Laterally Sloping Sand Filter Trenches and Constructed Wetlands

as Alternative Methods of Effluent Treatment

Raymond King
North Georgia Health District

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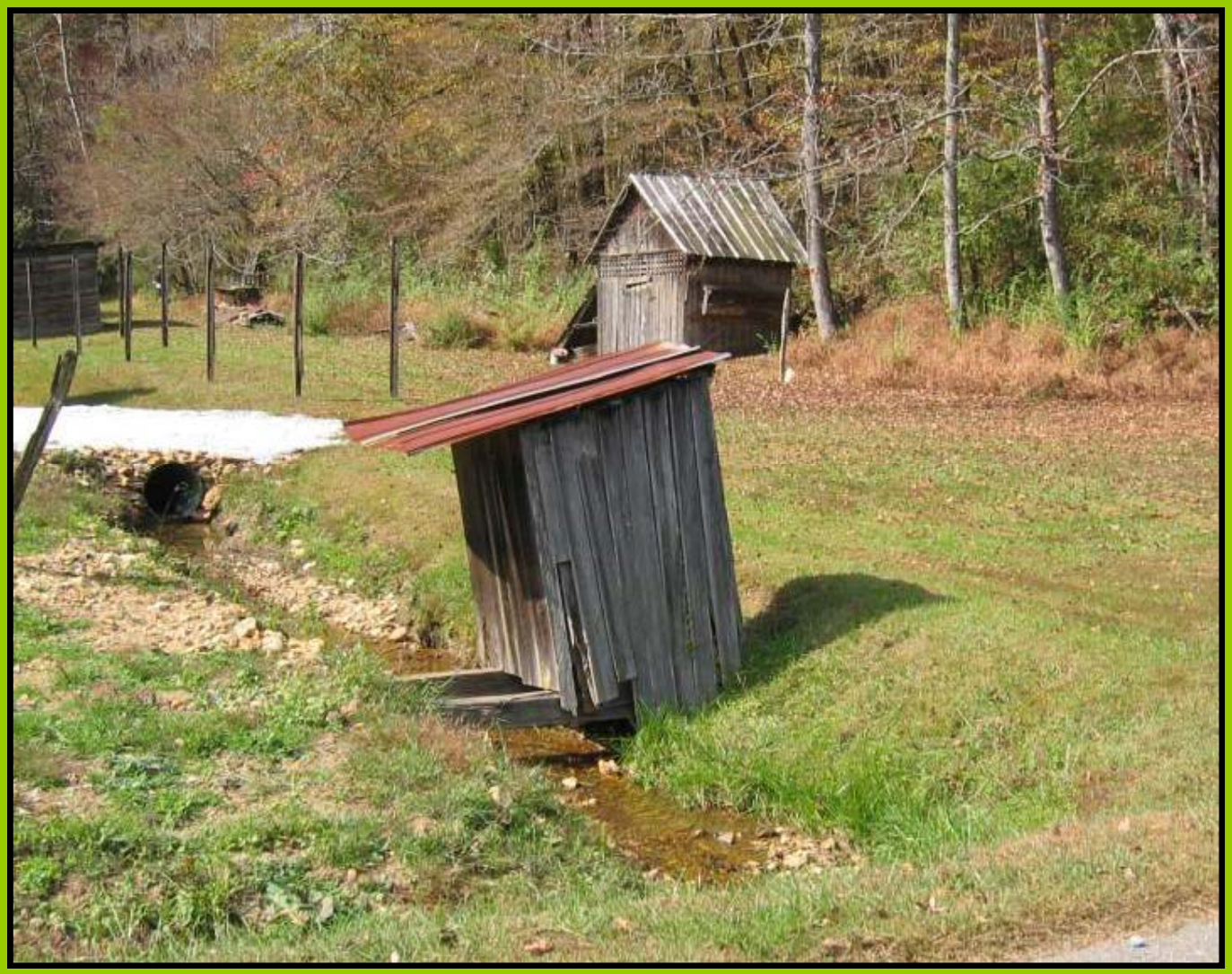
CONTRIBUTORS

Thanks to the following:

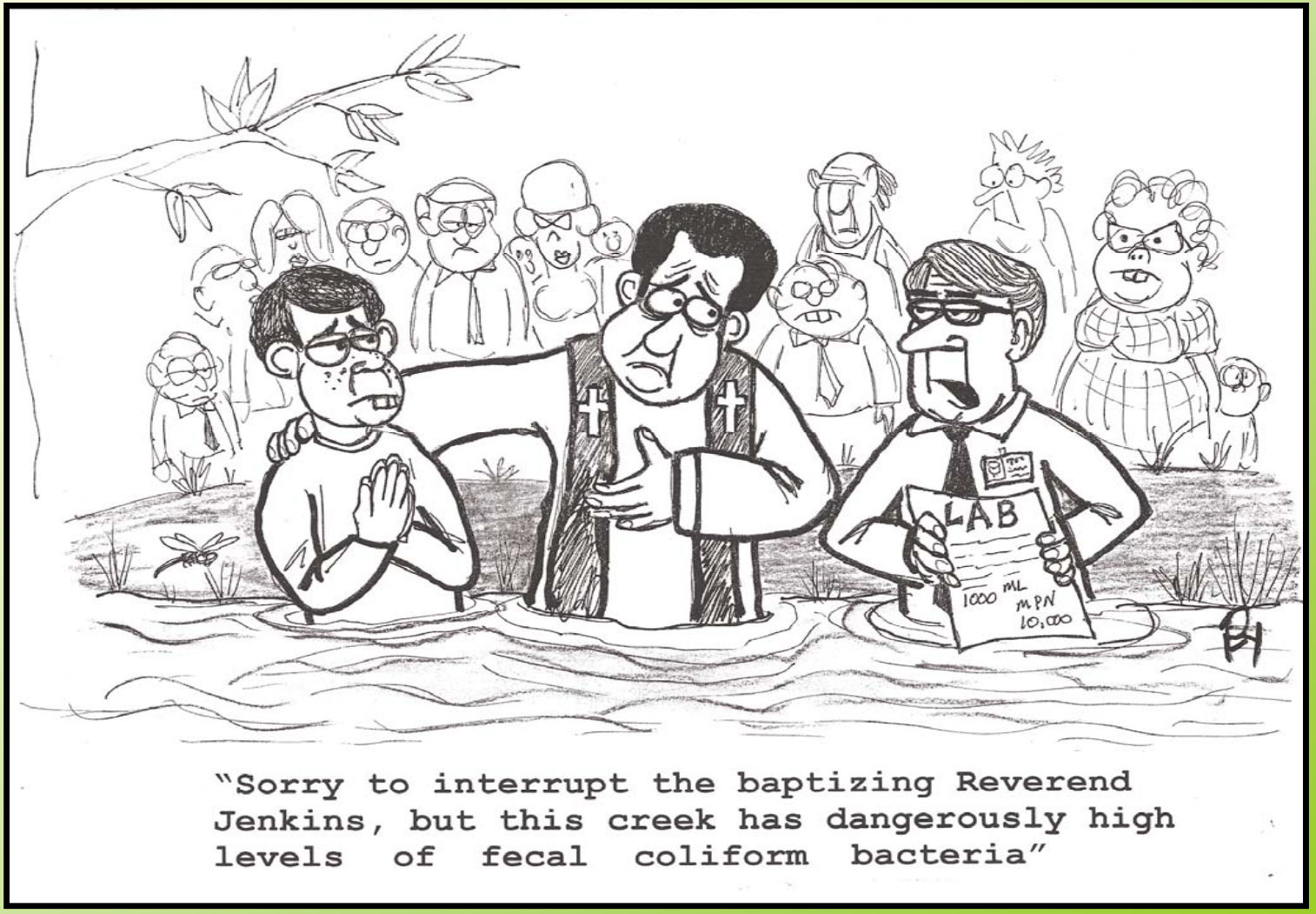
- Jason Osgatharp, Co-Presenter
  Murray County Environmental Health
- Chad Mulkey
  Whitfield Environmental Health
- Frank Sagona
  Conasauga River Alliance
- Doug Cabe
  Limestone Valley RC&D
- Don Bristol
  North Georgia Health District
- Jennifer Moorer, PIO
  North Georgia Health District

We all want to protect groundwater. . .

