be mounted crossways, inside the roofwasher and/or a vertical screen can be installed dividing the downpipe side from the tank inlet side (see figures 9 and 10). Roofwashers must have a drain and removable cover so that they can be cleaned after each rain.



Institute for Rural Water, 1982
(draft) by permission



UNEP (1979)
by permission

Figure 9, Roof Washers.

More complicated "automatic" foul flush devices tend to require more attention and stronger structures with more hardware for mounting in the downpipe. Reported in use in Australia are, "swing funnels" made of sheet metal, with a large inflow side divided into two compartments, and hinged on a horizontal pin (see figure 10 below). At the start of a storm, water pours from the gutter into the first compartment. As the weight of the assembly increases, the funnel swings so that water pours from the gutter into the second compartment which leads through the downpipe into the tank. Such a funnel would have to be quite large to hold the recommended volume of foul flush. Mounting and hinge-pins would also have to be quite strong. This particular device is unlikely to be the most attractive of foul flush options in most places, but it is an interesting idea.

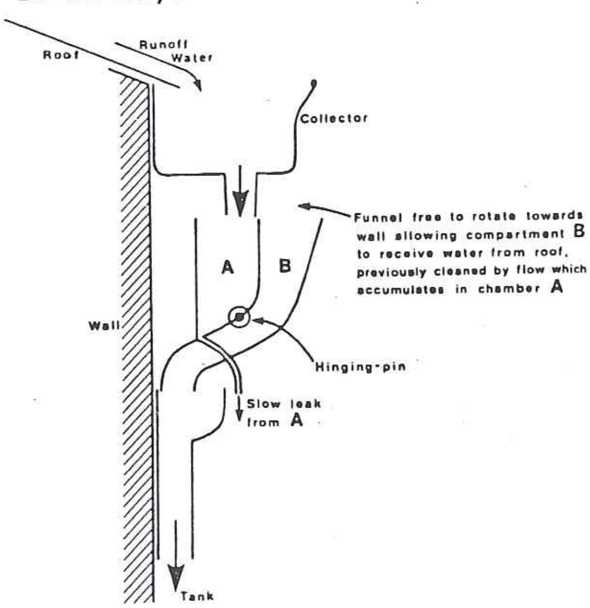


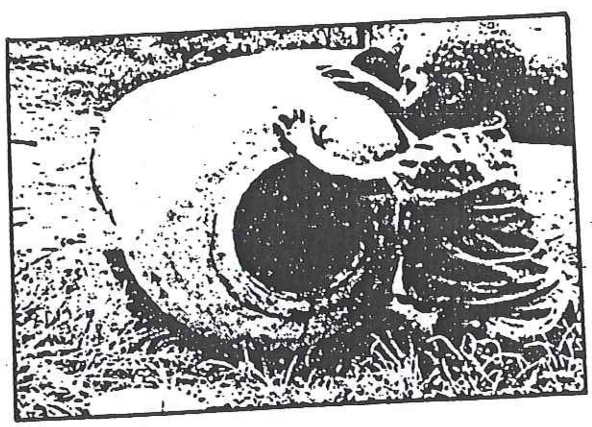
Figure 10, Swing Funnel.

picture at the front of this report). These drums hold about 0.17 m^3 and cost about US $2.50 (1969); they can be covered with a board and a rock. Watt (1975) notes that Thais collect rainwater from roofs in large pottery jars. He reports a price of about US $5.00 (1975) for a 0.3 m^3 jar.

6.2.2 Cement Mortar Jars

Apparently first devised in Thailand (Watt, 1975), these jars have been enthusiastically built in other parts of southeast Asia and Africa (McDowell, 1976). Cloth sacking filled with rice hulls or some vegetable waste is used as a jar-shaped mold, onto which cement mortar is plastered. McDowell (1976) says that jars can be constructed with capacities up to 3 m^3 using this method. Prototypes of even larger models, made of soil-cement, have been made in Java. A great attraction of this method of storing rainwater is its low cost. Watt (1975) reports materials costs of US $0.50 per 0.25 m^3 jar. That entire sum was for cement (see figure 11 below).

Most jars of this type are apparently made in the size range of 0.15-0.5 m^3, as larger jars, lacking reinforcement, tend to crack where the wall meets the base. See Chapter 8 for Watt's instructions for making a 0.25 m3 jar.



McDowell (1976)
both by permission

Figure 11, Homemade Cement Jar

James Bell*(personal communication) reported on a variation of this method widely practiced in Liberia for making water jars of about the same size. A hole the shape of the jar is excavated in the soil. Wire netting ("chickenwire") is pegged to the wall of the hole, which is then plastered with cement mortar. After the jar has cured, it is dug out of its earthen "mold".

6.2.3 Traditional Baskets Plastered With Cement Mortar

Originating in Thailand, this technique has been used to build hundreds of tanks in Kenya, Burundi, Rwanda, Swaziland, Tanzania, Lesotho, and Zambia. The usual technique is to plaster a granary basket which is set into a cement or concrete foundation.

"In Kenya, the basket frame is made from sticks cut from woody shrub which grows throughout the country. In Rwanda and Burundi, the frame is made from bamboo. Presumably provided that the material is strong, the basket could be made from any number of shrubs or sticks which can be woven into basket form. The basket is constructed on the ground by weaving the sticks into round shapes. The actual shape does not seem very important, but it is recommended that the bottom be omitted so that the sides can bond with the base" (UNICEF, Eastern Africa Regional Office, 1982) (figure 12 below).

Apparently tanks up to 7.5 m^3 in capacity have been constructed by reinforcing the basket frame with bands of straight wire or wire mesh. The more common size, requiring no metal reinforcement, is about 1.5 m high and has a capacity of about 2.3 m^3. Assuming a cement price of $7.14 per 50-kg bag (rural Zaire, 1981) and allowing about 20 percent of total materials costs for sand, gravel and outlet pipe, a 2.3 m^3 tank of this type could be built for about US $42.00 (1981). See Chapter 8 for detailed notes on tank construction using a "Gnala" basket in Kenya (UNICEF East Africa Regional Office, 1982).

Figure 12, Plastered Basket

* Peace Corps Water and Sanitation Specialist

6.2.4 Cast Concrete Ring Tank

Relying on thin unreinforced concrete rings, poured between concentric steel forms, these tanks have been promoted by the Thai Ministry of Health for use at schools in a country where many buildings in rural areas have galvanized sheet metal or tile roofs (Watt, 1978 b). The rings, which are about 1.5 m in diameter and 0.6 m high, can be stacked to give tank capacities of up to 7 m^3. Watt estimates materials costs of US $40.00 (1977) for a tank of this size, not including the cost of the forms. Watt points out that forms could be used again and again in a tank construction project and suggests central production of the rings under skilled supervision. The cured, high-quality rings could then be transported by truck to the tank location for placement on their concrete foundations.

Brian Grover (personal communication) reports that the Thai Ministry of Health and the Population Development Association of Thailand, in collaboration with the U.S. Peace Corps, are building similar tanks with bamboo staves cast into the rings for reinforcement.

6.2.5 Ferrocement Tanks

These tanks are built using a technique in which cement mortar paste is applied by hand to a reinforcing wire mesh. "True" ferrocement has much more steel reinforcement than called for in the tanks described here. Still the principle is the same: metal reinforcing strands distribute loads evenly through the cement mortar, preventing the cracking that would occur in unreinforced materials of similar thickness (NAS, 1973). Tank walls 4 cm thick are strong enough to hold 2 m depths of water above ground. Thus reinforced cement walls require much less total material than conventional concrete walls. (Briscoe, 1981, notes that ferrocement tank walls do not necessarily require less cement than concrete walls.)

In his handbook for field workers (Watt, 1978, Ferrocement Water Tanks and Their Construction, see section 8.2 below), Watt notes:

"The main advantages...of this material over other tank construction materials, such as galvanized corrugated iron, are its cheapness and easy working using the minimum of expensive materials, equipment and skills. It is, in addition, very durable. Some of the tanks described in the manual have been in constant use for over 25 years with only a few instances of failure--due in the main to poor workmanship in construction."

Watt goes on to say that ferrocement techniques are particularly suited for low-income rural areas because 1) they use commonly available materials (cement, sand, water, and wire); 2) only simple skills are needed: "...untrained people can make satisfactory tanks after only a few days supervision..."; 3) users of the tanks can help in construction; and 4) only simple hand tools are required.

Clearly an important advantage of ferrocement tank construction is that it can be taught and learned readily. Early development of these techniques was done at the Friends Rural Training Center, Hlekweni, near Bulawayo, Zimbabwe. Roy Henson of the Center reports training of a half-dozen craftsmen and construction of 210 9 m^3 tanks in Matabeleland in 1971-72 (Farrar and Pacey, 1974). At the Asian Institute of Technology (AIT) in Bangkok, training is provided for field workers from developing nations who, in turn, train local craftsmen in the techniques. AIT-trained field workers in Central Java make modified ferrocement tanks and have begun using woven bamboo staves to reinforce smaller tanks. They and their trainees have reportedly built 1,400 tanks up to 10 m^3 in capacity (Winarto, 1981) (figure 13). And in West Java, two separate programs are planned to construct a total of 650 tanks using the Central Java techniques (Pompe et al, 1982).

Ferrocement tanks are typically built by one of two methods. In the first, layers of wire netting ("chickenwire") are attached to a grid framework of 6 mm (or larger) steel rod (see figure 14). Mortar is trowelled directly onto this framework from the outside (Sharma and Gopalaratnam, 1980) or against a sheet of woven bamboo mat tied temporarily against the inside of the framework wall to act as a "form" (Winarto, 1981; Pompe et al, 1982). When the reinforcing vertical rods are continuous from the floor through the wall and into the cover, cured tanks can be moved on makeshift rollers. The materials costs for a 1.2 m^3 tank of this type with integral floor and cover were estimated at US $33.00 (Thailand; Sharma and Gopalaratnam, 1980).

In the second construction method, no reinforcing framework of steel rods is used. Wire netting and plain straight wire are wrapped around a sturdy inner cylindrical form and plastered with thin coats of cement mortar (Watt, 1978; Watt, 1977; Farrar and Pacey, 1974; see <u>Ferrocement Water Tanks and Their Construction</u>, and "Catchment Tanks in Southern Africa: A Review", section 8.2). Like tanks with steel rod reinforcement, these tanks are installed on a concrete foundation; but unlike them, they must be built in place. Materials costs are usually substantially less than for tanks of the first type because a single layer of wire netting and plain wire cost less than the steel rod framework. Assuming a cement price of US $7.14 per 50-kg bag and a wire netting price of $1.00 per m^2, the 10 m^3 tank described by Watt (his construction steps are presented in Appendix B) could be built for about $150.00. Similar tanks of 9 m^3 capacity built at the Friends Rural Training Center, Hlekweni, cost $62.50 including gutters (1973, Zimbabwe; Farrar and Pacey, 1974).

These costs do not include money spent on materials for the cylindrical inner forms around which the wire and netting are wound. Calvert and Binning (1977) report using mats woven from wood and bamboo, pitpit, or wildcane for forms in the New Hebrides. However, the forms recommended by Roy Henson and Watt, made of sections of corrugated iron roof sheet bolted together, make it much easier to plaster to a uniform wall thickness and build consistently good tanks. If corrugated iron sheeting costs US $2.20 per m^2, this kind of form for a 10 m^3 tank would cost $50.00 plus costs of angle iron, hardware, and fabrication. The form will, in some areas, cost as much as the materials for one tank. However, the form is portable and can be used to build many tanks. Where a large number of tanks are to be built in one area, this technique should be considered.

In New Zealand, ferrocement water tanks are manufactured by a number of firms using methods similar to those described by Watt. With a welded grid of 10 mm rod in the floor, tanks with capacities of 0.7 m^3 to 18 m^3 are portable (hauled from factory to farms in trucks) and often guaranteed for 25 years (Office of the Foreign Secretary/NAS, 1973).

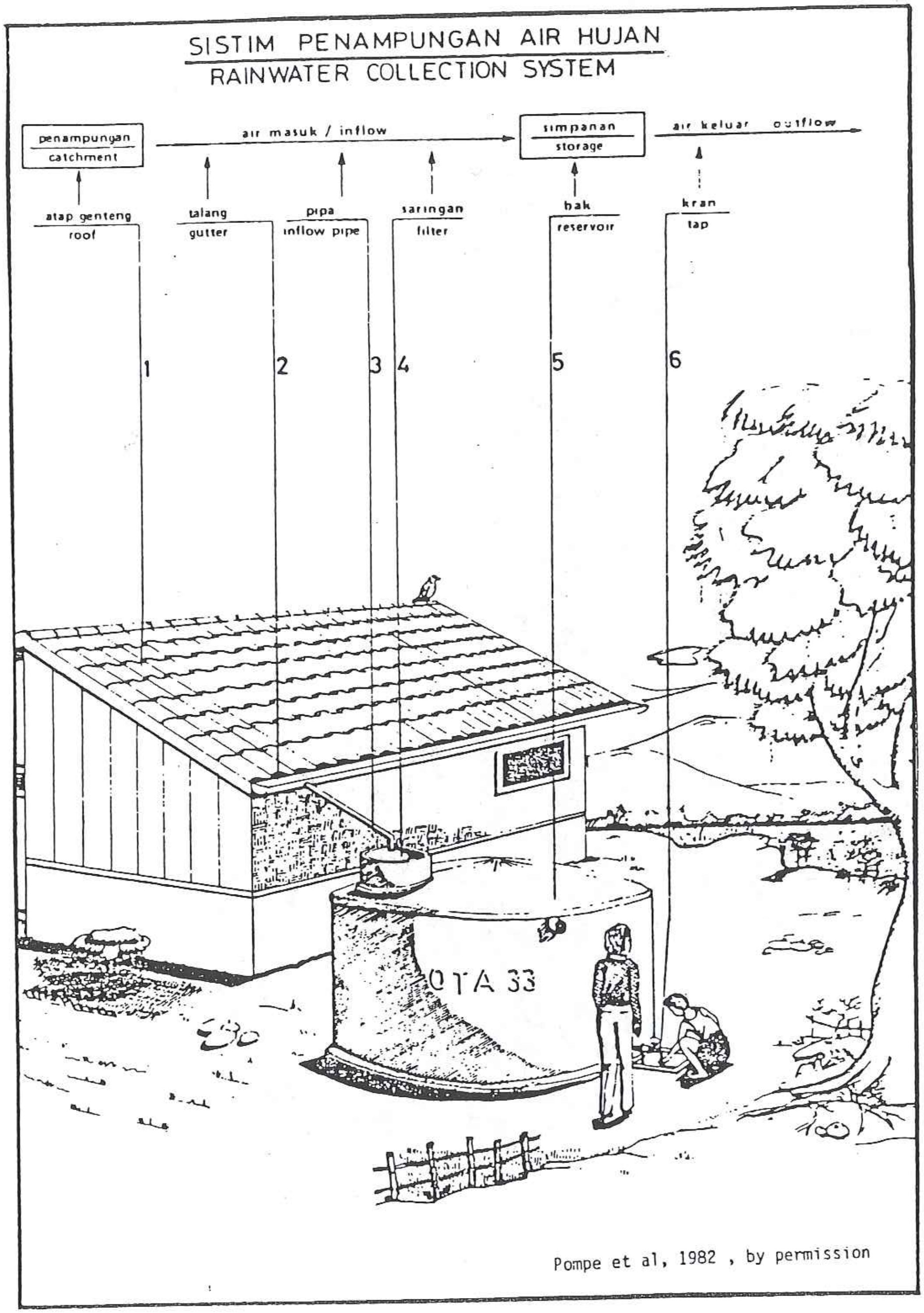
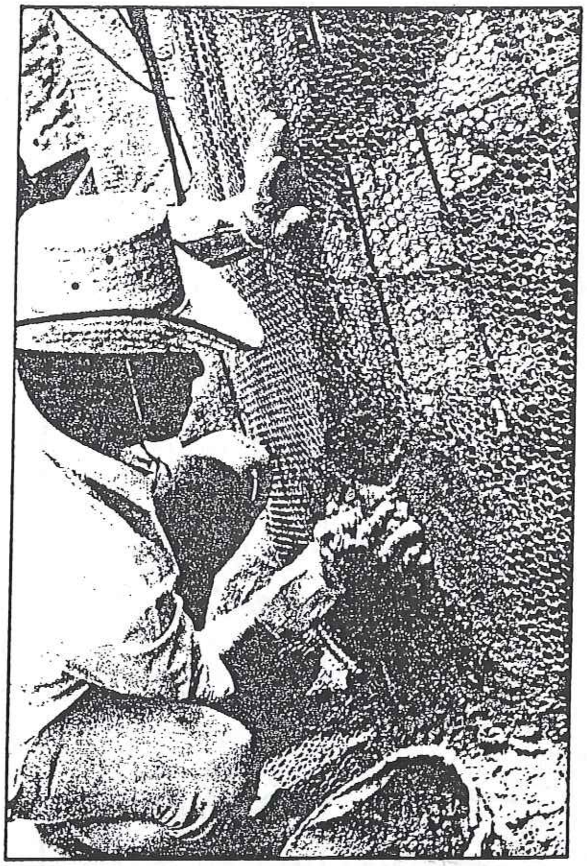
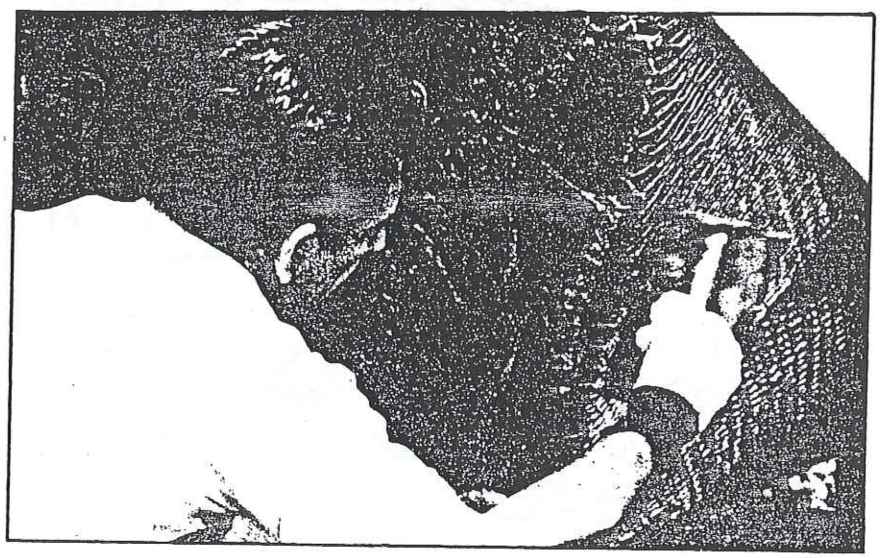


Figure 13, Ferrocement Tank Installation in Java.



A paste of mortar is forced into the layers of mesh by hand . . . (Smith Kampempool, Applied Scientific Research Corporation of Thailand)

. . . or trowel. The mortar is dry enough to remain in place when applied; a formwork is not needed. (Noel D. Vietmeyer, National Academy of Sciences)



Office of the Foreign Secretary/NAS, 1973
by permission

Figure 14, Building Ferrocement Tank.

6.2.6 Manufactured "Tin" or Corrugated Sheet Metal Tanks

These tanks have been used for many years in many areas. Farrar and Pacey (1974) report that in parts of southern Africa, most foreigners have "tin" tanks alongside their homes. The costs of these tanks are high and extremely variable, depending on distance from point of manufacture. Farrar and Pacey give the cost of a 9 m^3 version as US $112.00 in 1973 Zimbabwe; White et al (1973) say that "tin" tanks of 1.4 m^3 capacity cost $39.00 to $84.00 in East Africa (1972). The corrugated metal from which these tanks are fabricated may not last longer than 5 years in a damp climate, even then galvanized. Calvert and Binning (1977) report that in the salt-laden atmosphere of New Hebrides, 16 gage tanks fail after 3 or 4 years.

6.3 Tanks For Use With Larger Rooftops or Several Rooftops*

6.3.1 Underground Ferrocement Tanks

Most tanks of this type are basically an earthen pit lined with wire-reinforced mortar. As with other underground tank designs, structural strength is provided by the confining earth walls, meaning that the ferrocement lining can be made only a centimeter thick. A further advantage of these tanks is that their construction requires neither the steel rod framework nor forms needed to build aboveground ferrocement tanks.

Calvert and Binning (1977; see "Low Cost Water Tanks in the Pacific Islands" in section 8.2 below) describe an innovative design complete with reinforced cover, 3.5 m in diameter and 2 m deep, volume 15-20 m^3. First a circular concrete ring or "footing" is poured; soil from the footing trench is used to make a gently sloping earthen dome in the center of the circle. A 5 cm layer of cement plaster reinforced with wire netting and steel rod is laid over the dome, and two 0.6 m holes are left near opposite edges. After this ferrocement dome cures digging begins through the holes, and the tank is excavated beneath. Two layers of wire netting are used to strengthen the plaster applied to the earth walls.

The authors believed that these tanks should not cost more than about US $250 in 1976 in New Hebrides. They suggest that the design is suitable for "collecting a village's water supply drained from the roof of a large public building." While fabrication of a cover which will not crack may require some experimentation, the approach seems promising. Maikano and Nyberg (1980) report trials of similar covers for underground tanks in Botswana.

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*This report does not deal with tanks used with surface catchments (see section 3.1.2). There are, however, at least 3 types of tanks used with surface catchments which should be briefly mentioned here because they might also be used with larger rooftops or several rooftops. Maikano and Nyberg (1980) describe 10-25 m^3 ferrocement-lined pits collecting water from grain threshing floors in Botswana; Farrar and Pacey (1974) describe the "Water Harvester" (three linked brick cisterns) with 9 m^3 capacity in Zimbabwe; and Ionides et al (1969) describe a project in Botswana to promote "beehive" tanks, built of polythene "sand sausages", with capacities in the 50 m^3 range. Cost information for these tanks is included in section 7.4.

A ferrocement-lined underground grain storage bin suitable for storing water has been documented in the Harar Province of Ethiopia (NAS, 1973; Sharma et al 1979; see Ferrocement: Applications in Developing Countries and "State-of-the-art Review on Ferrocement Grain Storage Bins", section 8.2 below). Traditional grain pits, conical in shape with sides sloping inward to a narrow mouth at the surface, are lined with plaster reinforced with wire netting and given a concrete floor. A small cover is needed, and provision made so that surface water will run away from the mouth of the pit. Ferrocement linings have been installed in pits of this type with depths of up to 3 m and floor diameters of 4 m (see figure 15).

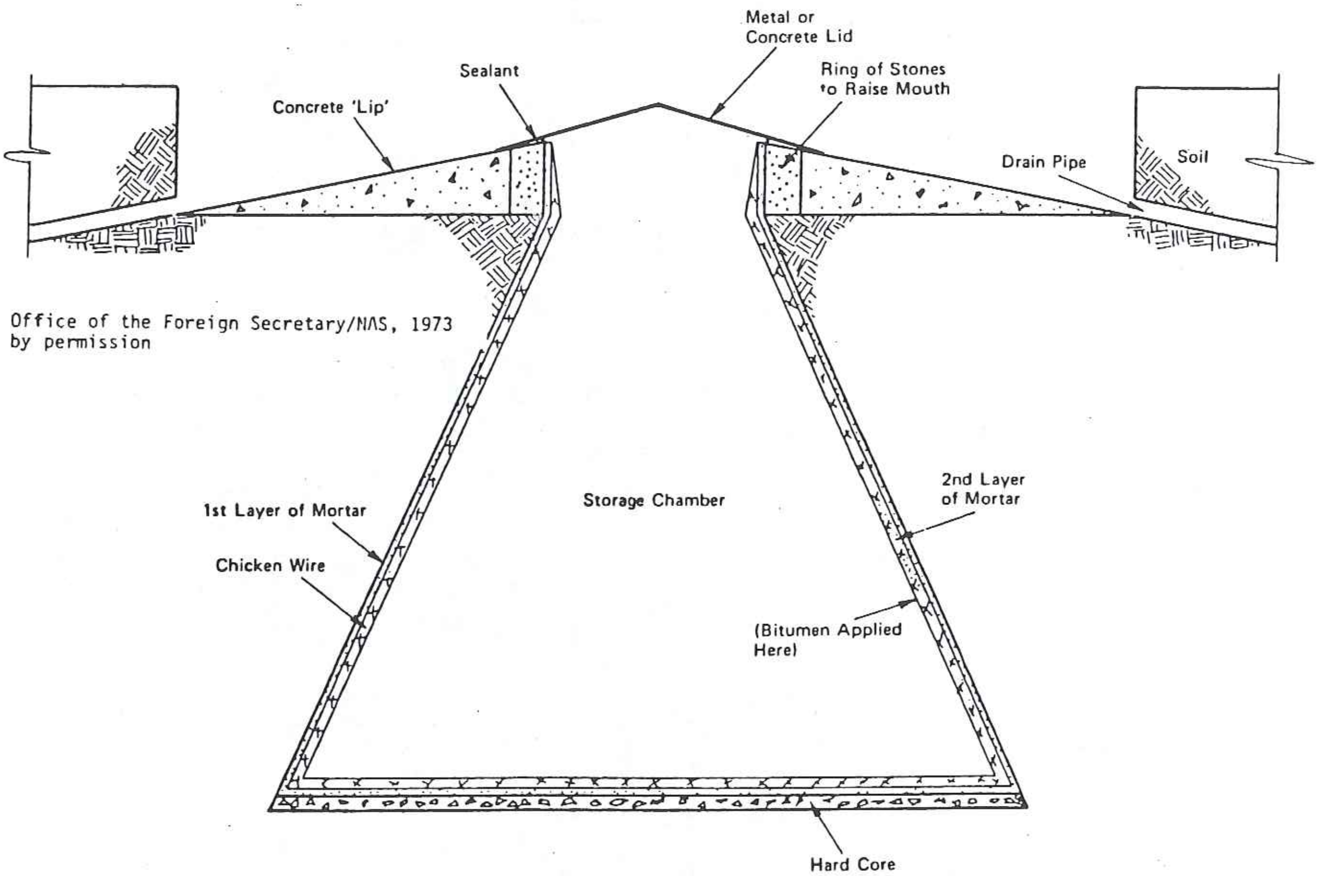


Figure 15, Cross-section of Ferrocement-lined Underground Storage Pit.

Soil type will affect smoothness of earthen walls and the ease with which plaster can be applied to the sides of an excavation. Calvert and Binning (1977) say that their tanks should be dug out in "soft" soil. Sharma et al (1979) say that traditional grain pits have been lined successfully in all the major soil types of the Harar province of Ethiopia.

The lining of traditional Dogon granaries with ferrocement pioneered by Hans Guggenheim and described by Watt (1978), represents an interesting above-ground version of the Ethiopian scheme. Existing adobe-brick granaries, about 2.4 m high and 2.6 m in diameter, are lined with plaster reinforced with wire netting

Chapter 6

STORAGE TECHNOLOGIES OR "TANKS"*

6.1 General Considerations

A satisfactory storage tank is the key element in a rooftop catchment system. As has been noted in other sections, the water storage facility or "tank" is usually the most expensive part of simple RWH systems and at the same time the most difficult to construct so that it will perform satisfactorily over a long period. An adequate tank must not leak. It must be structurally strong enough to support the great load of the water it will hold and it must be covered to keep out sunshine, dirt, insects, and (if the tank is buried) dirty surface and ground water.

As far as users are concerned, the tank is also the focus of the system. It is usually both the storage and distribution point, requiring cleaning and maintenance to ensure both these functions.

Tanks can be categorized into three groups:

1. those used with individual household rooftops (mostly above ground).
2. those used with larger rooftops or several rooftops (above, partially buried, and below ground).
3. those used with surface catchments.

Within each of these three groups there are many different kinds of tanks, each with its own construction methods, materials costs, and labor requirements. Each of these factors, along with the required capacity of the tank (see technical note on using rainfall data to design a RWH system, Appendix A), enters into decisions about what kind of tank to build.

The tank's function--as an individual household source or source for a group of families--is probably the single most important determinant of tank size and design. This choice can be made only in close consultation with the people who will build and use the tank. Without their participation and genuine support a tank-building effort has little prospect of success. In their comments on the slow progress of open tank construction for irrigating school gardens in Botswana, Farrar and Pacey (1974) note:

"In any community where a tank programme is contemplated, it would seem important to inquire into the 'felt needs' of the people. To which category of water use do they give highest priority?

"a) drinking water: for home or school use?
"b) washing water
"c) water for gardens: again, at home or at school?

"In most parts of southern Africa, water for school gardens would be given the lowest priority."

*From Keller, Kent, Rainwater Harvesting for Domestic Water Supplies in Developing Countries, WASH Working Paper No. 20, Water and Sanitation for Health Project, Arlington, VA 1982.

**For References in text see annotated bibliography which follows the Session Guides in this Training Guide.

Whether to build an above-ground tank or an excavated (underground) tank deserves considerable thought. Watt (1978) notes:

"Storing water in tanks built on the surface has many advantages when compared with storage tanks excavated into the ground. Besides avoiding the need for laborious excavation which is almost impossible in some hard dry soils, the tanks can be observed for leaks and easily repaired by trowelling a layer of mortar onto the inside of the empty tank. In addition, although the stored water is likely to become hotter in the sun, the risks of polluted material falling into the tanks are reduced. Water stored above ground can flow out under its own weight whereas it has to be pumped out of a ground tank."

The main advantage of underground tanks, on the other hand, is that the earth supports the tank lining and contents, making it possible to build deeper tanks with thinner walls. This means that building materials can be conserved and used to make leakproof wall surfaces instead of structural wall reinforcement.

Underground tanks do not always require a pump. Figures in section 6.3 (below) show how a concrete block tank supported with earth embankments can be fitted with a tap.

Larger tanks require fewer materials per unit of water storage capacity than smaller tanks, which tend to give them a cost advantage. Constructing smaller tanks, though, tends to require less expertise and preparation, fewer tools, and less cash "up-front". Large tanks may bring with them structural problems. For example, large areas of flat plastered wall are more vulnerable to cracking than smaller walls (e.g. Maikano and Nyberg, 1980). Thus, in many cases, smaller tanks or groups of smaller tanks will be chosen in preference to a single larger one.

Different kinds of tanks demand different standards of workmanship in construction. Ferrocement and other tanks made with mortar plaster will crack and leak if mortar is not made with clean components in proper proportions, and applied properly to the reinforcing framework. A prototype made by people who have never made one before may not perform satisfactorily. A failure should be planned on or experience sought.

The walls of underground tanks must be built carefully, especially if they are of brick or masonry. Cairncross and Feachem (1978) say these tanks should only be built by an experienced builder (and indeed, local masons should always be involved). Individual Water Supply Systems (Office of Water Programs/EPA, 1974) emphasizes the importance of high-quality workmanship and recommends against "unskilled labor".

6.2 Household Tanks

6.2.1 Recycled Used Containers

A wide variety of locally-available containers can be used to catch water flowing from guttering or simply dripping off the edge of roofing. White et al (1973) describe the use in West Africa of steel petrol drums with one end cut out (see

Water for the World

Designing Structures for Springs

Technical Note No. RWS. 1.D.1

Protective structures are a very important part of developing springs as sources for a community water supply. A properly designed protective structure ensures an increased flow from the spring. To protect the spring, silt, clay and sand deposited at the spring outlet, and other material washed down from the slope by surface run-off, must be cleared away. When these materials are removed, water flow increases. Clearing away vegetation from the spring effluent will also allow better flow. A protective structure will improve the accessibility of the water. By channeling the spring flow into one collection area, a good quantity of water can be stored for the community. Spring water can be distributed to community standpipes or to individual houses. A third benefit of a protective structure is that it protects the spring water from contamination.

This technical note discusses the design of structures used to protect and develop springs for community water supplies and makes suggestions for spring development in a specific area. The design chosen for a particular project will depend on local conditions, materials available and spring yield. Read this entire technical note and refer to "Selecting a Source of Surface Water," RWS.1.P.3, before choosing a design that will best meet a community's needs.

The design process should result in the following three items which should be given to the construction supervisor:

1. A map of the area. Include the location of the spring; the locations of users' houses; distances from the spring to the users, elevations, and important landmarks. Figure 1 is a map of a small village with a spring located on high ground above it. A map of this type is useful in helping the people building the spring box locate the spring site.

2. A list of all labor, materials and tools needed as shown in Table 1. This will help make sure that adequate quantities of materials are available so construction delays can be prevented.

3. A plan of the spring box with all dimensions as shown in Figure 2. This plan shows a top, side, and front view, and the dimensions of a cover for a spring box 1m x 1m x 1m.

Useful Definitions

DISCHARGE - The flow of water from an opening in the ground or from a pipe or other source.

EFFLUENT - At a spring site, the point from which water leaves the ground.

GROUT - A thin mortar used to fill chinks, as between tiles.

HEAD - Difference in water level between the inflow and outflow ends of a system.

HYDRAULIC GRADIENT - The measure of the decrease in head per unit of distance in the direction of flow.

MORTAR - A mixture of cement or lime with water in a basic proportion of 4 units of sand to 1 unit of cement or lime.

PERPENDICULAR - Exactly upright or vertical; at a right angle to a given line or plane.

PUDDLED CLAY - A mixture of clay with a little water so clay is workable.

REINFORCING ROD - Steel bars placed in concrete structures to give it tensile strength.

UNDERFLOW - Flow of water under a structure.