Automatic Flushing in the North Georgia mountains



. . . so, we must protect our streams and rivers.



"Sorry to interrupt the baptizing Reverend Jenkins, but this creek has dangerously high levels of fecal coliform bacteria"

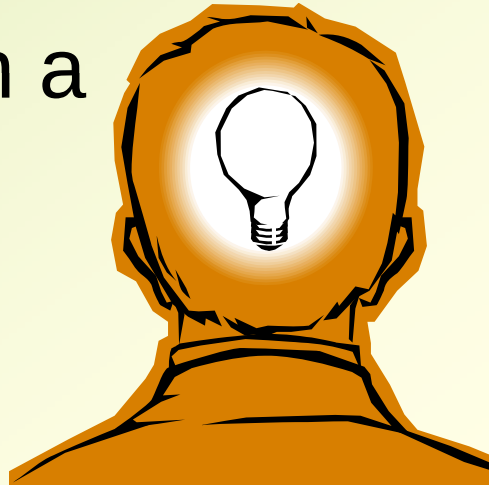
Creeks, rivers and streams have an ability to clean themselves of most organic pollutants given enough time and distance of flow.

GENESIS:

- My background in stream ecology and on-site systems combined with…
- Research in laterally sloping sand filter *beds* in Nova Scotia by the Centre for Water Resources Studies, DalTech, Dalhousie University, Halifax, N.S., and…
- A need for a simple and inexpensive effluent treatment method for failing systems in our Ridge & Valley soils of NW Georgia.

THE MAIN IDEA:

Just as streams and rivers have the innate ability to cleanse themselves of most organic pollutants given time, length and available oxygen, this same principle could be applied to treatment of effluent in the form of a laterally sloping long sand filter *trench* with additional polishing in a constructed wetland if needed.



1994 design by D.H. Waller for a sloping sand filter as remedial option for cottage system

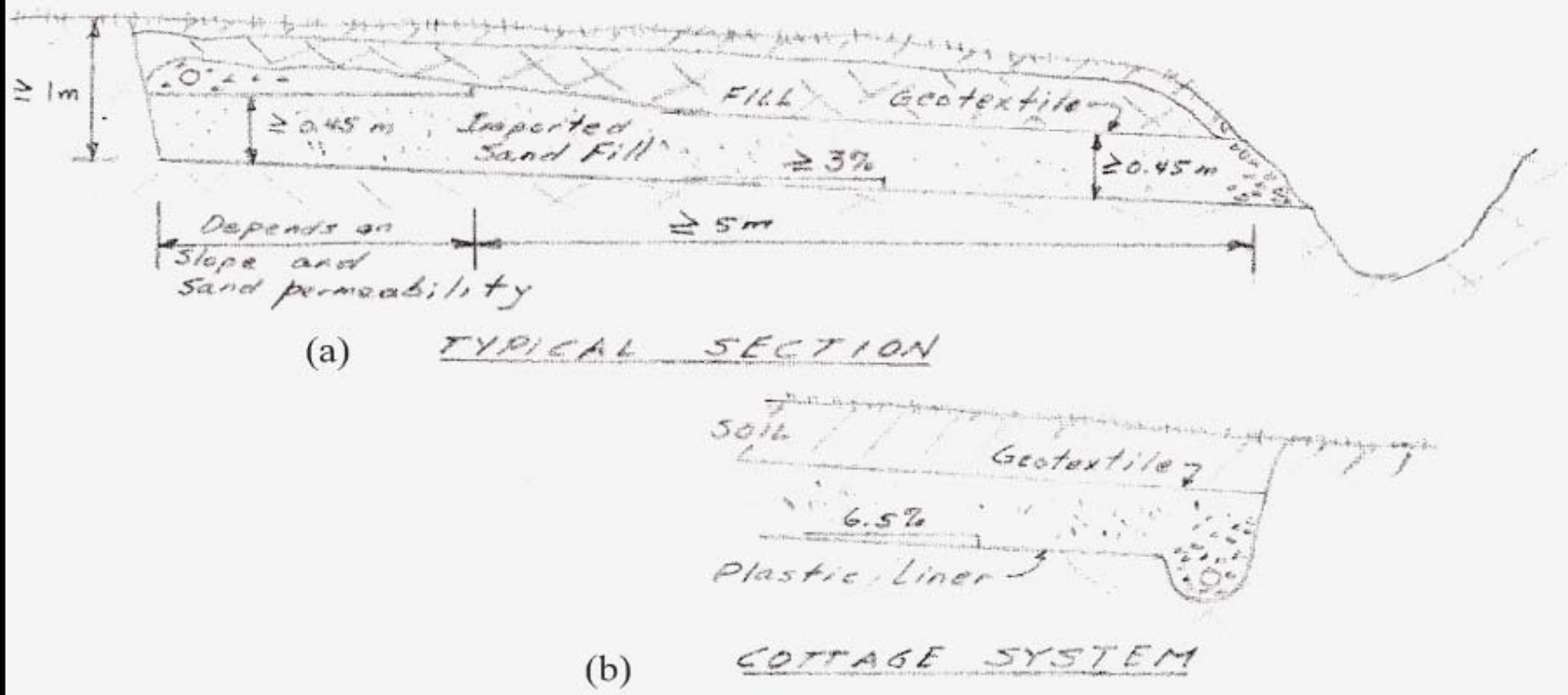
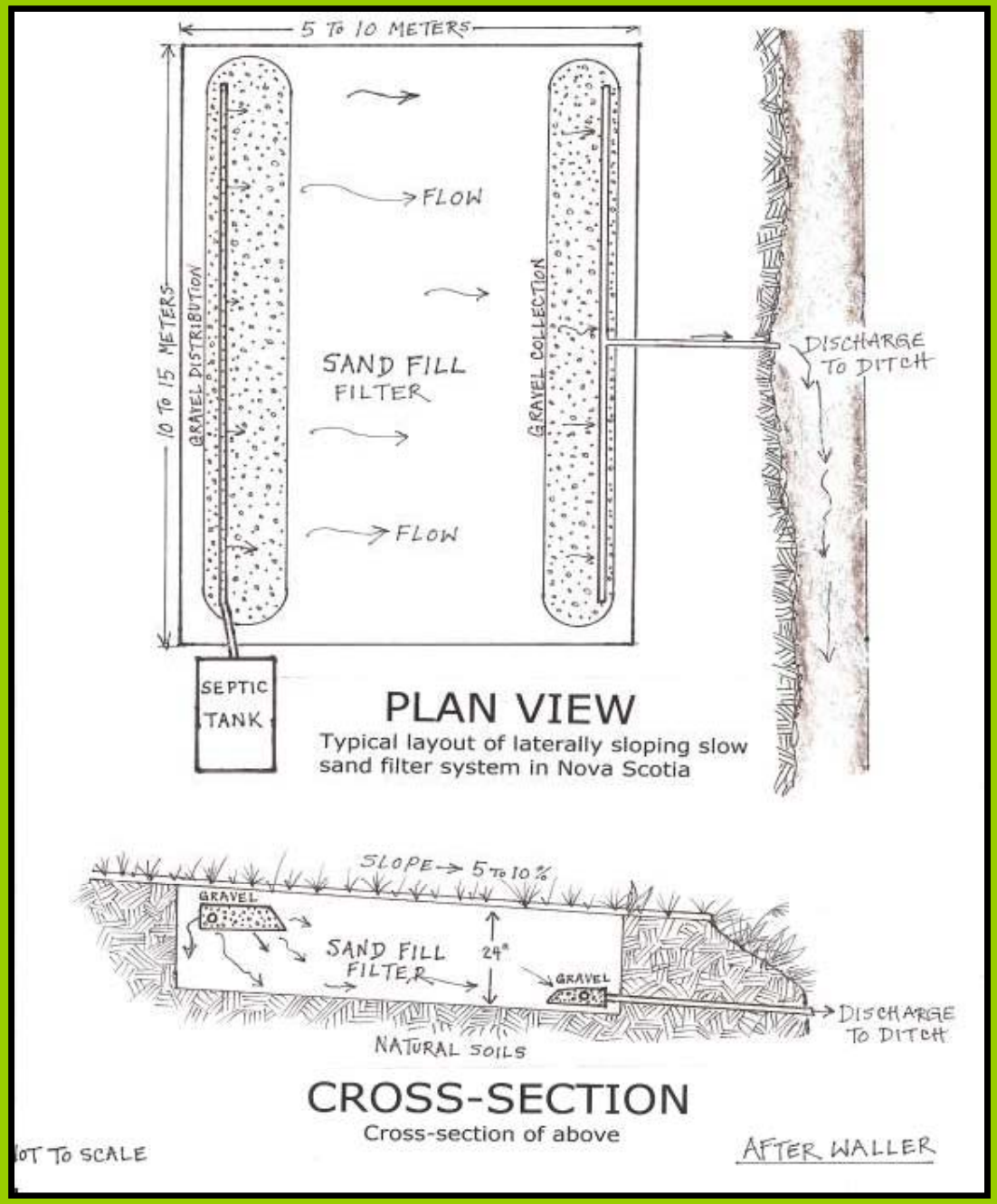


Figure 1: Sloping Sand Filter

Typical Lateral Sand Filter Bed - Nova Scotia



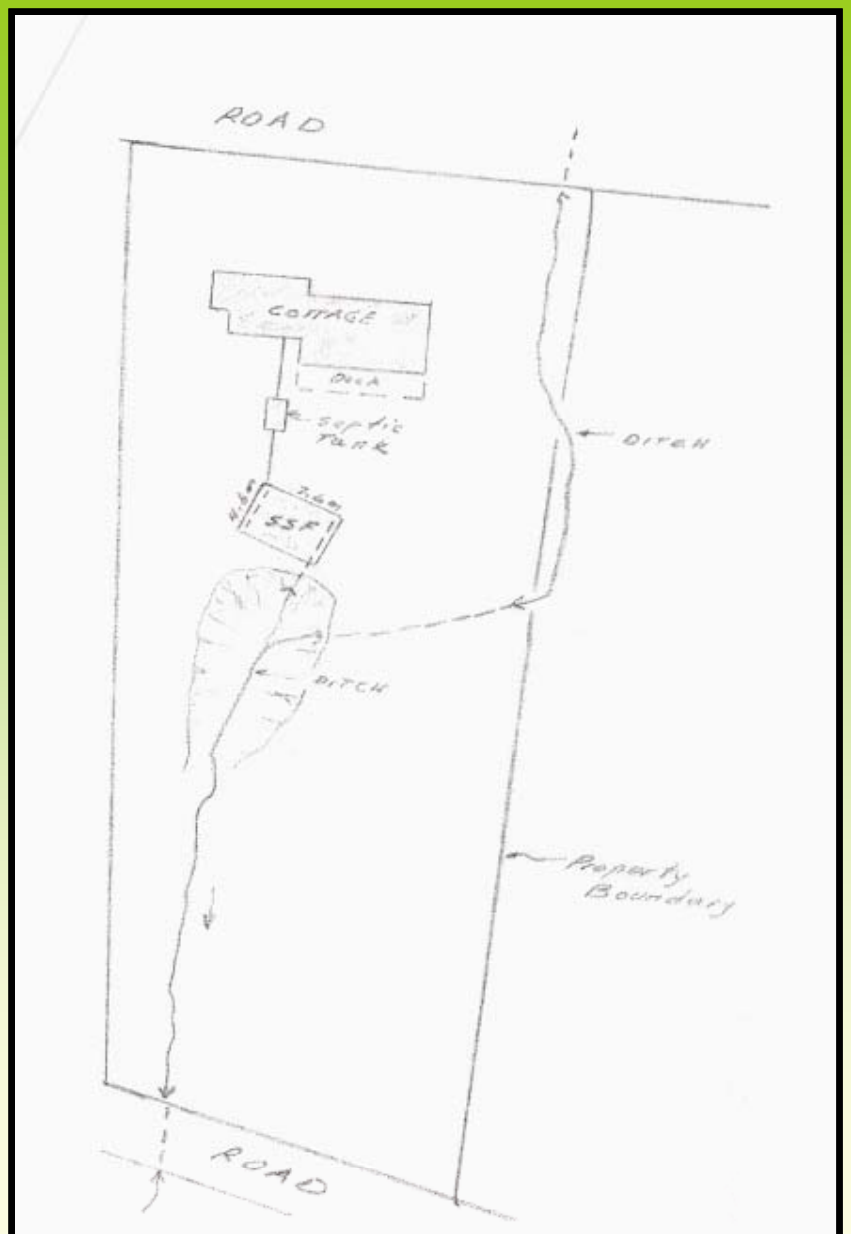
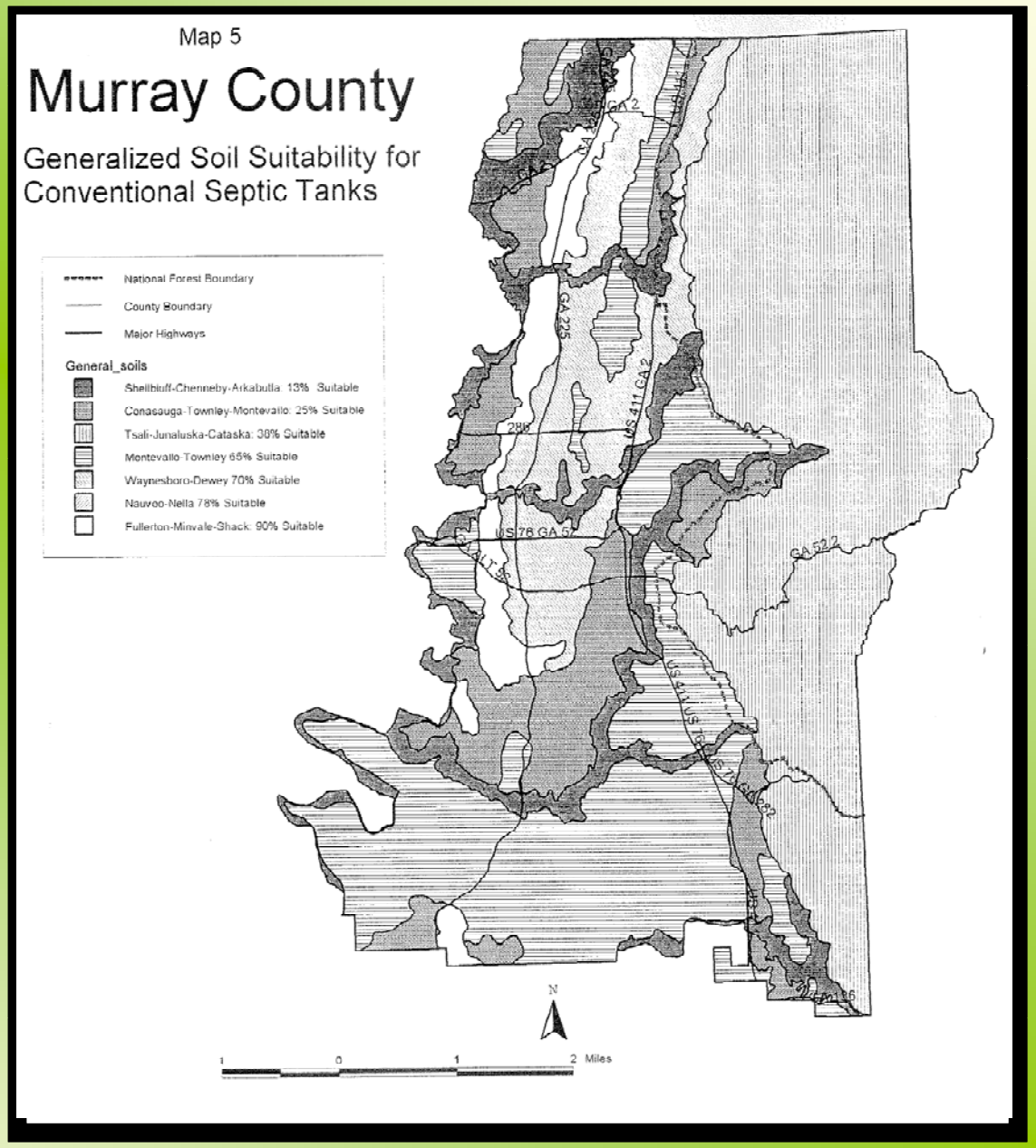