Table 1. Sample Materials List

Item	Description	Quantity	Estimated Cost
Labor	Foreman Laborers	____ ____	____ ____
Supplies	Portland cement Clean sand and gravel, if available, or locally available sand and gravel Water (enough to make a stiff mixture) Wire mesh or reinforcing rods Galvanized steel or plastic pipe (for outlets, overflow, and collectors) Screening (for pipes) Boards and plywood (for building forms) Old motor oil or other lubricant (for oiling forms) Baling wire Nails	____ ____ ____ ____ ____ ____ ____ ____ ____ ____	____ ____ ____ ____ ____ ____ ____ ____ ____ ____
Tools	Shovels and picks (or other digging tools) Measuring tape or rods Hammer Saw Buckets Carpenter's square or equivalent (to make square edge) Mixing bin (for mixing concrete) Crowbar Pliers Pipe wrench Wheelbarrow Adjustable wrench Screwdriver Trowel	____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____	____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____

Total Estimated Cost ____

General Construction Steps

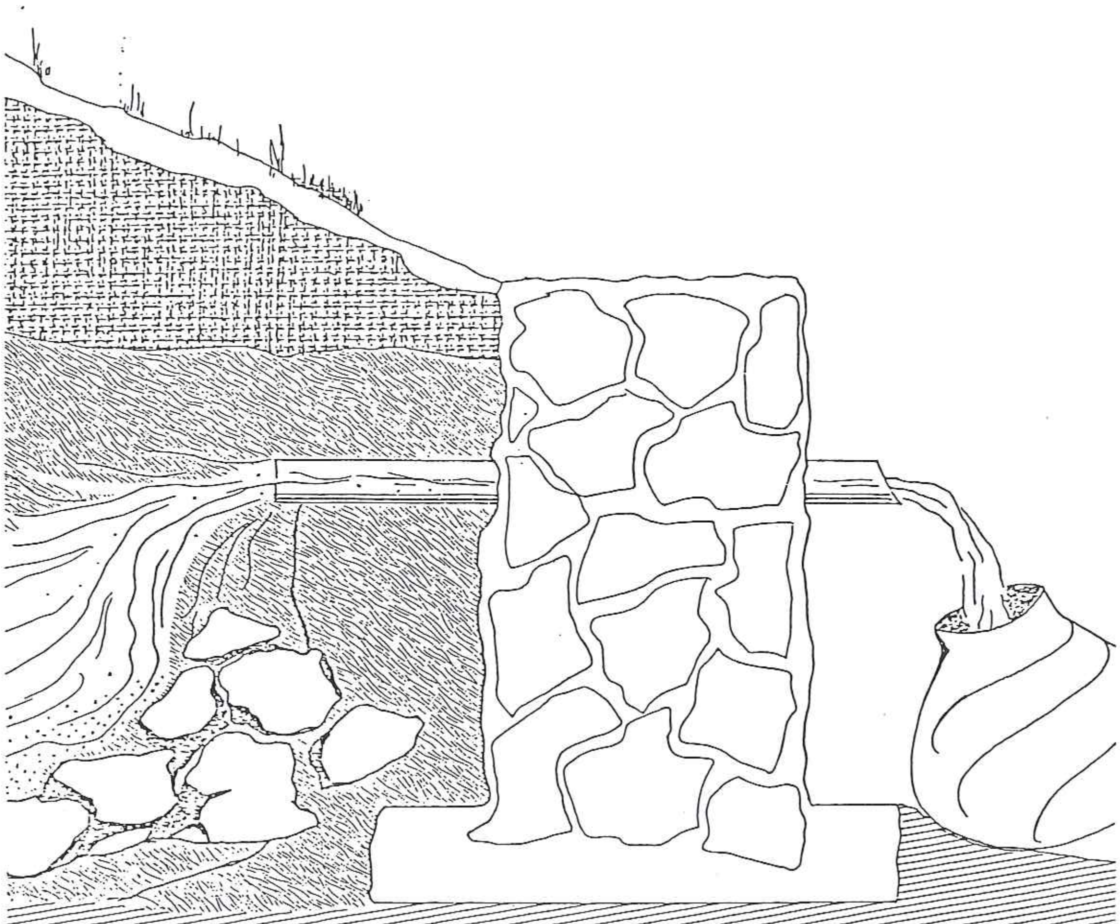
Follow the construction steps below. Refer to the diagrams noted during the construction process.

1. Locate the spring site and with measuring tape, cord and wooden stakes, or pointed sticks, mark out the construction area as shown in Figure 3.

2. Dig out and clean the area around the spring to ensure a good flow. If the spring flows from a hillside, dig into the hill far enough to determine the origin of the spring flow. Where water is flowing from more than one opening, dig back far enough to ensure that all the water flows into the collecting area. If the flow cannot be channeled to the collection area because openings are too separated, drains will have to be installed. Information on the installation of drains appears in the section on the development of seep collection systems.

Flow from several sources may be diverted to one opening by digging far enough back into the hill. When digging out around the spring, watch to see if flow from the major openings increases or if flow from minor seeps stops. These signs indicate that the spring flow is becoming centralized and that most of the water can be collected

RETAINING WALL STRUCTURE



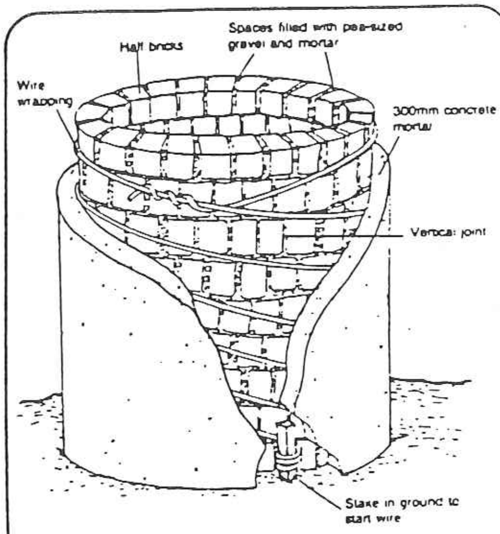


Figure 11. Brick Spring Box

8. Let the concrete structures set for seven days, wetting the concrete at least daily. After seven days, the forms can be removed and the box can be installed.

When constructing a masonry ring to protect a spring, follow the construction steps listed below.

1. Mark out a circle on the ground the diameter of the proposed masonry ring.

2. Using half bricks, place a circle of brick around the outside of the ring. Whole bricks broken in half or broken bricks can be used for the structure. In some places, broken bricks are available free.

3. Fill the spaces between the bricks with pea gravel and mortar mixed in a proportion of 1 part cement to 3 parts sand. As mortar is applied, add the next line of bricks. Be sure the vertical joints do not line up.

4. When reaching the desired height, strengthen the structure using baling, barbed or any available wire. Put a stake in the ground next to the ring and attach the wire to it. Wrap the wire around the ring several times as shown in Figure 11. Once the wire is wrapped around, secure and cut it.

5. Mix mortar in the proportion of 1 part cement to 3 parts sand. Cover the outside of the ring with a layer of mortar. The layer should be thick enough to cover the wire completely.

6. A circular cover should be built. Follow the same techniques as for the construction of concrete spring box covers.

Installing a Spring Box

The spring box must be installed correctly to ensure that it fits on a solid, impervious base and that a seal with the ground is created to prevent water seeping under the structure.

1. Place the spring box in position to collect the flow from the spring. If the flow comes from a hillside, the back of the spring box will be open. Stones should be placed at the back of the box to provide support for the structure and to allow water to enter the spring box. Figure 4 shows the placement of open-jointed rock in a completely installed spring box on a hillside. On level ground, be sure that the spring box has a solid foundation of imprevious material. Place gravel around the box or in the basin so that water flows through it before entering the box.

2. Seal the area where the spring box makes contact with the ground. Use concrete or puddled clay to form a seal that prevents water from seeping under the box.

3. Be sure that the area where the spring flows from the ground is well lined with gravel, then backfill the dug out area with gravel. The gravel fill should reach as high as the inlet opening in the spring box so that the water flowing into the structure passes though gravel. In Figure 4, the gravel layer reaches the same level as the open stone wall. For spring boxes on level ground, gravel backfill is unnecessary.

4. Place the pipes in the spring box. Remove the pipe pieces used to

form the holes and put in the pipe needed for outflow and overflow. On both sides of the wall, use concrete to seal around the pipes so water does not leak out from around them. Place screening over the pipe openings and secure it with wire.

5. Disinfect the inside of the spring box with a chlorine solution. Before the spring box is closed, wash its walls with chlorine. Follow the directions for disinfection in "Disinfecting Wells," RWS.2.C.9.

6. Place the cover on the spring box.

7. Backfill around the area with puddled clay and soil. On a hillside, place layers of puddled clay over the gravel so that they slope away from the spring box. The clay layer should nearly reach the top of the spring box and should be tamped down firmly to make the ground as impervious as possible. If only soil were used for backfill, it would have to be as least 1.5-2m deep so that contaminated water could not reach the gravel layer. For springs on level ground, clay should be placed around the box. The clay foundation should slope away from the spring box so that water runs away from the spring outlet.

8. Backfill the remaining areas with soil to complete the installation.

Constructing Seep Collection System

Sometimes springs flow from many openings over a large area. To collect the water, a system of collectors made of perforated pipe, an anti-seepage wall, and a spring box must be built.

The collectors must extend on both sides of the spring box and anti-seepage wall. Figure 12 shows an example. To install collectors dig trenches into the water-bearing soil until an impervious layer is reached. In this way, water is taken from the deepest part of the aquifer and most of the available water can be collected. The trenches should extend the necessary length for collecting all available water and should be about 1m wide.

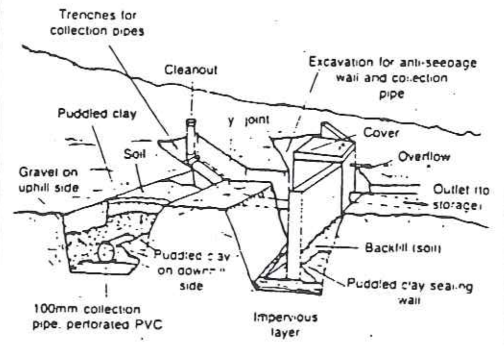


Figure 12. Seep Collection System

Lay 50-100mm diameter plastic perforated pipe or 100mm clay pipe in the trenches. Perforations in the plastic pipe should be about 3mm in diameter. On the uphill side of the trench, place enough gravel to cover the pipe. On the downhill side, build up a small clay wall to support the pipe. The pipe should have a 1 percent slope (0.01m slope per 1m distance) toward the point of collection. Flexible plastic tubing with slots already formed should be used if available. It is light and can be cut with a handsaw.

Clean-out pipes should be installed in the collection system. Attach lengths of pipe to the ends of the collection pipes. At the end of the clean-out pipes, place an elbow joint to which a vertical length of pipe is connected as shown in Figure 12. The pipe extends above ground level and is capped.

The next step is to build a concrete or impervious clay cutoff or anti-seepage wall. Dig down to an impervious layer for a good foundation. Make the forms for the cutoff wall 0.15m thick. Figure 13 shows a concrete cutoff wall 1.2m long and 0.9m high. Follow the same procedures for constructing the cutoff wall as for the spring box. There must be a good seal between the wall and the ground so that no water seeps underneath. Water must be

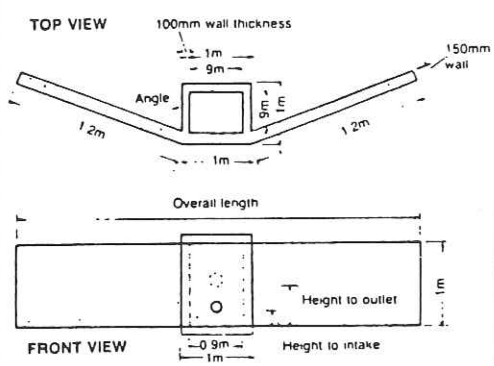


Figure 13. Anti-Seepage Wall and Collection Box

directed into the trenches and collectors. A small spring box can be built at the inside angle of the winged-wall with the wall forming two sides. If a spring box is built, the forms must be set at the same time as the cutoff wall. Water must be diverted from the construction area by small ditches for the seven days needed for the concrete to dry. Forms must be well braced and have holes for the inflow and outflow pipes as shown in Figure 14. Always pour the seep collection wall and spring box in place. The structure will be much too heavy to move after casting.

When using clay, be sure to remove any debris from the site and tamp the clay well so that the small dam or wall does not let water seep through. The clay walls should be built like walls of a dam with a 2:1 or 3:1 slope. Put

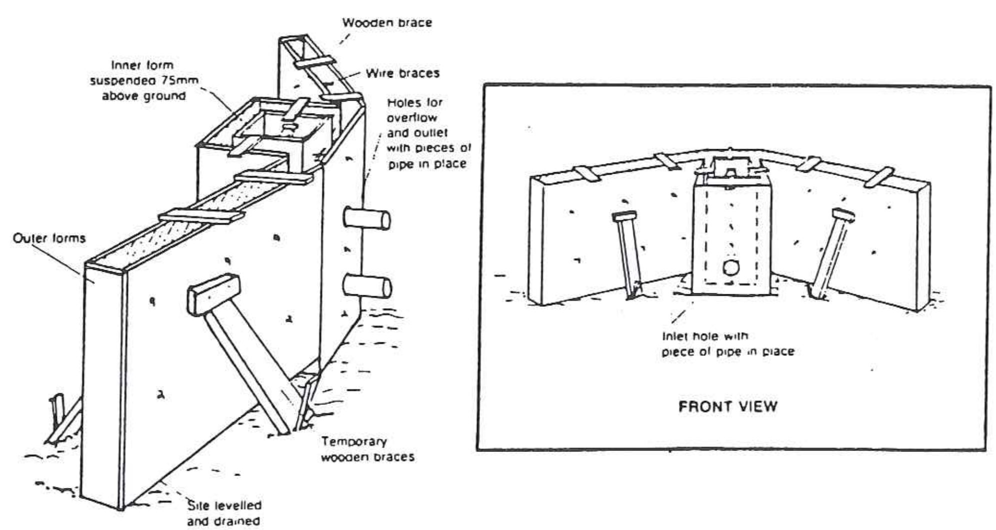


Figure 14. Forms for Anti-Seepage Wall and Collection Box

the clay down in layers 150mm thick and tamp each layer down well to ensure good compaction. Keep the clay moist. Lay and tamp each 150mm layer until the maximum height is reached. The walls should be well bonded to the spring box.

The construction of a seep collection system is more difficult and expensive than a simple spring box. Installation of collectors requires more work and some experience. Once the collectors are installed, however, the construction of the seep cutoff wall is no different from spring box construction. The same steps must be followed, the same mixture of concrete used and the same general rules for curing concrete and for placement must be followed.

Water for the World

Constructing Structures for Springs
Technical Note No. RWS. 1.C.1

There are two important reasons to build structures for springs and seeps. First, they protect the water from contamination caused by surface run-off and by contact with people or animals. Secondly, the structures provide a point of collection and storage for water. Water from springs and seeps is stored so it will be readily available to the users. This technical note discusses the construction of spring boxes and seep collection systems and outlines the construction steps to follow. The steps are basic to small construction projects and should be followed for the construction of most spring structures.

Useful Definitions

CONVEX - Curving outward like the surface of a sphere.

DISINFECTION - The process of destroying harmful bacteria.

EFFLUENCE - An opening from which water flows.

PUDDLED CLAY - A mixture of clay and a little bit of water used to make something watertight.

UNDERFLOW - Flow of water under a structure.

VOIDS - Open spaces in a material.

Materials Needed

Before construction begins, the project designer should give you the following items:

(1). A map of the area, including the location of the spring; locations of users' houses; and distances from the spring to the users, elevations, and important landmarks. Figure 1 is a map of a small village with a spring located on high ground above it. Use your map to locate the construction site for the spring box.

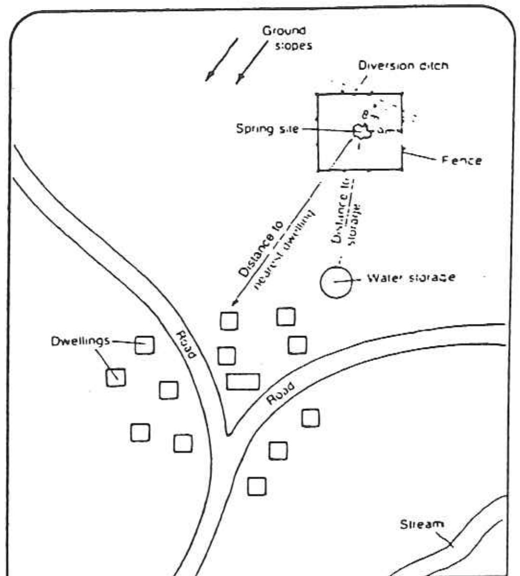


Figure 1. Location Map

(2) A list of all labor, materials and tools needed as shown in Table 1. Ensure that all needed materials are available and at the work site before work begins. Make sure that adequate quantities of materials are available to prevent construction delays.

(3) A plan of the spring box with all dimensions as shown in Figure 2. This plan shows a top, side, and front view, and the dimensions of a cover for a spring box 1m x 1m x 1m.

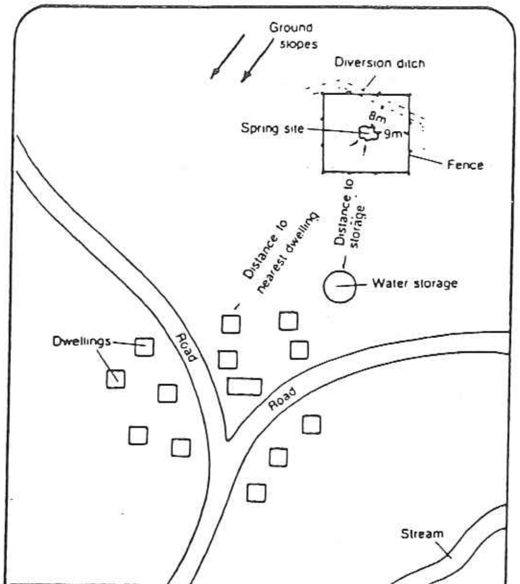


Figure 1. Location Map

Spring Box Design

There are several possible designs for spring boxes but, generally their basic features are similar. Spring boxes serve as collectors for spring water. They are sometimes used as storage tanks when a small number of people are being served and the source is located near the users. When larger numbers of people are served, the water collected in the spring box flows to larger storage tanks. The two basic types of spring boxes discussed in this paper are a box with one pervious side for collection of water from a hillside, and a box with a pervious bottom for collection of spring water flowing from a single opening on level ground. To determine which design to use dig out around the area until an impervious layer is reached, locate the source of the spring flow, and design to fit the situation.