Figure 3: Location of Cottage System

View of design by D.H. Waller
Note that system discharges after treatment.

Excluding the National Forest on the east, approximately 80% of Murray County soils would be deemed unsuitable for conventional on-site systems.



Typical Ridge and Valley “Soil”

Common Problems with Ridge & Valley Soils and Systems

- FAILURES: Murray County EH often issues more repair permits than new installation permits due to limestone and shale soils with percolations from 90 to 500 minutes/inch.
- Economically Depressed Area: Many property owners do not have expendable income to make expensive repairs, especially those using Advanced Treatment Systems. A typical repair may be several hundred linear feet of conventional absorption field.
- Many systems are old and never functioned properly.
- Most property owners do not have expendable income to operate and maintain the Advanced Treatment Systems needed for repairs.
- Certain area waters are impaired, exceeding fecal coliform TMDL (319h Grant to Conasauga River Alliance and Limestone Valley RC&D Council)

LOCATION CONASAUGA AL+GA TN

Established Series
Rev. CFM:HCD
07/2002

CONASAUGA SERIES

The Conasauga series consists of moderately deep, moderately well drained, slowly permeable soils that formed in residuum weathered from shale and shaly limestone. Slopes range from 1 to 45 percent.

TAXONOMIC CLASS: Fine, mixed, semiactive, thermic Oxyaquic Hapludalfs

TYPICAL PEDON: Conasauga silt loam--forested. (Colors are for moist soil unless otherwise stated.)

A--0 to 1 inch; brown (10YR 4/3) silt loam; weak fine granular structure; very friable; many fine roots; extremely acid; clear wavy boundary. (thickness of the A horizon is 1 to 4 inches)

E--1 to 4 inches; brown (10YR 5/3) silt loam; weak fine granular structure; very friable; few medium roots; extremely acid; clear wavy boundary. (thickness of the E horizon is 0 to 6 inches)

Bt1--4 to 10 inches; brownish yellow (10YR 6/6) silty clay loam; weak medium subangular blocky structure; friable; few medium and fine roots; few faint clay films on faces of peds; very strongly acid; gradual wavy boundary.

Bt2--10 to 19 inches; yellowish brown (10YR 5/6) silty clay loam; strong medium angular blocky structure; firm; few medium roots; common faint clay films on faces of peds; common medium distinct strong brown (7.5YR 5/6) iron accumulations and common medium prominent very pale brown (10YR 7/3) iron depletions; very strongly acid; gradual wavy boundary.

Bt3--19 to 30 inches; yellowish brown (10YR 5/6) channery silty clay; strong medium angular blocky structure; firm; many faint clay films on faces of peds; common medium distinct strong brown (7.5YR 5/6) iron accumulations and common medium prominent light gray (10YR 7/2) iron depletions; 20 percent small channers of shale; very strongly acid; clear irregular boundary. (combined thickness of the Bt horizon is 10 to 36 inches)

Cr--30 to 60 inches; partially weathered, fractured shale in horizontal beds; few fine roots in partings between shale fragments at irregular intervals.

TYPE LOCATION: Cherokee County, Alabama; about 4 miles east of Cedar Bluff in the SE1/4SW1/4NW1/4 sec. 25, T. 9 S., R. 12 E.

RANGE IN CHARACTERISTICS: Solum thickness and depth to a paralithic contact ranges from 20 to 40 inches. Content of fragments range from 0 to 5 percent above 20 inches and 0 to 20 percent below 20 inches. Reaction is extremely acid to moderately acid throughout. Some pedons are slightly acid just above the weathered shale.

The A horizon has hue of 10YR or 2.5Y, value of 3 to 6, and chroma of 2 to 4. Texture is silt loam,

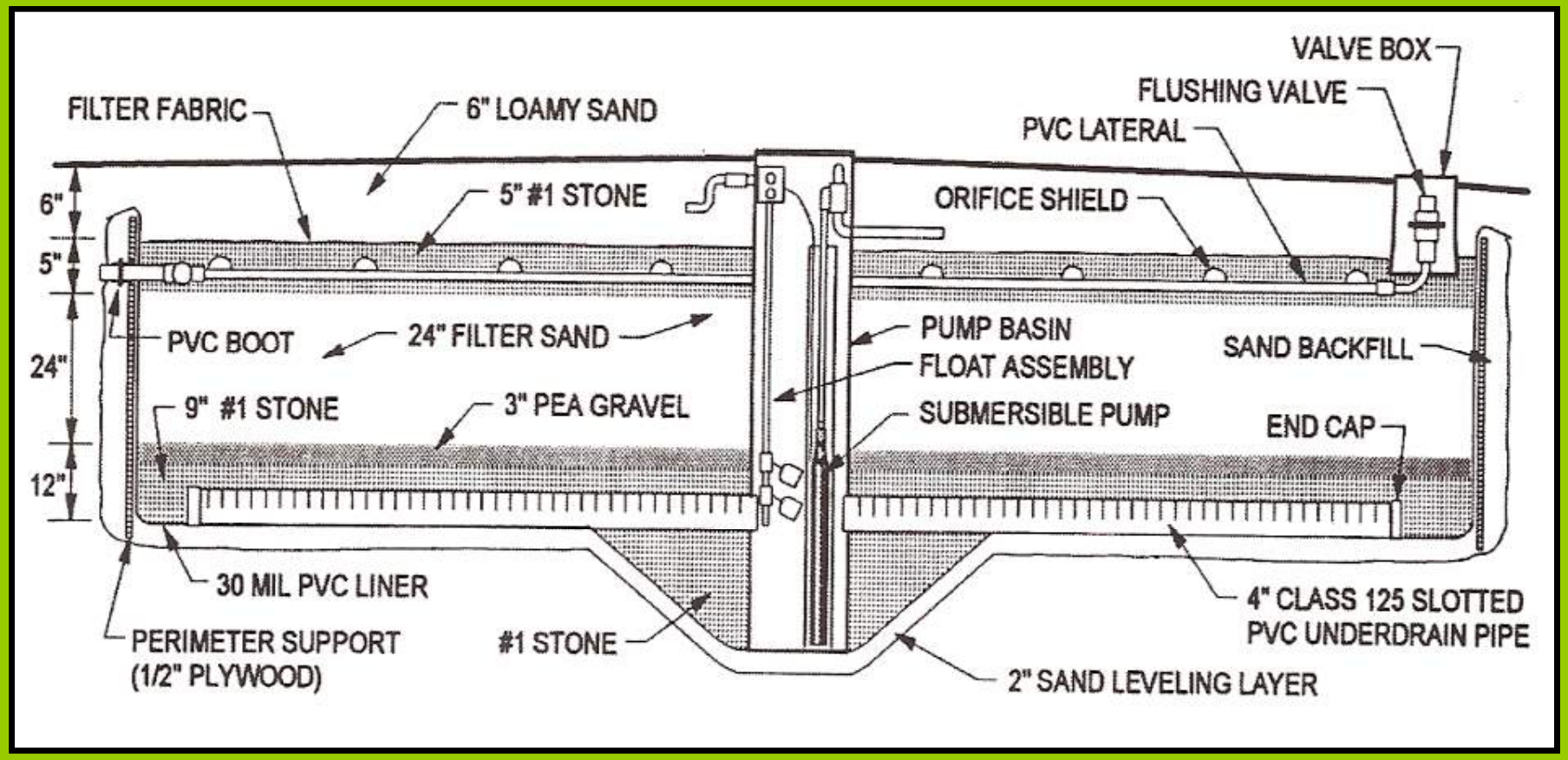
Conasauga soils have been involved at almost every repair made with sloping sand filters and wetlands in Murray County using 319h grant funds.

Close up of limestone cherty matrix typical of Ridge & Valley Soils with fossil (maclurite)

Problems with repairs using advanced treatment and disposal methods:

- Initial Expense
- Property owners don’t understand systems (or want to understand them)
- Continuing maintenance and costs.
- Poor record of maintenance responsibility by installers of advanced treatment and disposal systems.
- Success rate of advanced systems is only 50% for new systems or repairs in Ridge & Valley soils.

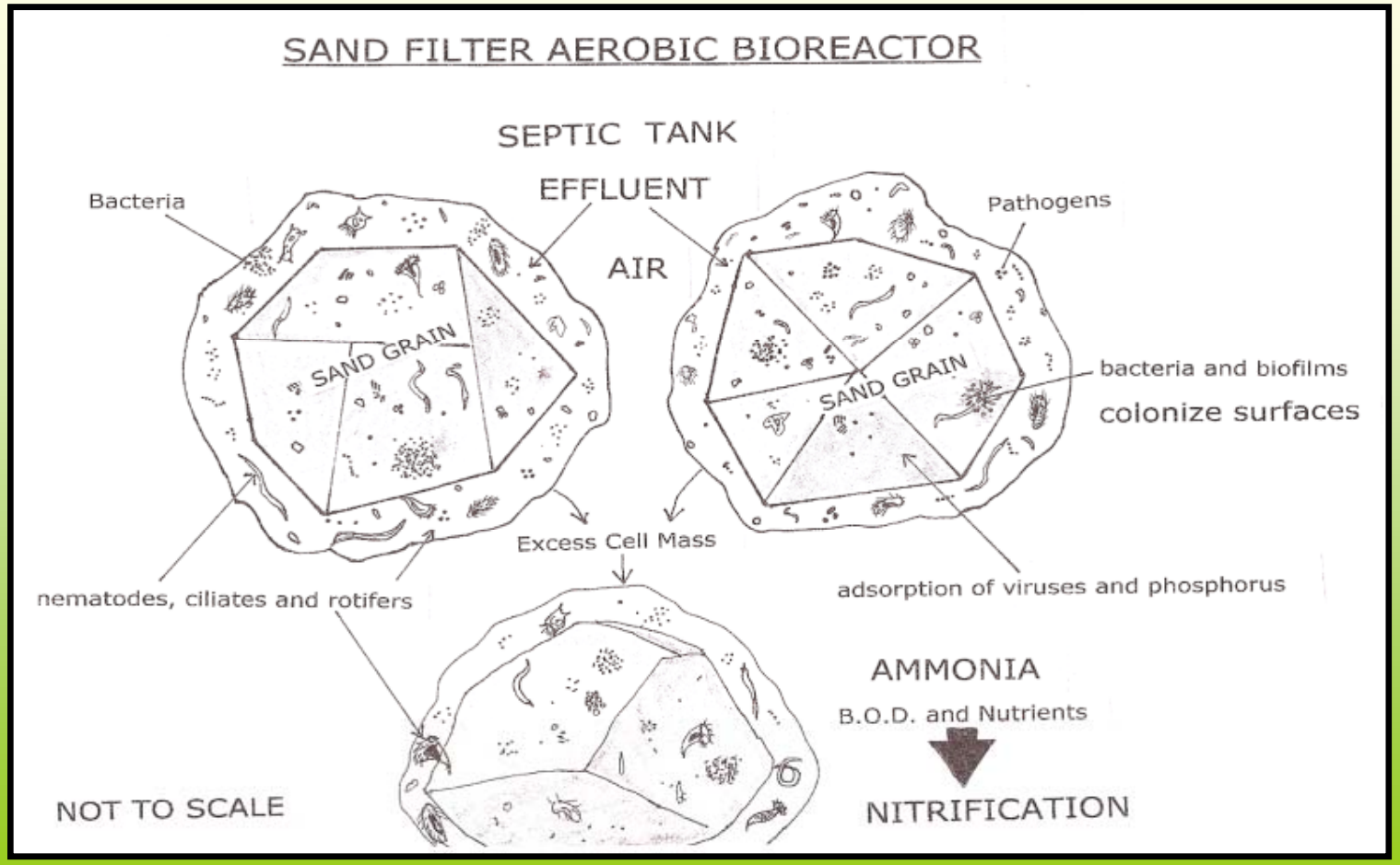
TYPICAL DESIGN OF SINGLE-PASS SAND FILTER



Single-Pass Sand Filters

- ✓ Can be simple and inexpensive
- ✓ Little or no maintenance
- ✓ Removes most organics from effluent
- ✓ Great pretreatment for absorption fields
- ✓ Readily recovers microbial community if shocked by chemicals or too much organic matter
- ✓ Treatment residence time is very short (through only 2 or 3 feet of sand)
- ✓ Treatment results may be highly variable
- ✓ No adjustment for peak flows
- ✓ Very little Nitrogen or Phosphorus removal with single-pass
- ✓ Standard designs are uncommon as are mistakes in installations. Some states have adopted sand filter design criteria but more often are for recirculating sand filters
- ✓ Sand size is critical and often over-looked. Small ‘cement sand’ is often substituted with poor results
- ✓ Clogging at surface of sand is common, esp. when wrong sand size is used.
- ✓ Access for maintenance is limited by most designs
- ✓ Unequal distribution by gravity leaves a plume of active treatment in sand and unused sands around plume

Micro-communities, not simply bacteria, live on the film of effluent water surrounding each sand grain. Oxygen is available in spaces between grains for aerobic digestion. Virus removal is mainly through adsorption as well as some phosphorus removal.