Table 1. Sample Materials List

Item	Description	Quantity	Estimated Cost
Labor	Foreman	____	____
	Laborers	____	____
Supplies	Portland cement	____	____
	Clean sand and gravel, if available, or locally available sand and gravel	____	____
	Water (enough to make a stiff mixture)	____	____
	Wire mesh or reinforcing rods	____	____
	Galvanized steel or plastic pipe (for outlets, overflow, and collectors)	____	____
	Screening (for pipes)	____	____
	Boards and plywood (for building forms)	____	____
	Old motor oil or other lubricant (for oiling forms)	____	____
	Baling wire	____	____
	Nails	____	____
Tools	Shovels and picks (or other digging tools)	____	____
	Measuring tape or rods	____	____
	Hammer	____	____
	Saw	____	____
	Buckets	____	____
	Carpenter's square or equivalent (to make square edge)	____	____
	Mixing tin (for mixing concrete)	____	____
	Crowbar	____	____
	Pliers	____	____
	Pipe wrench	____	____
	Wheelbarrow	____	____
	Adjustable wrench	____	____
	Screwdriver	____	____
	Trowel	____	____

Total Estimated Cost ____

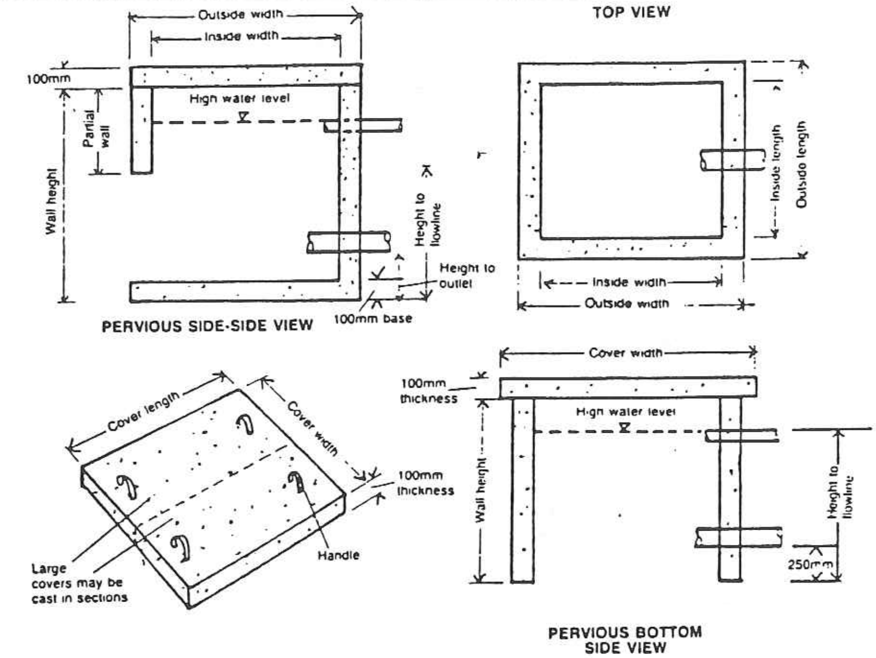


Figure 2. Spring Box Design

<u>Spring Box with Open Side</u>. A spring box with a pervious side is needed to protect springs flowing from hill-sides. The area around the spring must be dug out so that all available flow is captured and channeled into the spring box.

After this has been done, a collection box can be built around the spring outlet as shown in Figure 3. The dug-out area should be lined with gravel. The gravel placed against the spring opening serves as a foundation for the box and prevents the spring water from washing soil away from the area. The gravel pack also filters suspended solids. The gravel-filled area should be between 0.5-1m wide depending on the size of the spring collection area. To ensure that no contamination reaches the water, the gravel pack should be at least 1m below the ground surface. This is done either by locating the spring catchment in the hillside or by raising the ground level with backfill.

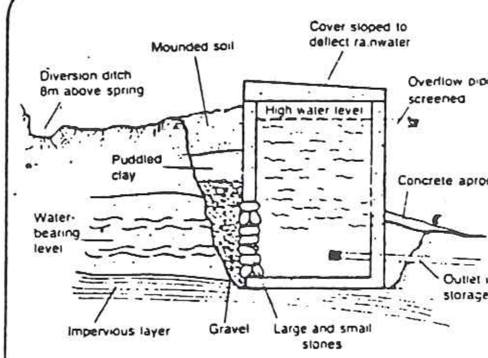


Figure 3. Spring Box with Open Side

Caution must be taken not to disturb ground formations when digging out around the spring. Without care, the flow of the spring may be deflected in another direction or into another fissure. The area must, however, be dug out enough so that the spring box fits into impermeable material. In cases where the box does not reach impermeable material, puddled clay should be used to seal the area around the sides of the spring box.

Spring Box with Open Bottom. If a spring flows through a fissure and emerges at one point on level ground, a spring box with an open bottom can be developed as shown in Figure 4. The area around the spring is dug out until an impermeable layer is reached. The area around the spring is then leveled and lined with gravel. The spring box is placed over the spring and gravel to collect the flow, and clay or concrete is packed around the box to prevent seepage between the ground and the box. Sometimes a small sump can be built at the bottom so that sediment settles in one place.

The design of both types of spring boxes is basically the same and includes the following features:

(a) a water-tight collection box constructed of concrete, brick, clay pipe or other material,
(b) a heavy removable cover that prevents contamination and provides access for cleaning,
(c) an overflow pipe, and
(d) a connection to a storage tank or directly to a distribution system.
The spring box with an open bottom is simpler and cheaper to construct. Generally, on level ground, flow from only one source must be captured and collection of all available flow is much easier. Costs are lower because less digging and fewer materials are required.

The spring box should be constructed at the spring site for easy installation. If the appropriate materials are available, the spring box should be made of concrete. Information on the use of concrete is included in Worksheet A. Three sides of the spring box must be impervious and depending on the type of spring selected for development, either the bottom or the

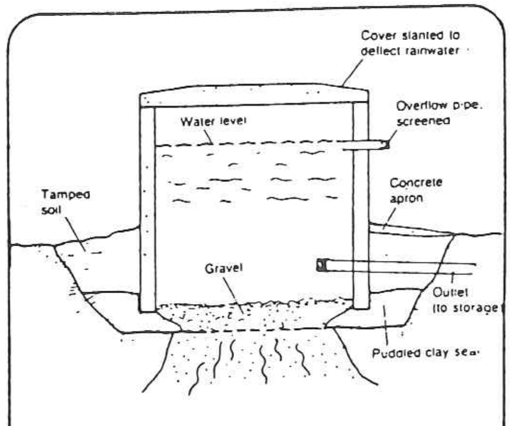


Figure 4. Spring Box with Open Bottom

upslope side must be pervious or open. The upslope side of an open sided spring box can be constructed partially with concrete and partially with large rocks and gravel as shown in Figure 3. Large rocks support the spring box and allow water to enter. Smaller stones should be used between the large rocks to close large openings so that sediment is filtered from the water.

If materials for building a concrete box are not available, or are expensive, there are alternatives that are particularly useful in developing a single source spring. Large prefabricated clay or concrete tubes, like regular spring boxes, can be placed around the spring. Water rises in the tube and flows out the outflow pipe. Rings for collecting spring water can even be constructed using bricks and mortar. Half or broken bricks can be used to build a ring as shown in Figure 5. The bricks are laid in a circular pattern, so that vertical joints do not line up. Spaces between the bricks are filled with gravel and mortar. Bricks are laid until a height of between 0.9-1.2m is reached. The diameter may vary but should be around 0.7-1.0m. An outlet and overflow pipe should be placed in the structure before installation and with reinforcement added. This type of structure is very practical and inexpensive to construct. Little cement is needed and locally available materials can be used.

Worksheet A. Calculating Quantities Needed for Concrete

(Calculations for a box 1m × 1m × 1.0m with open bottom)

Total volume of box = length (l) x width (w) x height (h)

Thickness of walls = 0.10m

1. Volume of top = l 1.2 m x w 1.2 m x t 0.10 m = 0.144 m^3
2. Volume of bottom = l 0 m x w 0 m x t 0 m = 0 m^2
3. Volume of two sides = l 1 m x w 1 m x t 0.10 m x 2 = 0.20 m^3
4. Volume of two ends = l 1 m x w 1 m x t 0.10 m x 2 = 0.20 m^3
5. Total volume = sum of steps 1, 2, 3, 4, 5 = 0.54 m^3
6. Unmixed volume of materials = total volume x 1.5; 0.54 m^3 x 1.5 = 0.81 m^3
7. Volume of each material (cement, sand, gravel, 1:2:3):

   cement: 0.167 x volume from Line 6 0.81 = 0.13 m^3 cement.
   sand: 0.33 x volume from Line 6 0.81 = 0.26 m^3 sand.
   gravel: 0.50 x volume from Line 6 0.81 = 0.4 m^3 gravel.

8. Number of 50kg bags of cement = $\frac{\text{volume of cement}}{\text{volume per bag}}$

   volume of cement 0.13m^3 - .033m^3/bag = 4 bags.

9. Volume of water = 28 liters x 4 bags of cement = 112 liters.

(NOTE: 1) Do not determine volume for an open side or bottom.
2) The top slab has a 0.1m overhang on each side.
3) The same calculations will be used to determine the quantity of materials for construction of a seepage wall.
4) To save cement a 1:2:4 mixture can be used.)

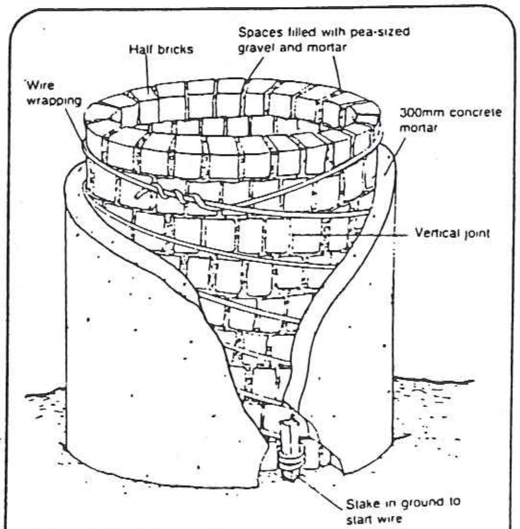


Figure 5. Brick Spring Box

The capacity of the spring box depends on whether it is being used for storage or pre-storage. If the spring box is used for storage, it should be large enough to hold a volume of water equal to the needs of the users over a 12-hour period. For example: If 100 people each use 25 liters of water per day, the amount of water consumed in 12 hours is 1250 liters. There are 1000 liters per m^3. Therefore the volume of the spring box should be 1.25m^3. (Volume = length x width x height). If the collection box is used only for pre-storage and water flows on to another storage tank, the collection box can be smaller.

A reinforced concrete cover must be constructed to protect the tank from outside contamination. The cover should be cast in place to ensure proper fit. It should extend over the spring box about 0.1m on each side so rain does not fall at the base of the spring box. The cover should be heavy enough so children cannot lift it off.

The spring box should have an overflow pipe. The pipe is placed a little below the maximum water level and at least 0.15m above the floor of the tank. If the pipe is above the maximum water level, water will not flow out and pressure is created in the tank. The pressure could cause a back-up and diversion of the spring. The overflow pipe should be covered with a screen fine enough to keep out mosquitoes and strong enough to keep out small animals. The size of the pipe depends on the flow of the spring. A rock drain or concrete slab should be placed outside the tank below the overflow pipe to prevent erosion near the base and to carry the water away from the spring. A pipe which extends 3-5m from the tank is desirable in order to keep the site free from still water.

An outlet pipe for connection to a distribution system should be located at least 0.1m above the bottom of the spring box to prevent a blockage due to sediment build-up. The pipe size depends on the grade to the storage tank and the spring flow. A general rule to follow is that at a one percent grade, a 30mm pipe should be used. A grade between 0.5 and one percent requires a 40mm pipe, while a 50mm pipe should be used for grades of less than 0.5 percent. In some cases the same pipe will be both outlet and overflow. The outlet pipe should slope downward for best flow.

After the spring box is installed, the space behind it must be filled with soil and gravel. The gravel is the bottom layer. On top of it, a water-tight layer should be formed to prevent the entrance of surface water. This can be done with concrete or puddled clay. Puddled clay is a mixture of clay and water formed into a layer 150mm thick. The layer is placed on the ground and worked in by trampling on it. Several layers of puddled clay should be placed behind the box.

After sealing the area, the box can either be completely covered with soil or stand above the ground surface. The box should be at least 0.30m above ground level so that run-off does not enter it. For further sanitary protection, a ditch should be dug at least 8m above the spring box to take surface water away from the area. The soil from the ditch should be piled on the downhill side to make a ridge and help keep surface water away. A fence around the area will keep animals from getting near the spring box and help prevent contamination and destruction of the area. The fence should have a radius of between 7-8m.

Seep Design

Designs for seep development are similar to those for spring boxes. Figure 6 shows the basic design. Intakes (collectors) are very important features of seep development. The collector system consists of small channels containing 100mm clay open-joint or 50mm plastic perforated pipe packed in gravel. The collectors are installed in the deepest part of the aquifer. They take advantage of the saturated ground above them for storage during times when the groundwater table is low. The perforations in the pipes must be about 5mm in diameter or large enough to collect sufficient water but small enough to prevent suspended matter from entering the pipes. In fine and medium-sized sand, perforated pipe should be packed in gravel but suspended material often will enter the pipe in spite of the gravel.

To prevent clogging, the collectors should be sized so that the velocity of water flow in them is between 0.5m per second and 1m per second. See "Methods of Delivering Water," RWS.4.M.

Water collected by the pipes is channeled to the spring box through a gravel pack. The collectors must extend across the entire width and length of the water-bearing zone and should be perpendicular to the flow of the aquifer. These intakes should extend below the water-bearing zones to collect the maximum amount of water and permit free flow into the collector. The advantage of a collector system is that water seeping over a large area can be channeled into a central storage basin.

Clean-out pipes to flush sediment from the collection pipes should be attached to the collection pipes. To install clean-out pipes, add a length of pipe to the far end of the collection pipe. At the end of this length, place an elbow joint facing upwards and attach a vertical length of pipe.

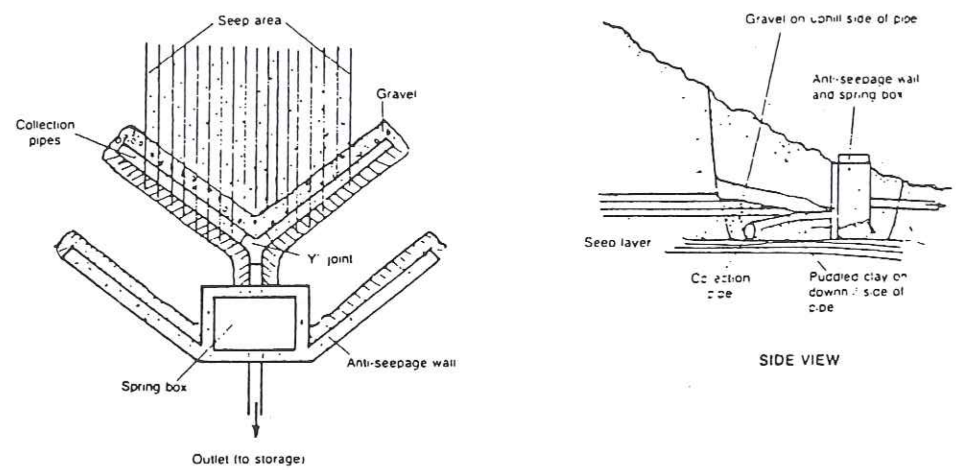


Figure 6. Seepage Collection System

The pipe should extend a little above the ground and be capped. If the collector system clogs, water can be added to the clean-out pipes to flush out the system.

For seep development, a cutoff wall of clay, concrete or other impervious material should be constructed. The cutoff is usually constructed as a large "V" pointing downhill with wing walls extending into the hill to prevent water from escaping. The cutoff should extend down into impervious material to force the flowing water to move to the collection point and to prevent loss of water due to underflow.

The use of concrete for the cutoff wall is best but most expensive. A wall 0.15m thick will ensure adequate strength against increased flow. The height of the cutoff wall depends on the size of the flow being collected. If desired, a spring box may be constructed inside the "V" shaped meeting of two walls as shown in Figure 7. The spring box will provide a settling basin for sediment removal and storage. The spring box should be designed so that water enters it

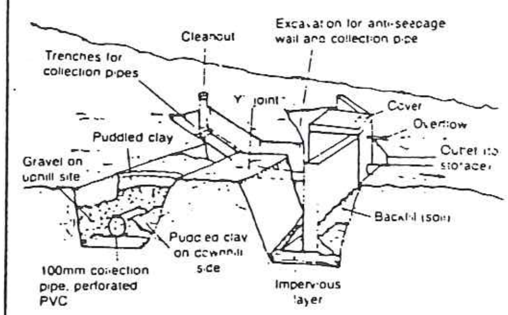


Figure 7. Basic Design Feature of a Seep Collection System

through openings in the upper wall. These openings must be screened to prevent entrance of debris.

Puddled clay instead of concrete can be used to form the cutoff wall. The clay is piled up and tamped down to form an impervious wall. It acts as a small dam which prevents spring water from flowing away from the collection area. The clay cutoff wall works as well as the cement wall and is much cheaper and easier to install. Good impervious clay should be available if this type of cutoff wall is chosen.