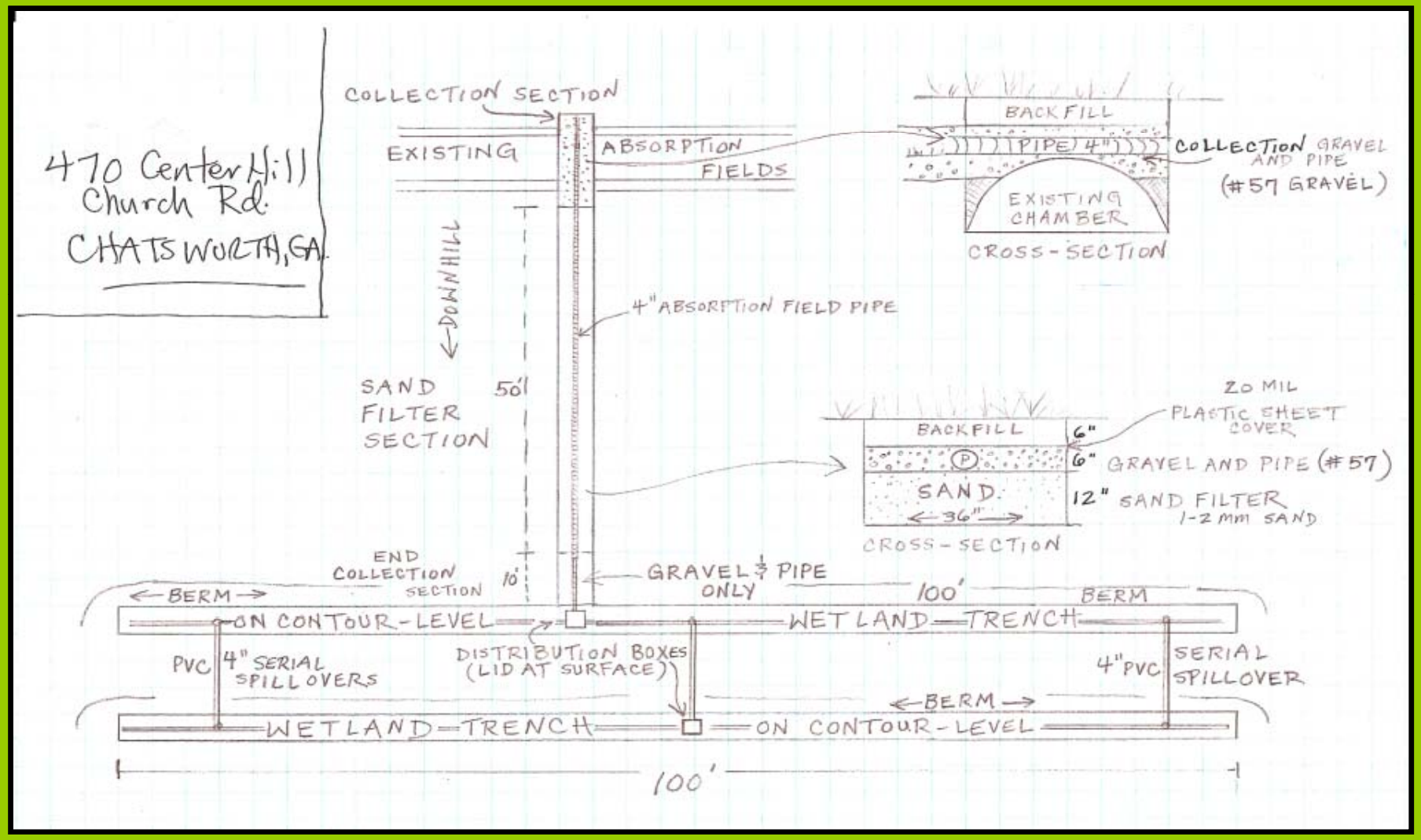
Use of sand and wetlands for sewage treatment is nothing new…

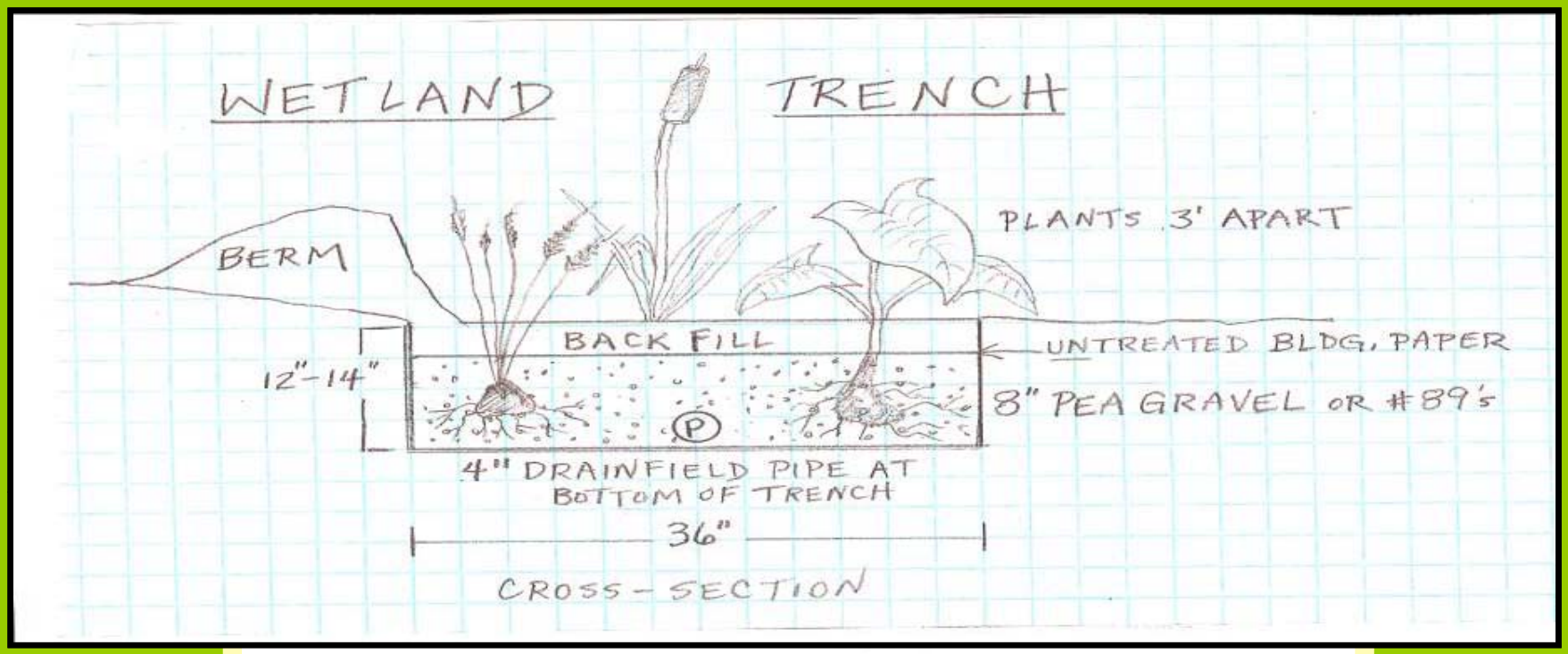
SO WHAT *IS* NEW?

1. Sloping sand filter trenches have similar ability for removing organics over length as streams and rivers.
2. Uses long (50’ to 100’ for repairs) lateral flow in trenches rather than short vertical flow in conventional sand filters, resulting in many times more treatment for all parameters.
3. Handles peak flows much better by spreading effluent downgrade by gravity into unsaturated areas.

5. Effluent cannot skip treatment by nature of trench configuration.
6. Areas of sand do not dry out as much as conventional sand bed filter, preserving the microbial communities for quick recovery when needed.
7. Allows for easy manipulation of treatment process by linear stratification, i.e., roughing filters, different sand sizes, additives (Fe+) for phosphorus or other removals, and addition of an anaerobic section following aerobic sections for more nitrogen removal.

First Experimental System





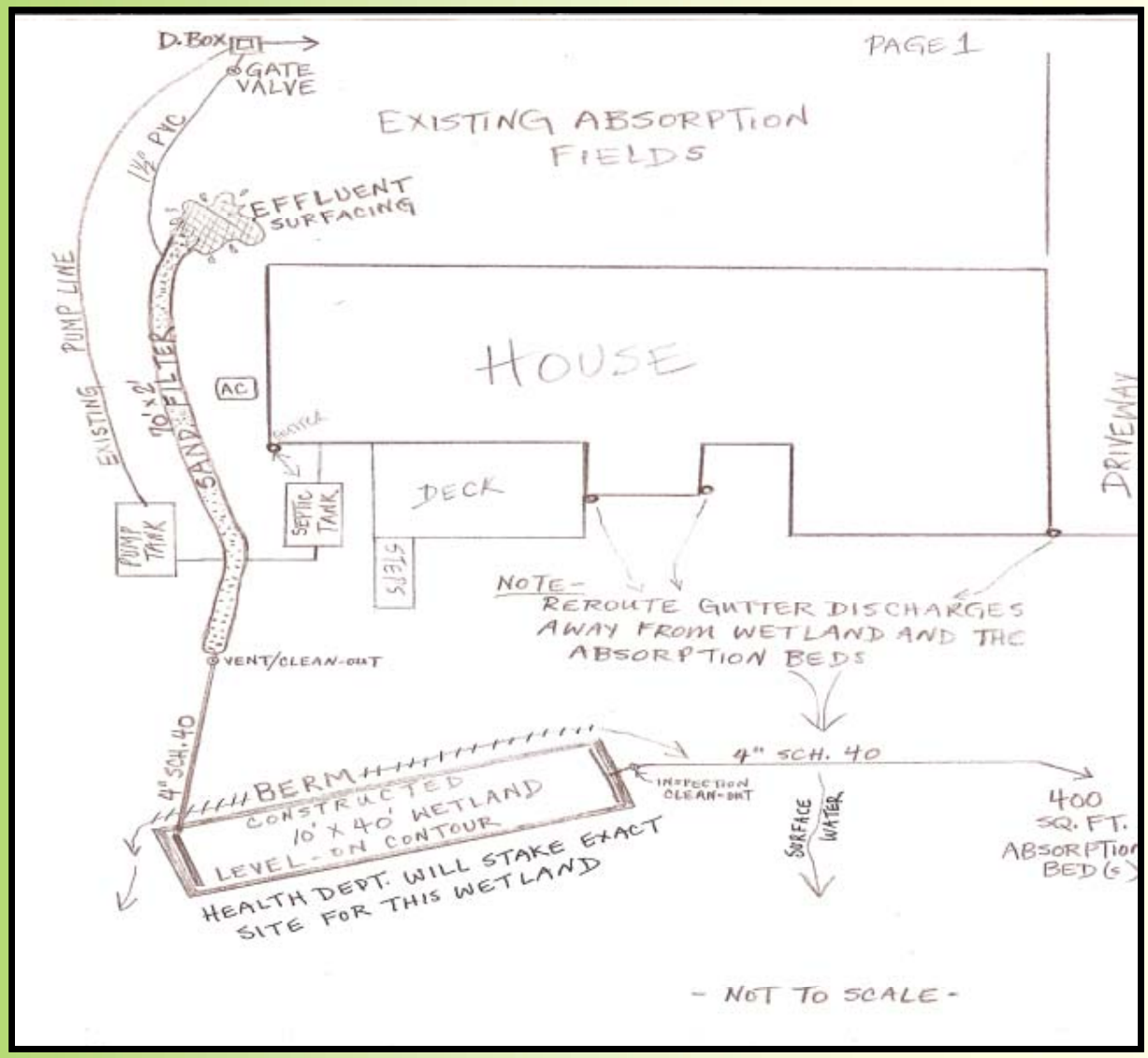
CONSTRUCTION NOTES AND SPECIFICATIONS:

The main idea is to collect only the amount of effluent that is coming out of the ground, run it through a sand filter and send it into two trenches that combine features of a shallow gravel absorption field and a constructed wetland. The purposes of the distribution boxes are to allow monitoring of the filtered effluent and wetland water level, and to add water during dry periods to keep wetland plants alive (critical). Although it will probably be necessary to purchase some wetland plants, native wetland plants should be collected from surrounding areas and used including bulrush, cattail, arrowhead, native bamboo and others. Small water-loving trees and shrubs may also be collected and used such as willow, magnolia, boxelder, tulip poplar, alder, river birch, water oak, and American elm. Purchased wetland species include elephant ears, canna lily, blue flag iris, giant cutgrass and maidencane. No imported (non-native) bamboo should be used because it tends to overgrow and become a nuisance. Whether a plant, shrub or tree, it is critical to collect as much of the root system and surrounding soil as possible for transplanting. After transplanting is complete, the wetland trenches must be filled with water. The property owner must keep water in the trenches during dry periods or the plants, shrubs and trees will die.

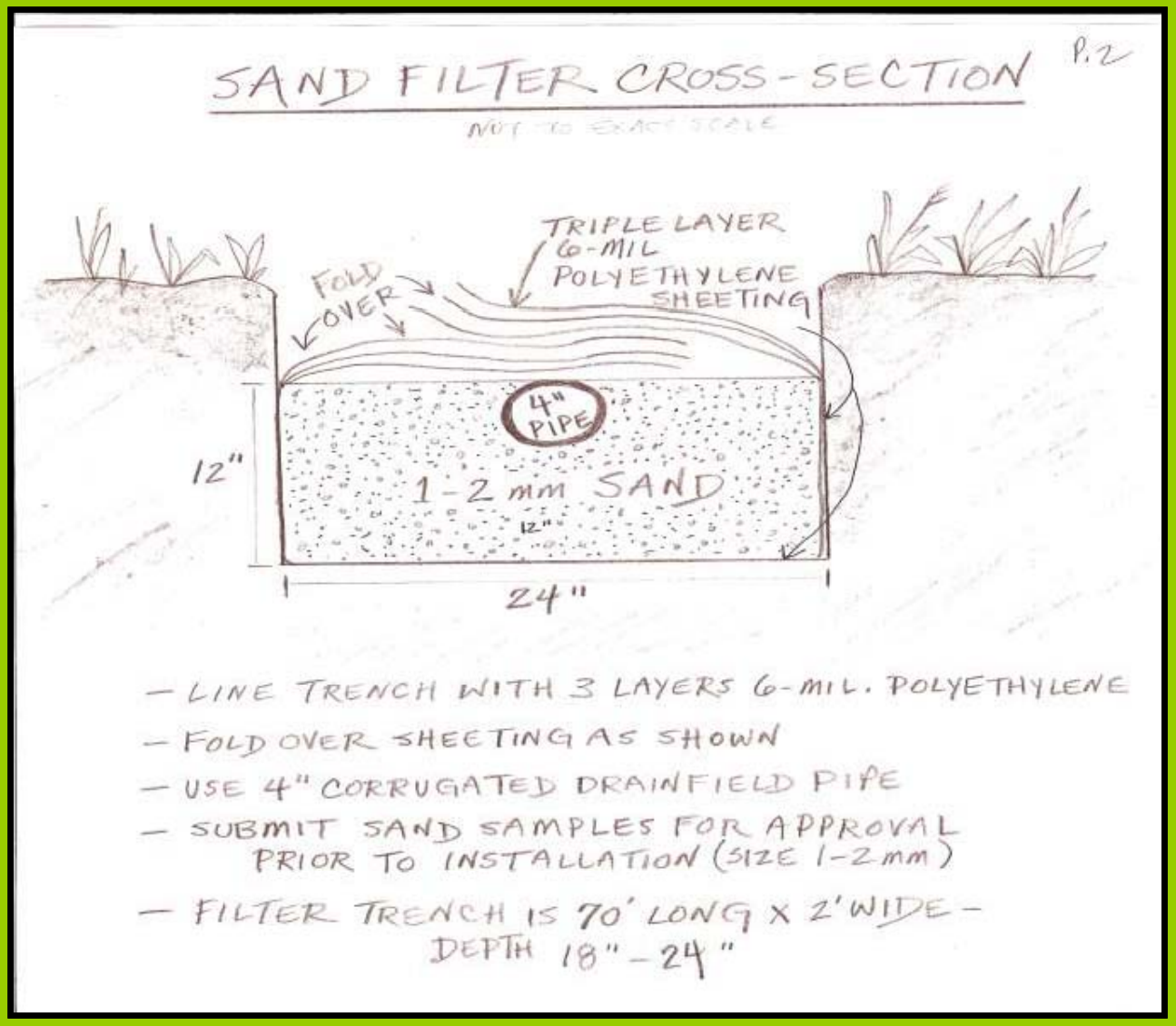
What Was Learned?