An outlet pipe is installed to move water from the collection point to storage. The diameter of the pipe depends on the grade to storage and will generally range between 30-50mm. To determine the correct pipe size, see "Methods of Delivering Water," RWS.4.M. The outlet pipe for a spring box or simple collection wall should be at least 150mm from the bottom of the collection area. A watertight connection should be made where the pipe leaves the spring box or goes through the cutoff wall. As in the case of spring boxes, the outlet pipe must be screened with small mesh wire. Because of the cost, this type of structure should be used only where seeps cover an extensive area. Skilled laborers will be needed for construction.

Horizontal Well Design

Horizontal wells are very simple and can be quite inexpensive. In order to use a horizontal well, an aquifer must have a steep slope or hydraulic gradient. Steep hydraulic gradients generally are found in chilly, sloping land and follow the ground surface. Horizontal wells, shown in Figure 8, are installed in much the same manner as vertical driven and jetted wells. See "Designing Driven Wells," RWS.2.D.2, and "Designing Jetted Wells," RWS.2.D.3 for specific design features.

A horizontal well can be driven if the spring flows from an aquifer in permeable ground. A pipe with an open end or with perforated drive points is driven into the aquifer horizontally or at a shallow slope to tap it at a point higher than its normal discharge. In some soils, the pipe can be driven by hand. Generally the pipe is driven using machinery.

"Designing Driven Wells," RWS.2.D.2, outlines the steps in designing a driven well. These same steps should be followed in designing horizontal wells. One design difference is that extra care must be taken

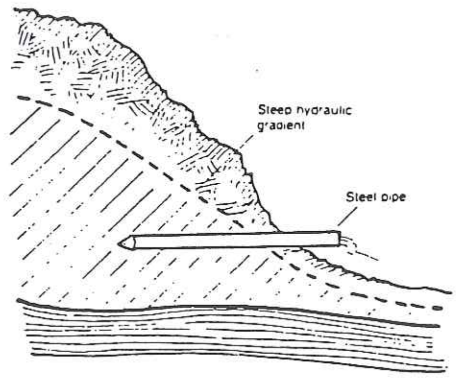


Figure 8. Horizontal Well

to avoid leakage between the driven pipe and the ground. If exterior flow occurs, it can be stopped by forcing clay or grout into the space, or by digging by hand 1m back along the pipe and installing a concrete cutoff wall. The wall should have a diameter of $0.6m^2$ and no more than 0.05m thick. After the concrete slab hardens, the dug-out area should be packed and backfilled with clay.

If the aquifer that feeds the spring is behind a rock layer, driving a horizontal well will be very difficult if not impossible. In this case, a jetted horizontal well will have to be installed. "Designing Jetted Wells," RWS.2.D.3, explains the process of jetting wells. The problem is that horizontal well drilling is different from vertical drilling, and may be too difficult for inexperienced people. Drilled horizontal wells should only be considered when there are no other reasonable alternatives.

Materials List

In addition to a location map and design drawings, give the person in charge of construction a materials list similar to Table 1 showing the number of laborers, types and quantities of materials needed to construct the spring protection. Some quantities will have to be determined in the field by the person in charge of construction.

Concrete. Concrete is the major material used in the construction of spring boxes and cutoff walls. Concrete is a mixture of Portland cement, clean sand, and gravel in a fixed proportion. The proportion generally used is one part cement, two parts sand, and three parts gravel (1:2:3). Water is used to mix the concrete. Twenty-eight liters of water should be used for each bag of cement. Worksheet A will help determine the amount of materials needed. Use the worksheet in making the following calculations.

1. Calculate the volume of mixed concrete needed (length x width x thickness; Worksheet A, Lines 1-5).

2. Multiply this number by 1.5 to get the total volume of dry loose material (cement, sand and gravel) needed (Worksheet A, Line 6).

3. Add the numbers in the proportion in order to find the fraction of the total needed for each material (1:2:3 = 6, so 1/6 of the mixture should be cement, 2/6 sand, and 3/6 gravel. In decimals, this is 0.167 cement, 0.33 sand, and 0.50 gravel).

4. Determine the amount of each material needed by multiplying the volume of dry mix from step 2 by the proportional amount for each material (1/6 x volume of dry mix = total amount of cement needed; Worksheet A, Line 7).

5. Divide the volume of cement needed by $.033m^3$ (33 liters), the amount of cement in a 50kg bag, to find the number of bags of cement required. When determining the amount of cement, figure to the largest whole number (Worksheet A, Line 8).

6. An extra quantity of cement should be figured into the total for use in grouting and sealing areas around the outlet pipes.

7. Calculate the amount of water needed to mix the concrete (28 liters of water per bag of cement; Worksheet A, Line 9).

8. Extra gravel will be needed for backfill of areas behind springs. Graded gravel is preferable, but local materials can be used if necessary. Calculate the volume of the area to be backfilled by taking length x width x height of area.

Reinforced Concrete. Concrete can be reinfored to give it extra strength. This is best done with wire mesh or specially made steel rods. Reinforced concrete sections must be at least 0.10cm thick. Reinforced concrete should be used for all spring box covers and for the walls of seep structures. If wire mesh is used, the quantity needed will be approximately equal to the area of the slab being constructed. If steel bars (rerod) are used, they should be placed in the wooden form before the concrete is poured. 10mm diameter rods should be used.

The reinforcing rod should be located as follows:

- So that the rods are at least 25mm (0.25m) from the form in all places;
- So that the rebar rests in the lower part of the cover; two-thirds the distance from the top or .70mm from the top of a 100mm slab;
- So that a 150mm (0.15m) space lies between a parallel rods in a grid pattern as shown in Figure 9.

Where the reinforcing rods cross, they should be tied together with wire at the point of intersection.

To determine the number of reinforcing bars, divide the total length or width of the spring box cover by 0.15m (distance between bars). For example, $\frac{1.2m}{0.15m} = 8$ bars.

To determine the length of each bar, subtract 0.05m (0.025m each side) from the total length or width of the cover. For example, 1.2m - 0.05m = 1.15m.

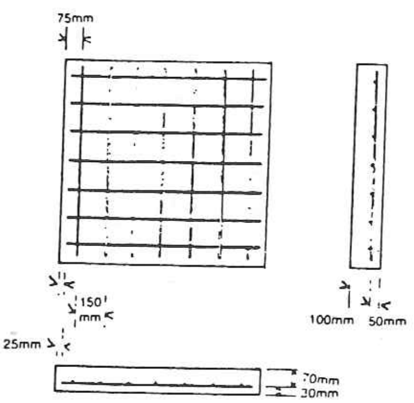


Figure 9. Placement of Rebar in Concrete Slab

Pipes. Outlet pipes can be of galvanized steel, or plastic depending on what is available. Galvanized steel is preferable because of its strength. Steel pipe lasts longer and does not shatter like plastic pipe. Intake pipes should be either clay, perforated plastic open-joint cement or in some cases, bamboo. The choice again will depend on availability of materials and cost. The pipe should have a minimum diameter of 50mm to be sure that an adequate supply of water enters the collection system. All pipes must be laid at a uniform grade to prevent air lock in the system.

When labor requirements, materials, and tools have been decided on, prepare a materials list similar to Table 1 and give it to the construction supervisor.

Important Considerations

Spring protection should ensure that the source is always protected from contamination. Before attempting to develop a spring, conduct a sanitary survey as described in "Conducting Sanitary Surveys to Determine Acceptable Surface Water Sources," RWS.1.P.2. Follow the guidelines for measuring the quantity of available water present in "Selecting a Source of Surface Water," RWS.1.P.3, to be sure that the source will meet community needs. The preliminary work described in these technical notes should be done before designing a protective structure.

The choice of the structure for spring protection depends on the geologic conditions of the area, the type of spring, the materials available, and the skill level of available labor. Spring boxes are easy to design and require little construction expertise, although workers should have some construction experience. Driven horizontal wells are also easy and inexpensive to develop although some expertise is needed to complete a successful well.

Structures for seeps are more difficult to design and require that workers have a much higher level of construction experience. The cost of developing a seep may be very high depending on the length of the retaining wall and the amount of pipe needed for intakes.

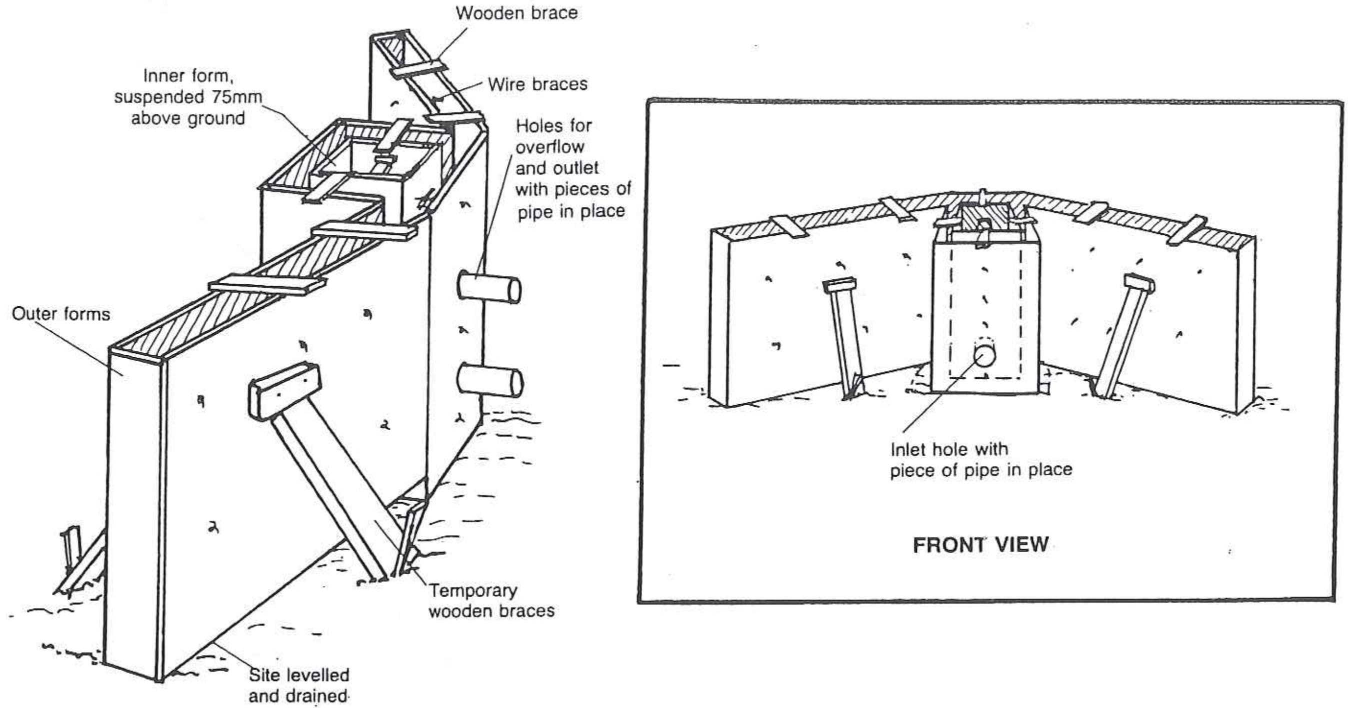


Figure 3. Forms for Anti-Seepage Wall and Collection Box

Operating and maintaining seepage collection systems is similar to spring boxes except that extra care must be taken in the maintenance of the collection pipes. Although collection pipes are lined with gravel to filter out sediment, the pipes can still clog.

If clogging occurs, substantially less water will reach the collection box. If water flow decreases, suspect that the collection system is clogged.

To clean the clogged pipes, remove the cap from the clean-out pipe and pour water into it. Use either a hose or a bucket so that sufficient force is available to break up the sediment. See Figure 4.

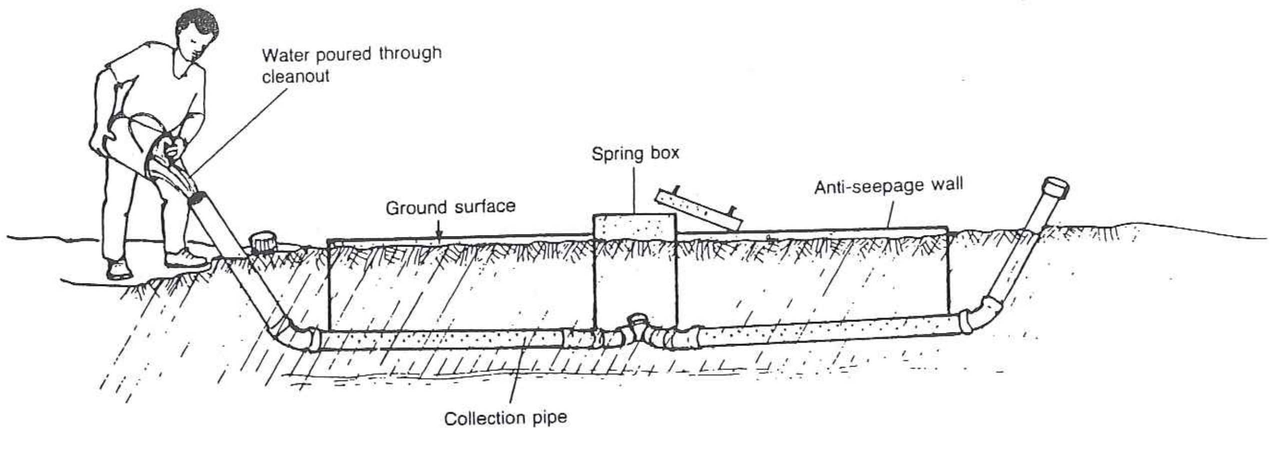


Figure 4. Flushing Out Seepage Collection System

STORAGE TANK

Purpose of Storage Tank

The construction of a storage tank for spring flow is an effective way to improve a spring water source with a low rate of flow. Storage tanks can be built as an addition to any type of spring containment system, retaining wall, spring box, or seepage collection system. The water flow from the spring is piped to a storage tank where the water accumulates and can be accessed by villagers through an outflow pipe and faucet. The water is stored in the tank overnight and is then available in large quantity when needed. Figure 1 shows a village map of a spring and a collection tank. The advantages of collection tanks are these:

1. The tank serves to store water that is provided by the spring during low-demand periods (such as overnight) for use during high-demand periods (such as early morning).

2. Water can be accumulated in vessels more quickly, since stored water will flow from the tank faster than from many direct-access spring flow pipes. Thus villagers won't have such a long wait for water during high use periods.

3. Water is captured overnight, thus resulting in less waste from unused run-off water.

4. Water can be kept clean, since it is stored in a tight, covered storage tank.

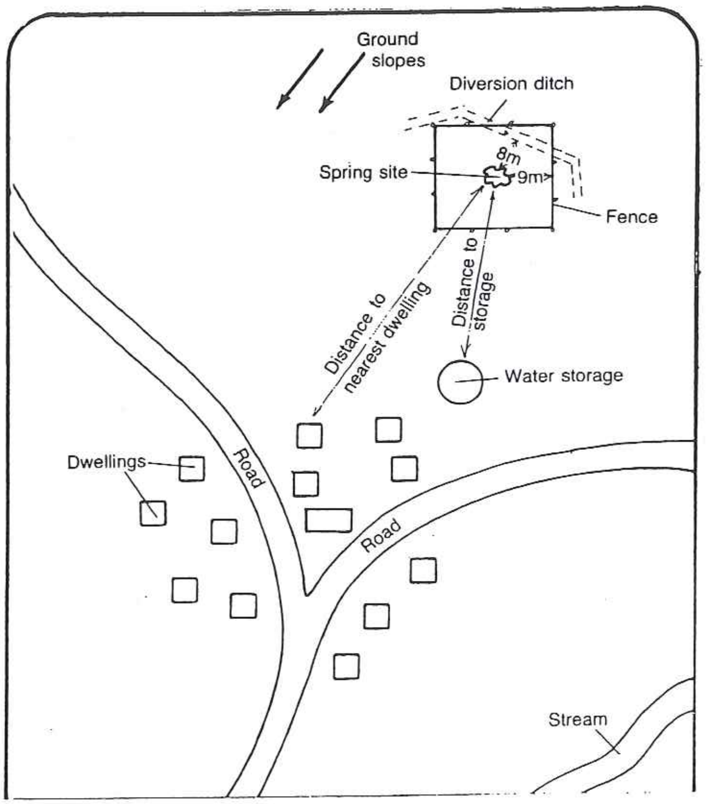


Figure 1. Location Map

Sizing a Storage Tank

To determine how large a storage tank must be, it is necessary to calculate how much water is used at various times during the day, and compare this to how much water is supplied by the source for those same time periods. The difference between supply and use will mean either that water will be drawn out of the tank or will flow into the tank. There are a number of ways to determine tank capacity; however, they are beyond the scope of this training program. The tank could be a variety of sizes and still serve as an improvement to villagers; however, it never need be larger than the volume of water yielded by the spring during the night.

Shape of a Storage Tank

All other factors being equal, the most economical tank shape is circular, then nearly-circular, then square, and then rectangular. For ease of construction, certain shapes are easier than others:

Circular tanks: The most economical shape to use, but not easy to construct, especially for small diameters.

Octagonal (8-sided) tanks: The best shape to use, but not easy to construct for diameters less than 2.5 meters (or capacities smaller than 3,200 liters).

Hexagonal (6-sided) tanks: Good for tanks between 1,700-3,200 liters (diameters not less than 2 meters).

Square tanks: This is the traditional shape, and easiest to construct for small capacities.

Rectangular tanks: The least-economical shape, especially as one side becomes much longer than the other. However, due to physical constraints of the site, it may be necessary to use this shape. Keeping it as nearly square-shaped as possible will make a more economical design.

For example the most economical dimensions for a 1,000 liter tank would be 1 meter wide, 1 meter long, and 1 meter high.

Constructing a Storage Tank

Storage tanks should be constructed with a reinforced concrete foundation and floor, followed by rock and mortar walls. The roof can be of wood frame or reinforced concrete construction.

The location of the storage tank must be selected so that water from the spring can flow into the tank and fill it. Further,the tank should be in a location that is convenient for drawing water from a faucet piped from the bottom of the tank.

The foundation for a storage tank is constructed in a similar way as that described for the retaining wall. Excavation to a suitable soil sub-base is first performed, then a layer of broken stone or gravel is placed over the sub-base. The location of the foundation for the walls should be carefully aligned by staking the locations of corners. After the foundation is completed, the construction of the rock and mortar walls should be started at the corners. After the corners are built to the height of two or three courses of rock, then build the walls from corner to corner maintaining the straight alignment of each wall.

Storage tank walls can be stepped as shown in Figure 2. Stepping the wall is an economical use of construction materials and puts the thickest portion of the wall at the base where the water pressure will be the greatest.

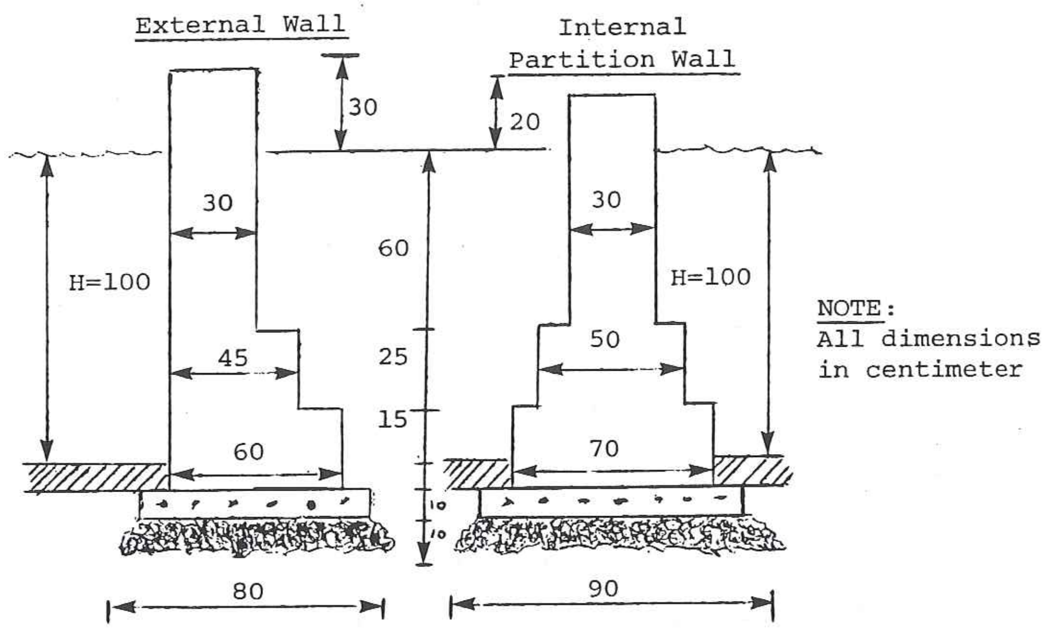


Figure 2. Storage Tank Wall

The floor of the tank may be either of masonry (i.e., mortared brick or stone) or reinforced concrete. A bed of gravel or crushed stone must be put down, roughly pitched so the floor will slope downwards to the drain pipe. As soon as the final concrete or plaster has set, the tank should be filled to a depth of about 30 cm to help the curing process (a deep depth of water would exert too much pressure on the floor which the cement would not be strong enought to support). After two weeks the tank can be filled completely and checked for any visible leakage.

Roof design and construction is complicated, but the basic considerations for a storage tank roof include:

a. It must be able to support its own weight, plus the weight of one or more persons

b. It should be relatively tight to prevent rain and dust and debris from entering the tank

c. It should have an access way for a person to inspect or enter the tank

d. It should be made of a durable material, timber and slate, or concrete, or galvanized iron sheeting. Avoid a material such as thatch, which can house vermin.

The finished walls and floor should be plastered with cement mortar to make the tank as watertight as possible. Plastering is discussed in Handout 8-1: Cement, Concrete, and Masonry.

Piping for a Storage Tank

The piping for a small storage tank will include:

a. an inlet pipe from the water source

b. an outlet pipe to the supply tap (faucet)

c. a drain pipe at the bottom of the tank

d. an overflow pipe near the the top of the tank

e. a valved bypass pipe which connects the inlet and outlet directly, allowing the tank to be emptied for maintenance

Figure 3 shows a typical piping arrangement.

Finished Grading

The ground around the reservoir should be mounded so that rain run-off will flow away from the tank. The surrounding land should be stabilized against erosion. If there is generally heavy rain run-off, then suitable drainage channels should be made. The drainage channel for the overflow should also be carefully constructed, and preferably should carry the water to where it can be utilized (such as for an animal water-hole, or for irrigation of a nearby garden).

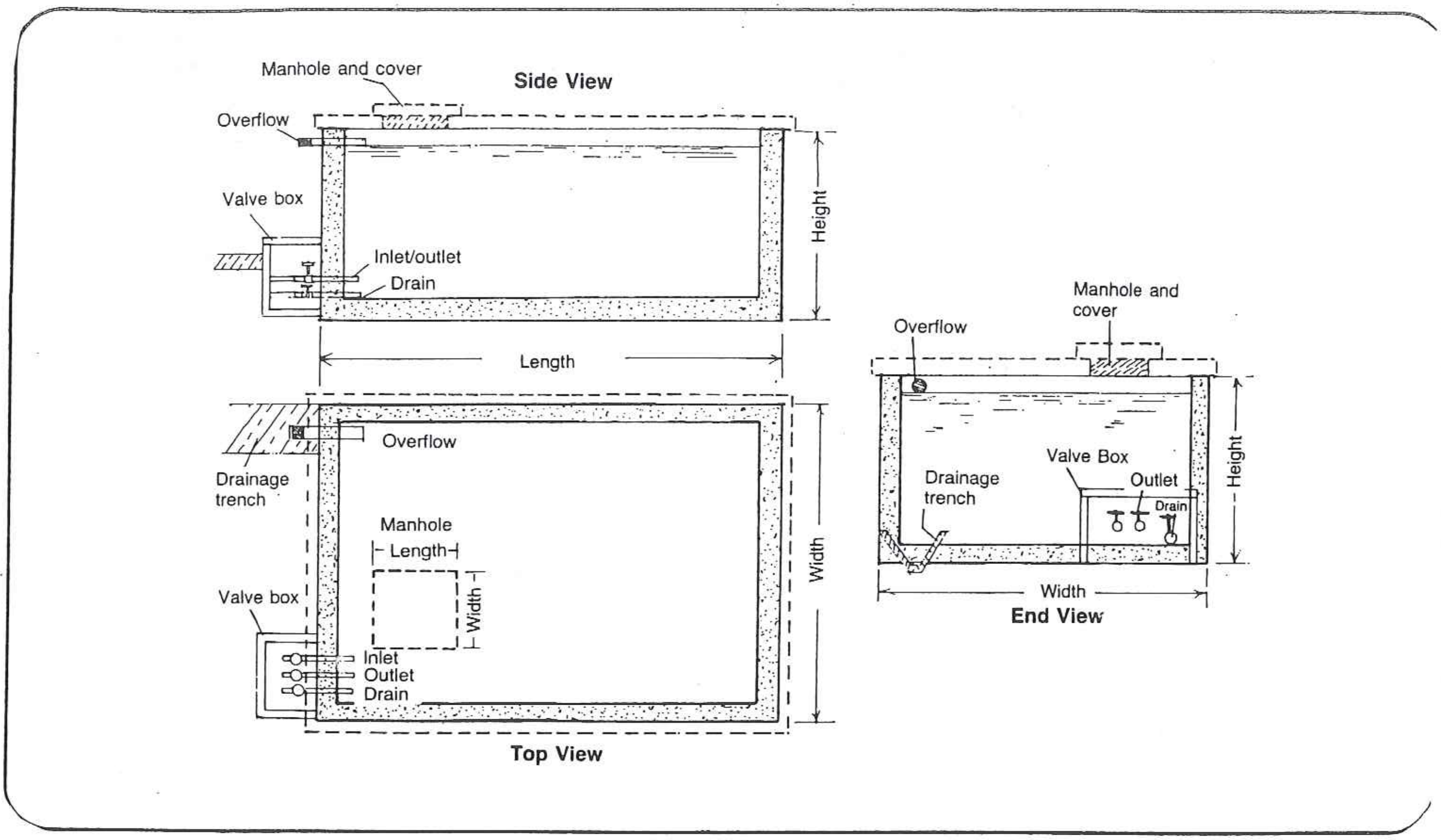


Figure 3. Storage Tank Design

Maintaining a Storage Tank

The maintenance of water storage tanks is necessary to ensure the quality of the water stored. Maintenance of tanks basically involves two important procedures: prevention of contamination, and cleaning the tank periodically to ensure that water is fresh.

General Maintenance

Water quality in storage tanks should be preserved. All storage tanks should be checked monthly to ensure that all necessary maintenance is done when needed. Never delay in attending to any problems that arise.

When looking at the tank, make sure to check the following:

- Covers. Make sure the cover fits tightly over the tank. There should be no space for dust or leaves to enter the storage tank. The cover should fit tightly enough to prevent the entry of light. Light stimulates the growth of algae in the tank.

- Potential Sources of Contamination. Check the area around the storage tank to make sure that no contaminants have been introduced to the area.

No waste disposal or garbage disposal sites should be near the storage tank, especially when they are located below ground. Under no circumstances should any disposal sites or animal pens be placed on ground above the cistern. Contaminants can flow downhill and destroy the quality of water. A ditch should be dug near the cistern to direct surface water away from the cistern or storage area. Keep animals out of the drainage area.

- Screens. Check the screens covering the pipe ends to make sure they are in good repair. Broken screens on outlet and overflow pipes are easy entry points for mosquitoes and small animals. All damaged screens should be replaced.

- Pipes. Check all pipe connections to ensure that there are no leaks in the system. When leaks occur, pipes should be tightened or repaired. Check all valves for proper functioning.

- Structure. Repair any damage that may occur to the cistern or storage tank. Add concrete to repair any chips, broken edges or cracks.

Cleaning the Tank

No matter how much prevention is practiced, a storage tank requires disinfecting and cleaning. To clean and disinfect the tank do the following:

- Drain all water out of the storage tank. Usually, this is easily accomplished by letting the supply in the tank fall over time and draining the last bit.

- After the tank is drained, sweep and scrub it until all dirt and loose material are removed.

Then choose the most appropriate method for disinfecting the tank.

- Fill the tank to overflowing with clean water and add enough chlorine to make a 50 mg/l solution. Add the chlorine to the tank as it is filling to get sufficient mixing. After the tank is filled, allow it to stand for at least six hours and preferably more. After sufficient time has passed, drain the tank and allow it to refill for regular use.

- A second and faster method can be used when little time is available. Directly apply a very strong, 200 mg/l, chlorine solution to the inner surfaces of the tank. For best results, brush the walls with the solution and allow the chlorine to stay on the walls for at least 30 minutes before the tank is refilled.

Appendix 2: Goal 2 – To provide sustainable options for paths throughout the property.

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Appendix 2a: Arsenic-Free Pressure-treated lumber (only for Nick and Nina)

Appendix 3: Goal 3 – Provide design for the integration of gardens throughout the community.

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Appendix 3a: List of Garden Plants

Appendix 3b: Figure 1

Appendix 3a: List of Garden Plants

The following is a list of native and traditional plant species recommended for inclusion in the garden areas. All except the listed horticultural species are native to the area. Note that this is neither a comprehensive nor complete list, but merely a starting point from which to gather inspiration. Plants are color-coded based on sun and moisture tolerances, correlated with Figure 1, Appendix 3b.

Food Garden Plants
Native

Common Name	Latin Name	Tolerance/Notes
Wild strawberry	*Fragaria chiloensis*	Sun/Ground cover
Evergreen huckleberry	*Vaccinium ovatum*	Sun/Shrub
Miner's lettuce	*Claytonia rubra*	Sun-Shade
Golden currant	*RIbes aureum*	Sun-Shade/Shrub
Red-flowering currant	*Ribes sanguineum*	Sun-Shade/Shrub
California blackberry	*Rubus ursinus*	Sun-Shade/Shrub
Salmonberry	*Rubus spectablis*	Sun-Shade/Shrub
Thimbleberry	*Rubus parviflorus*	Shade, moist

Horticultural

Common Name	Notes
Lettuce	Replace annually
Spinach	Replace annually
Kale	Replace as needed (every few years)
Chard	Replace annually
Kohlrabi	Replace annually
Broccoli	Replace annually
Cauliflower	Replace annually
Sunflower	Replace annually, may re-seed
Peas	Plant with ample air space between plants
Potatoes	Replace annually, may use cuttings from last season crop
Cucumber	Replace annually, may plant in partial shade
Pumpkin	Replace annually, may use seeds from last season crop
Squash	Replace annually, may use seeds from last season crop
Carrots	Replace annually
Beets	Replace annually
Cilantro	Replace annually
Celery	Replace annually
Garlic	Replace annually, may use cloves from last season crop; Cover in winter
Basil	Replace as needed; Cover in winter

Butterfly Garden Plants

Common Name	Latin Name	Tolerance/Notes
Fireweed	*Epilobium angustifolium*	Sun
Coastal sagewort	*Artemisia pycnocephale*	Sun
Monkey flower	*Mimulus aurantiacus*	Sun
Douglas iris	*Iris douglasiana*	Sun/Acid soil
Sea pink	*Armeria maritime*	Sun
California poppy	*Eschscholtzia californica*	Sun
Large-flowered godetia	*Godetia whitneyi*	Sun
Blue-bedder penstemon	*Penstemon heterophyllus* var. *heterophyllus*	Sun
Red columbine	*Aqueligia formosa*	Sun-Shade
Blueblossom	*Ceanothus thyrsiflorus*	Shade
Redwood violet	*Viola sempervirens*	Shade
Bleeding heart	*Dicentra formosa*	Shade
Trillium	*Trillium ovatum*	Shade
Inside-out flower	*Vancouveria hexandra*	Shade
Blue-eyed grass	*Sisyrinchium bellum*	Shade

Herb/Medicinal Garden Plants

Common Name	Latin Name	Tolerance/Notes
Gentian	*Gentiana sceptrum*	Sun
California rose	*Rosa californica*	Sun/Shrub
Pearly everlasting	*Anaphalis margaritaceae*	Sun
Seaside plantain	*Plantago maritima*	Sun, Moist saline soil
Self-heal	*Prunella vulgaris* var. *lanceolata*	Sun-Shade
Yarrow	*Achillea millefolium*	Sun-Shade
Cascara	*Rhamnus purshiana*	Sun-Shade/Tree (toxic in excess)
Blue blossom	*Ceanothus thyrsiflorus*	Sun-Shade/Shrub
Salal	*Gaultheria shallon*	Shade, Moist soil

Shrubs/Trees

Common Name	Latin Name	Tolerance/Notes
Oregon crab apple	*Malus fusca*	Sun, Moist soil
Twinberry honeysuckle	*Lonicera involucrate* var. *ledebourii*	Sun-Shade, Moist soil
Western redbud	*Cercis occidentalis*	Sun-Shade
Oregon grape	*Berberis aquifolium*	Shade-Sun
Spice bush	*Calycanthus occidentalis*	Shade, Moist soil
Rhododendron	*Rhododendron macrophyllum*	Shade, Acid soil
Wax myrtle	*Myrica californica*	Shade

Appendix 3b: FIGURE 1

Appendix 4: Goal 4 – To provide options for retaining walls using alternative materials.

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Appendix 4a : Report on research

Appendix 4b : Response to email

Appendix 4c : Hilfiker Retaining Wall info (only for Nick and Nina)

Appendix 4A

REPORT ON RESEARCH

THE UNIVERSITY OF ARIZONA.
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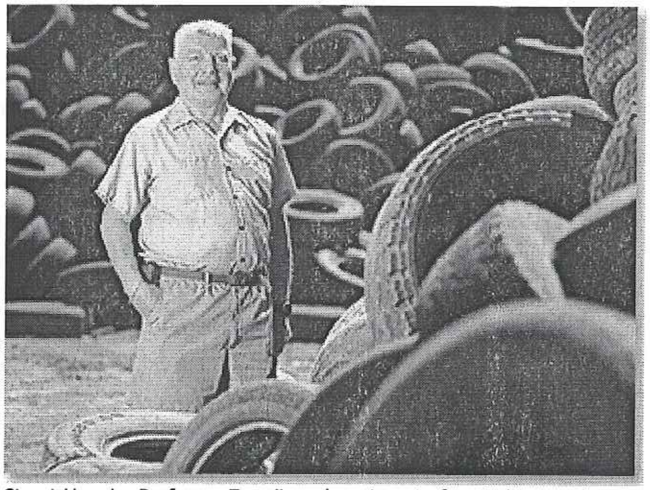
AGRICULTURE AND BIOSYSTEMS ENGINEERING

Building Tires

One UA Researchers Has High Hopes for Scrap Tires

by David Barber

Adjunct Professor Emeritus Stuart Hoenig, of the University of Arizona's department of agriculture and biosystems engineering, thinks he's on to the next wave in construction materials: scrap tires, especially for building houses.



Stuart Hoenig, Professor Emeritus, department of agriculture and biosystems engineering.

Actually, Professor Hoenig is known for carrying on a number of projects at once. One current project is a system for electrostatically taking water vapor out the air not really an Arizona problem, but one farmers in other parts of the country deal with daily. "For example the Midwest where they try to get two crops of hay," notes Hoenig. "The second crop gets rained on and you can't do anything with wet hay. This is a system that essentially dries out that hay."

Hoenig notes that the same system is being used commercially by the U.S. Department of Agriculture. USDA developed a similar system for cleaning the air of dust and killing bacteria in chicken coops. The successful system is now sold by a private company.

Hoenig has been at the University for 29 years. While he retired 6 years ago, he stays on as an adjunct to pursue research, thou; he no longer teaches. He received his doctorate from University of California-Berkeley in 1961, after receiving his bachelors degree at the University of Michigan. He received a number of offers but he and his wife did not want to stay in California. Though there were some better salary offers, they choose Arizona for the climate and the University's reputation.

Of the projects he is pursuing, he is most passionate about the varied uses of scrap tires, even for landscaping. The UA currentl; is monitoring one of his demonstration projects on campus.

"You split the tire like a bagel, then you roll the grass back; put the tires down; fill them with dirt and roll the grass back," explains Hoenig, a national expert in the use of scrap tires. "It uses about 50 percent of the water and the grass looks great"

In fact, the University of Arizona is acting as an agent for a California colleague who has patented this use of split tires to save water.

As another alternative to scrap tire disposal, the UA and other universities have been studying engineering applications for the:

scrap tires that would offer both cheap construction options and an environmental solution to a growing problem

There are some 500-million, used tires stockpiled in the United States, with a growth rate of the material equal to about 250 million per year posing both a fire and environmental hazard. When they are placed in landfills, they tend to rise, prompting 3: states to ban their landfill placement all together. Because the expected life of used tires is some 20 years, they have become an economical substitute for traditional construction materials.

In 2000, the nation used 32 million scrap tires (the amount generated annually in California alone) in civil engineering project: up by 28 percent from 1999 and making it the largest end-use for scrap tires in the nation, second only to fuel.

In Pima County, some 700,000 scrap tires find their way to landfills each year.

Currently nine states including Arizona allow the use of whole tires for the construction of dams, erosion control, houses (New Mexico is currently the leader in that), fencing, rifle range bullet stops, bridge supports, terracing, playgrounds, and grain storage structures.

Another use is as bedding for livestock corrals. The University of Southern California at San Luis Obispo has built a huge syster of livestock bedding. The bedding, made-up of tire bales, allows the liquid from water and urine to drain, keeping the animals drier and preventing foot diseases. Though the UA's Agriculture farm at Roger Road isn't "officially" using the technique, Hoen is trying to get the funds to pursue such a project.

Another use being pursued by the Center for Integrated Waste Management at the State University of New York (SUNY) at Buffalo is using scrap tires as a replacement for stone in septic tanks, a use that is on the rise.

What the scrap tire advocates like Hoenig are hoping for is that home builders and subcontractors become more aware of the variety of applications scrap tires can be used for in home building.

"The big thing is house construction, the installation is fantastic," says Hoenig. He feels that building inexpensive homes with tires would be great for poorer areas, particularly since the tires are free and construction doesn't take any special skills.

"For example, Cochise County has an enormous pile of tires and they can't afford to haul them to Phoenix to get chopped up, sc they're just sitting there," says Hoenig.

While chipped tires used in road construction and tire-derived fuel (TDF) are currently the best-known uses of scrap tires, it's the use of whole tires that has drawn Hoenig's interest. Whole tires can be "baled." There are a number of companies all over tl USA that bale tires, with five in New Mexico alone. The highly portable baling equipment typically costs $100,000. Hoenig not that there's one company that bales in New Mexico that actually produces a square final product, ideal for building.

The baled tires are used for tire wall construction for dams, fences and houses where they are stacked, rammed with earth, anc covered with stucco. Like rammed earth and straw bale, baled tire houses are well insulated and resistant to fire and insects.

Though the center for scrap tire home construction is New Mexico, Hoenig hopes it will catch on in Arizona, despite restraints put on it by the state.

"The state has some very archaic provisions," says Hoenig. "For example, you can't build a tire house in Tucson the way you car in New Mexico. You have to get special permission."

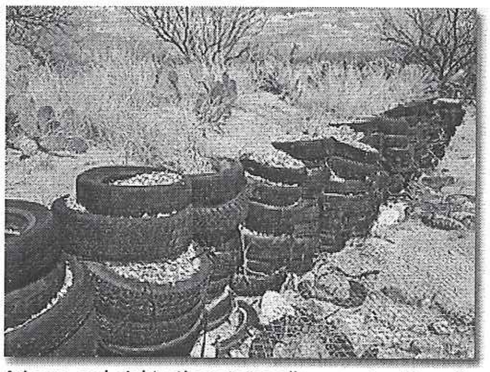
That permission comes from the Arizona Department of Environmental Quality, the same agency Hoenig had to approach to build a scrap tire dam. He said they were very accommodating.

In the southwest, typical wash and feeder arroyos frequently drop 10 feet per year due to erosion, and tires are being used to alleviate the problem and slow the flow of rushing water in the form retaining walls. In fact, dams constructed with baled tires cost 60 percent less than a concrete dam.

Hoenig, and his University colleagues, are responsible for a tire bale erosion control structure at the King's Anvil Ranch 10 mile west of Tucson. Construction was supported by the Goodyear Tire Company and Phelps Dodge. They stacked and tied together the tires with half-inch plastic straps, filled them with gravel and covered them with chain-link mesh.

Interestingly, the 1,200 tires were free and Pima County probationers supplied the free labor. The project was monitored by the Arizona Department of Environmental Quality. The 30-foot-long, 6-foot-high tire dam cost $6,500 to design, estimated to be about $63,000 less then a comparable concrete dam. The dam has stopped has stopped sand some 5 feet deep and 30 feet wide from being lost into the arroyo.

"The ranchers were very dubious of it at the time," notes Hoenig. "But now it's four years later and it has withstood two floods. Now they're convinced."



Arizona and eight other states allow construction of gomes, fencing, bridges and eroison control dams such as this one near Tucson.

So convinced area ranchers are screaming for more dams.

"They'd all like to have tire dams because they're cheap and they work well," says Hoenig. "Right now, we're trying to get some money to build more tire dams."

As if he doesn't have enough projects going, he's recently received an request for a proposal from Pima County for a 100,000-gallon Anaerobic Digester to break down organics in the county's growing garbage dumps. He's planning c using scrap tires to line the site.

Around the country other scrap tire construction projects abound: The U.S. Department of Interior has used whole tires for 20 years at the Salton Sea for erosion and dams. In New Mexico, a 4,400-foot section of Lake Carlsbad was stabilized against erosion with tire bales. In this case the bales were covered with a thin layer of concrete for visual purposes.

Twenty-five foot-high damn in Arkansas using more than 50,000 tires.

California used 860,000 tires to fill in a freeway embankment of a $30-million interchange reconstruction, due to be complete in 2004.

In Maryland, scrap tires have been used for playground structures and ground cover in seven state parks.

R

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Feedback on this article may be sent to Dennis St. Germaine, editor.

Appendix 4b

WebMail - Reply to your questions about gabions

Delete | File | Create | Reply | Reply All | Forward | Previous | Next | Options | Index | Help

Date Sent: Tuesday, April 29, 2003 5:00 PM

From: "Suzanne C. Blackburn" <suzanne@hilfiker.com> Add to Address Book

To: hmp4

Subject: Reply to your questions about gabions

Status: ☐ Urgent ☐ New

At 15:33 04.29.2003 -0700, hmp4 wrote:
>To whom this may concern;
>
>My name is Holly Pitts and I am a senior student at Humboldt State University.
> I am doing a research project regarding retaining walls and the use of
>Gabions. I have contacted your company once before and you sent me
>information about your bussiness and gabions via the mail. After reading
>through the information you sent me I still have some questions.
>
>What is the life expectancy of gabions verses a concrete wall such as you
>closed face concrib wall? How often do gabions have to be replaced or
>repaired?
>
>If you could send me a response to these questions it would be much
>appreciated.
>
>Thank you for your time,
>Holly Pitts
>HSU Student
****

Holly..your questions don't have a quick, simple answer. Gabions, MSE structures, and cribwalls can all be DESIGNED for the service life the owner requests, typically 50-yrs. for highway work. The design is a function of various criteria, such as the type of backfill to be used, existing site conditons, and the application of the wall [loading conditions] are but a few broad categories. They should not have to repaired/replaced unless there is damage caused to them by man-made or natural causes, such as a catastrophic failure caused by slope instability, a seismic event, etc. CALTRANS has done extensive research on gabion service life, and Jim Racin, the main author is very knowledgeable. That is the first website listed below. The FHWA website is the second one, and will probably have some useful information...if you can find it. Good luck, and feel free to contact me direct next time, should you think of more questions. [ps...I graduated from HSU in 1980...have worked here at Hilfiker since 1978!---I just turned the big 50!]

>http://www.dot.ca.gov/hq/oppd/hydrology/gabion.htm

http://www.fhwa.dot.gov/bridge/geopub.htm

****

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Appendix 5 – Time sheets and Time line

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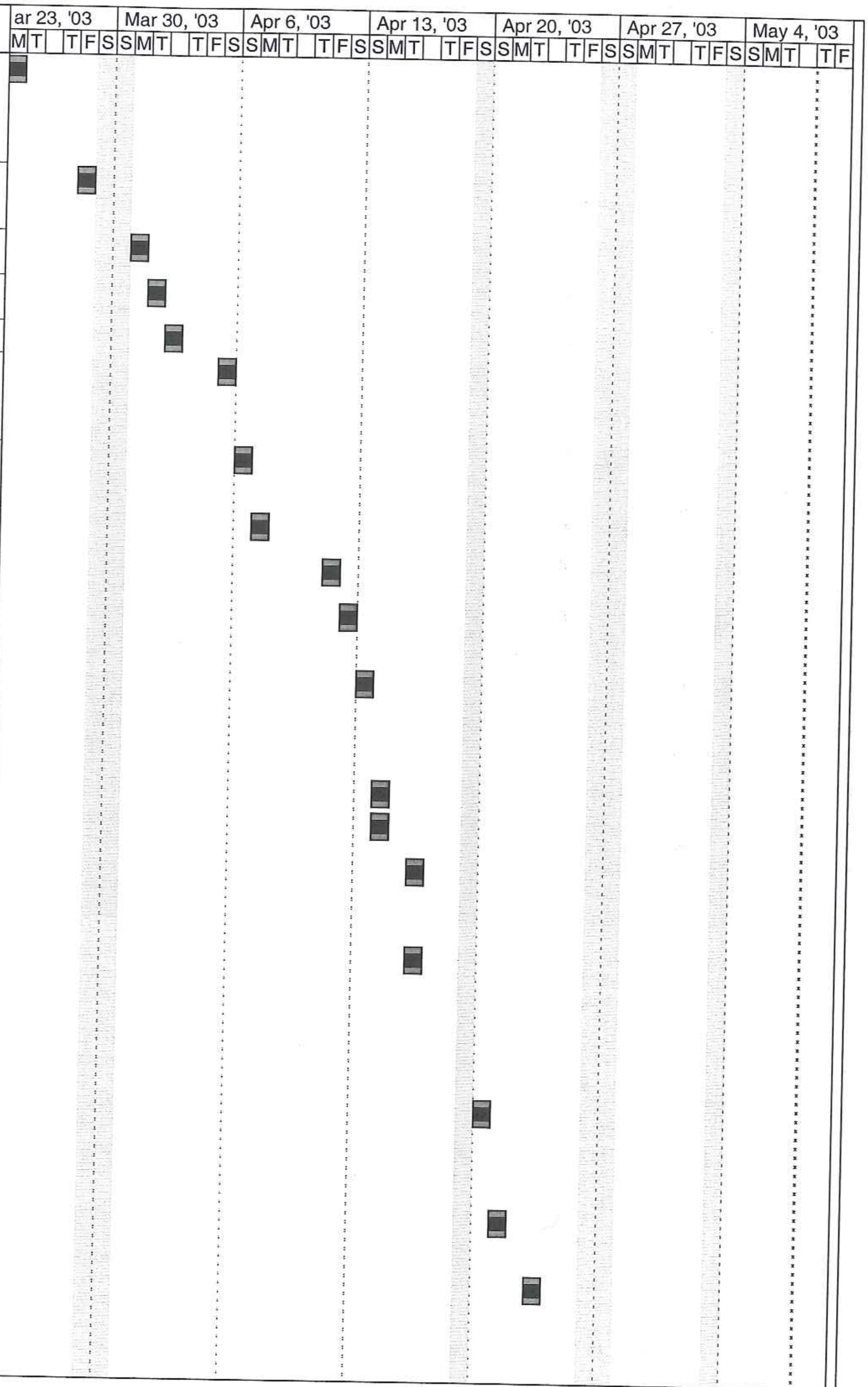
Appendix 5a : Time line

Appendix 5b: Presentation printout (for Nick and Nina only)

Appendix 5c: Time sheets (for Professor Hansis only)

Appendix 5a

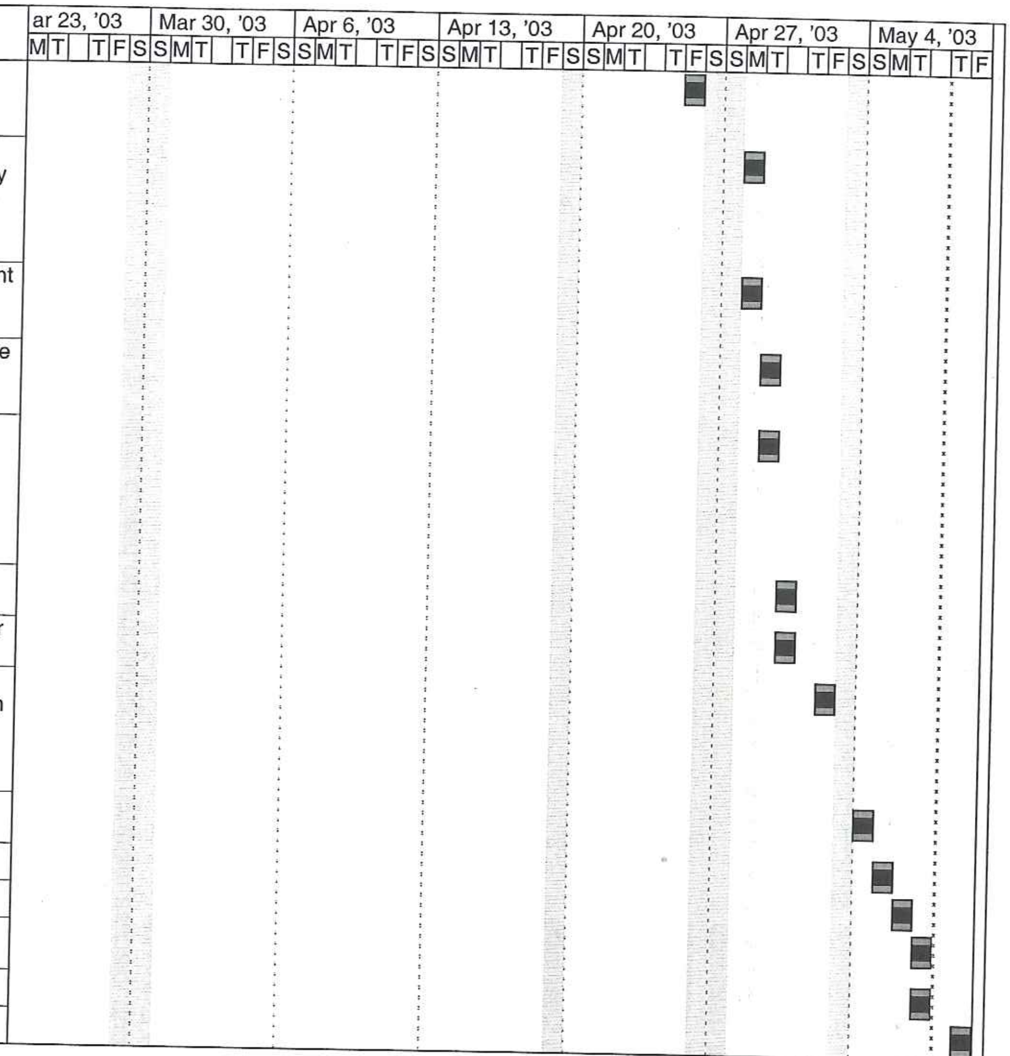
ID	Task Name
1	Kate and AJ complete research and prepares alternatives for housing design which includes materials, heating and solar alternatives
2	Group meeting to format & exchange documents including alternatives
3	Group completes formatting of his/her alternatives
4	Holly revises and formats the group's alternatives
5	Weighing alternatives due
6	Group writes up monitoring & evaluations for Goal 1; Ellen Revise Goal 3 Alternatives and begins Goal 3 appendix
7	Kate & Rooz complete corrections & formatting of draft monitoring/evaluations
8	Draft Monitoring and Evaluation due
9	Turn in alternatives to Nick and Nina, plan on meeting 4/14
10	Group prepares questions and documents for the meeting with Nick and Nina on Monday 4.14
11	Group prepares ideas for implementation to assist in writing; Ellen prepares Goal 3 References, Appendix for Nick and Nina
12	Group meets with Nick and Nina
13	Holly types implementation plan while group narrates their plan.
14	Kate researches and implements ideas for strategies to revise plans; Ellen Revise Goal 3 Appendix
15	Revision of alternatives due, turn in Implementation Strategies. Research is conducted by all members of the group on feedback and changes specified by Nick and Nina during the 4/14 meeting.
16	More research is conducted by all members of the group on feedback and changes specified by Nick and Nina during the 4/14 meeting.
17	Revised Monitoring and Evaluations due. Group meeting to check on improvements of work in progress.
18	Research is conducted and finalized by the entire group on changes specified by Nick and Nina. Ellen Preliminary sketch of Figure 1



Project: Envs410Timeline
Date: Thu 5/8/03

Task		Project Summary	
Split		External Tasks	
Progress		External Milestone	
Milestone		Deadline	
Summary			

ID	Task Name
19	Kate condenses and revises bibliography of previous research
20	Monitoring and Evaluation due. Revision of alternatives requested by Nick and Nina added to appropriate working documents by group members.
21	Group begins assembling power point presentation and works on the timeline.
22	Kate adds to power point and timeline and sends documents to group members for revising
23	Revised copies of documents are e-mailed to Holly; Prepare Timeline (revision of Implementation Plan), Ellen Prepare Goal 3 section of presentation
24	Group continues to work on power point
25	Powerpoint presentation parts due for all members of the group.
26	Group meets to work and format power point presentation & to work on other revisions. Ellen have final sketch of Figure 1, Goal 3 Appendix scanned
27	Group emails each other to discuss issues regarding last minute details.
28	Presentation due
29	Group meets to finalize project
30	Group meets to finalize formatting of project
31	Final report revisions due
32	Report due



Project: Envs410Timeline
Date: Thu 5/8/03

Task		Project Summary	
Split		External Tasks	
Progress		External Milestone	
Milestone		Deadline	
Summary			

Appendix 8c

AJ Gonzales - Timesheet

Hours	Date	Description
3	Wednesday, January 29, 2003	Group meeting with Nick, Nina and Joe
3	Thursday, January 30, 2003	Independent Research
2	Saturday, February 01, 2003	Group meeting at the site to explore
3	Monday, February 03, 2003	Met with Nick, Nina and Joe
2	Tuesday, February 04, 2003	Independent Research, got book from Library
3	Wednesday, February 05, 2003	Met with Nick, Nina and Joe
2	Thursday, February 06, 2003	Independent Research
1.5	Sunday, February 09, 2003	Independent Research
3	Monday, February 10, 2003	Met with group to brainstorm
2	Tuesday, February 11, 2003	Independent Research
3	Thursday, February 13, 2003	Independent Research
3	Monday, February 17, 2003	Met with Group, discuss research and brainstorm on how to break up tasks
2	Tuesday, February 18, 2003	Independent Research
3	Thursday, February 20, 2003	Independent Research
2	Friday, February 21, 2003	Independent Research
2	Saturday, February 22, 2003	Independent Research
3	Monday, February 24, 2003	Met with group, worked on problem statement
2	Tuesday, February 25, 2003	Independent Research
2	Thursday, February 27, 2003	Independent Research
1	Friday, February 28, 2003	Independent Research
3	Monday, March 03, 2003	Worked on Problem Statement w/group
2	Tuesday, March 04, 2003	Independent Research
3	Thursday, March 06, 2003	Independent Research
2	Friday, March 07, 2003	Independent Research, got another library book
2	Saturday, March 08, 2003	Independent Research
3	Monday, March 10, 2003	Worked on Goals and Objectives as a group
2	Tuesday, March 11, 2003	Independent Research, got another two library books
3	Thursday, March 13, 2003	Independent Research
1	Friday, March 14, 2003	Independent Research
2	Tuesday, March 18, 2003	Independent Research
3	Monday, March 24, 2003	Met with group, started writing alternatives section
2	Tuesday, March 25, 2003	Independent Research
3	Thursday, March 27, 2003	Independent Research
2	Saturday, March 29, 2003	Independent Research, revised my alternatives for tom.

	2	Tuesday, April 01, 2003	Independent Research
	3	Thursday, April 03, 2003	Independent Research
	2	Friday, April 04, 2003	Independent Research
	3	Monday, April 07, 2003	Started on Monitoring and Evaluation and Implementation
	2	Tuesday, April 08, 2003	Independent Research
	3	Thursday, April 10, 2003	Independent Research, got a third library book on sustainable design
	2	Friday, April 11, 2003	Independent Research, prepare for meeting with N&N
	3	Monday, April 14, 2003	Met with Nick and Nina, and w/ group for revisions, worked on Implementation plan revision
	2	Tuesday, April 15, 2003	Independent Research
	2	Thursday, April 17, 2003	Independent Research
	2	Friday, April 18, 2003	Independent Research
	3	Saturday, April 19, 2003	Independent research,called Thomas Noonan (Engr.) went to Thomas Home Center per recc
	3	Monday, April 21, 2003	Met with group
	2	Tuesday, April 22, 2003	Independent Research
	3	Thursday, April 24, 2003	Independent Research
	2	Friday, April 25, 2003	Independent Research
	3	Monday, April 28, 2003	Meet w/ group, turn in Monitor and Eval., talked about Pres.
	2	Tuesday, April 29, 2003	Independent Research
	3	Thursday, May 01, 2003	Called Gold Board, independent research
	3	Friday, May 02, 200	Group meeting for presentation
	1	Friday, May 02, 2003	Input data for timeline using MS Project
	3	Sunday, May 04, 2003	Practiced with Group
	5	Monday, May 05, 2003	Revised Pres. Practiced w/ Group and Gave Pres.
	6	Tuesday, May 06, 2003	Revised and Formatted Draft for Final Document
	1	Thursday, May 08, 2003	Revised report added, Timeline, revised references
	4	Friday, May 09, 2003	Revised and Polished document
Total	150.5		

Ellen's Timesheet

# of Hours	Day	Date	Description
3	Wed	1-29-03	Met with N&N and Joe as a group
2	Sat	2-1-03	Group went to site and explored
1	Mon	2-3-03	Independent research
3	Mon	2-3-03	Met with Nick, Nina, and Joe as a group
1	Wed	2-5-03	Independent research
3	Wed	2-5-03	Met with Nick, Nina, and Joe as a group
3	Mon	2-10-03	Met with group in class and brainstormed
3	Wed	2-12-03	Independent research
3	Mon	2-17-03	Met with group to brainstorm and report new findings
3	Wed	2-19-03	Independent research
1	Thurs	2-21-03	Revised Problem Statement
2	Sat	2-22-03	Explored site by myself, took pictures for presentation
3	Mon	2-24-03	Met with group to brainstorm and type problem statement
3	Wed	2-26-03	Independent research
3	Mon	3-3-03	Revised problem statement as a group
1	Wed	3-5-03	Independent research
3	Wed	3-5-03	Brainstorm for Goals and Objectives with group
3	Mon	3-10-03	Revised goals and objective as a group
3	Wed	3-12-03	Turned in goals and objectives as a group
2	Fri	3-14-03	Independent research
2	Mon	3-24-03	Prepare Goal 3 Alternatives
3	Mon	3-24-03	Present Goals and Objectives to class, meet with group.
3	Wed	3-26-03	Group started working on Alternatives
2	Sat	3-29-03	Revised Goal 3 Alternatives
2	Sat	4-05-03	Revised Goal 3 Alternatives, began Goal 3 Appendix
3	Mon	4-07-03	Group work on Monitoring and Evaluation
3	Wed	4-09-03	Revise Goal 3 Appendix, Monitoring and Evaluation
3	Sun	4-13-03	Prepare Goal 3 References, Appendix for Nick and Nina
3	Mon	4-14-03	Group meeting with Nick and Nina, typed Implementation
3	Wed	4-16-03	Revise Goal 3 Appendix, Alternatives
3	Wed	4-16-03	Turned in implementation plan and revised monitoring and evaluation as a group
1	Fri	4-18-03	Revise Goal 3 Monitoring and Evaluation
2	Sun	4-20-03	Explored site by myself
3	Mon	4-21-03	Group meeting

2	Wed	4-23-03	Draw preliminary sketch of Figure 1
3	Mon	4-28-03	Turn in monitoring and evaluation. Organize documents and talk about presentation as a group
3	Tues	4-29-03	Prepare Timeline (revision of Implementation Plan), Prepare Goal 3 section of presentation
2	Fri	5-02-03	Meet with group to practice presentation
3	Sun	5-04-03	Practice presentation with group
1	Mon	5-05-03	Present project
4	Fri	5-09-03	Formatting, binding, finishing touches and turning in document.

Holly's Timesheet

# of Hours	Day	Date	Description
3	Wed	1-29-03	Met with N&N and Joe
2	Sat	2-1-03	Group went to site and explored
3	Mon	2-3-03	Met with Nick, Nina, and Joe as a group
3	Wed	2-5-03	Met with Nick, Nina, and Joe as a group
3	Fri	2-7-03	Independent research
3	Mon	2-10-03	Met with group in class and brainstormed
3	Wed	2-12-03	Independent research
2	Sat	2-15-03	Went back to site by myself
3	Sun	2-16-03	Independent research
3	Mon	2-17-03	Met with group to brainstorm and report new findings
3	Wed	2-19-03	Independent research
2	Thurs	2-20-03	Independent research
3	Sun	2-23-03	Independent research
3	Mon	2-24-03	Met with group to brainstorm and type problem statement
3	Wed	2-26-03	Independent research
3	Sun	3-2-03	Independent research and revise problem statement
3	Mon	3-3-03	Revised problem statement as a group
3	Wed	3-5-03	Turned in Problem statement and started brainstorming Goals and Objectives.
2	Fri	3-7-03	Independent research and personal brainstorm on Goals and Objectives.
2	Sun	3-9-03	Independent research and type my own version of goals and objectives
3	Mon	3-10-03	Revised goals and objective as a group
3	Wed	3-12-03	Turned in goals and objectives
3	Sun	3-16-03	Independent research
3	Thurs	3-20-03	Independent research
2	Fri	3-21-03	Independent research
3	Mon	3-24-03	Went to class, listen to lecture, presented goals and objectives, and met with group.
3	Wed	3-26-03	Group started working on Alternatives
2	Fri	3-28-03	Worked on alternatives
4	Sun	3-30-03	Formatted all of the alternatives
3	Wed	4-02-03	Turned in alternatives and did independent research
3	Mon	4-07-03	Emailed Nick the work that was done so far. Started on monitoring and evaluation
3	Wed	4-09-03	Worked on monitoring evaluation and implementation plan
3	Sun	4-13-03	Independent research
3	Mon	4-14-03	Typed implementation plan and responded to

			emails and met with N&N as group
3	Wed	4-16-03	Turned in implementation plan and revised monitoring and evaluation as a group
3	Sun	4-20-03	Independent research
3	Mon	4-21-03	Met with group to discuss progress of project
3	Wed	4-23-03	One last revision for monitoring evaluation. Started on presentation
3	Fri	4-25-03	Work on presentation
3	Sat	4-26-03	Taking pictures for presentation
3	Mon	4-28-03	Turn in monitoring and evaluation. Organize documents and talk about presentation as a group
3	Wed	4-30-03	Finish presentation
3	Fri	5-02-03	Additional Independent research and group work on presentation
3	Sun	5-04-03	Practice presentation with group
3	Mon	5-05-03	Present project and listen to other presentations
6	Wed	5-07-03	More presentations and formatting document
4	Fri	5-09-03	Formatting, binding, finishing touches and turning in document.

Kate's Timesheet

# of Hours	Day	Date	Description
3	Wed	1-29-03	Met with N&N and Joe
2	Sat	2-1-03	Group went to site and explored
3	Mon	2-3-03	Met with Nick, Nina, and Joe as a group
3	Wed	2-5-03	Met with Nick, Nina, and Joe as a group
1	Fri	2-7-03	Independent research
2	Sun	2-9-03	Independent research
3	Mon	2-10-03	Met with group in class and brainstormed
3	Wed	2-12-03	Independent research
2	Thurs	2-13-03	Independent research
3	Sun	2-16-03	Independent research
2	Mon	2-17-03	Independent research
3	Mon	2-17-03	Met with group to brainstorm and report new findings
3	Wed	2-19-03	Independent research
2	Fri	2-21-03	Independent research, reviewed problem statement
3	Sun	2-23-03	Independent research, visited site for personal reference
3	Mon	2-24-03	Met with group to brainstorm and type problem statement
3	Wed	2-26-03	Independent research
3	Mon	3-3-03	Revised problem statement as a group
3	Wed	3-5-03	Turned in Problem statement and started brainstorming Goals and Objectives.
2	Thurs	3-6-03	Independent research
2	Sat	3-8-03	Independent research
3	Mon	3-10-03	Revised goals and objective as a group
3	Wed	3-12-03	Turned in goals and objectives
3	Mon	3-17-03	Independent research for alternatives
3	Sat	3-22-03	Independent research for alternatives
2	Sun	3-23-03	Independent research
3	Mon	3-24-03	Presented goals and objectives, and met with group.
3	Wed	3-26-03	Group started working on Alternatives
4	Sun	3-30-03	Writing and researching alternatives for goal 1.
3	Wed	4-02-03	Independent research
3	Mon	4-07-03	Started on monitoring and evaluation
3	Wed	4-09-03	Worked on monitoring evaluation and implementation plan
3	Sat	4-12-03	Independent research, preparation for group meeting with Nick & Nina
4	Mon	4-14-03	Worked on implementation, group meeting with Nick & Nina
3	Wed	4-16-03	Turned in implementation plan and revised

			monitoring and evaluation as a group
3	Fri	4-18-03	Independent research, revising monitor/evaluations
3	Sun	4-20-03	Independent research
3	Mon	4-21-03	Group meeting
3	Wed	4-23-03	Begin presentation work
3	Fri	4-25-03	Revise presentation
3	Mon	4-28-03	Turn in monitoring and evaluation. Organize documents and talk about presentation as a group
3	Tues	4-29-03	Prepare timeline, sent emails
3	Wed	4-30-03	Finish personal slides for presentation
3	Fri	5-02-03	Independent research + group meeting for presentation
3	Sun	5-04-03	Practice presentation with group
3	Mon	5-05-03	Present project and listen to other presentations
2	Tues	5-06-03	Bibliography
6	Wed	5-07-03	More presentations and formatting document
3	Thurs	5-08-03	Complete timesheet, sent emails
4	Fri	5-09-03	Formatting, binding, finishing touches and turning in document.

ozbehs time sheet

ours	Day	Date	Description
3	Wed	1/29/03	Group meeting with Nick & Nina (N&N) and Joe (the consultant)
2	Sat	2/1/03	Group meeting at the site to explore
3	Mon	2/3/03	Met with Nick, Nina, and Joe as a group
3	Wed	2/5/03	Met with Nick, Nina, and Joe as a group
5	Sun	2/9/03	Independent research
3	Mon	2/10/03	Met with group in class and brainstormed
3	Wed	2/12/03	Independent research
2	Sun	2/16/03	Independent research
3	Mon	2/17/03	Met with group to brainstorm and report new findings
3	Wed	2/19/03	Independent research
3	Sun	2/23/03	Independent research
3	Mon	2/24/03	Met with group to brainstorm and type problem statement
3	Wed	2/26/03	Independent research
4	Sun	3/2/03	Independent research
3	Mon	3/3/03	Revised problem statement as a group
3	Wed	3/5/03	Turned in Problem statement and started brainstorming Goals and Objectives.
4	Sun	3/9/03	Independent research
3	Mon	3/10/03	Revised goals and objective as a group
3	Wed	3/12/03	Turned in goals and objectives and I performed independent research
3	Sun	3/16/03	Independent research
2	Sun	3/23/03	Independent research
3	Mon	3/24/03	Went to class, listened to lecture, presented goals and objectives, and met with group.
3	Wed	3/26/03	Group started working on Alternatives
2	Sun	3/30/03	Independent research
3	Wed	4/2/03	Turned in alternatives and did independent research
3	Mon	4/7/03	Group started on monitoring and evaluation
3	Wed	4/9/03	Worked on monitoring evaluation and implementation plan
4	Sun	4/13/03	Independent research
4	Mon	4/14/03	Group worked on implementation plan and met with N&N
3	Wed	4/16/03	Turned in implementation plan and revised monitoring and evaluation as a group
4	Sun	4/20/03	Independent research
3	Mon	4/21/03	Met with group to discuss progress of project
3	Wed	4/23/03	One last revision for monitoring evaluation. Started on presentation
3	Sun	4/27/03	Independent research
3	Mon	4/28/03	Turn in monitoring and evaluation. Group work on presentation
3	Wed	4/30/03	Finish presentation
2	Fri	5/2/03	Independent research and group meeting for presentation

5	Sun	5/4/03	Practice presentation with group
3	Mon	5/5/03	Present project and listen to other presentations
4	Wed	5/7/03	More presentations and formatting documents
3	Th	5/8/03	Some finishing touches on hard documents to be turned in.
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