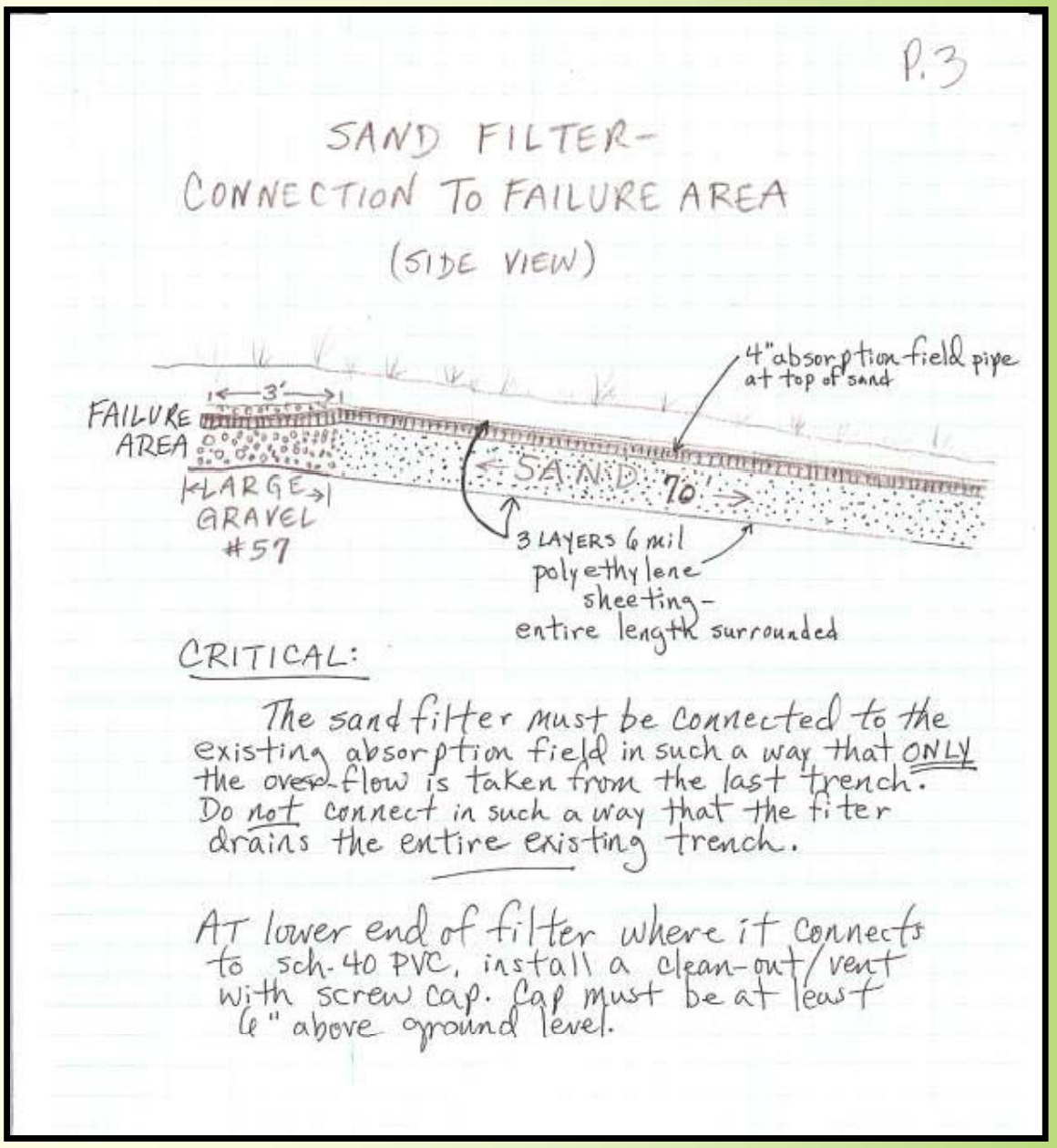
1. Sand filter treatment caused most of the effluent to be absorbed within the filter to soils. Made it difficult to obtain regular samples.
2. Wetland/Shallow Gravel system did not receive enough water. System was oversized and plants died.
3. Laterally sloping sand filter trench resulted in very high treatment; <1 fecal coliform/100 ml at end of filter.

Experimental Design Piney Hills Subdivision



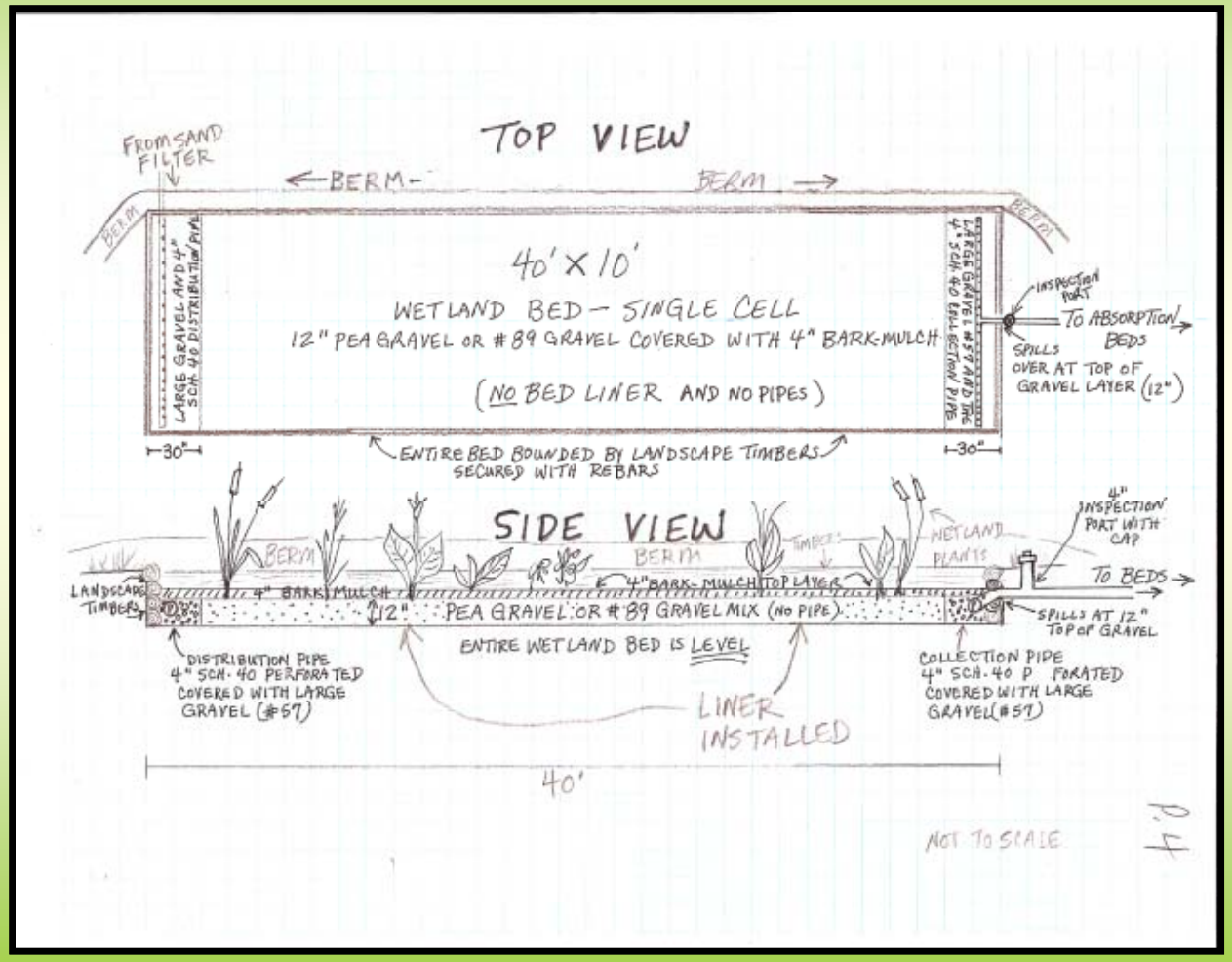
Cross-Section Sand Filter Trench



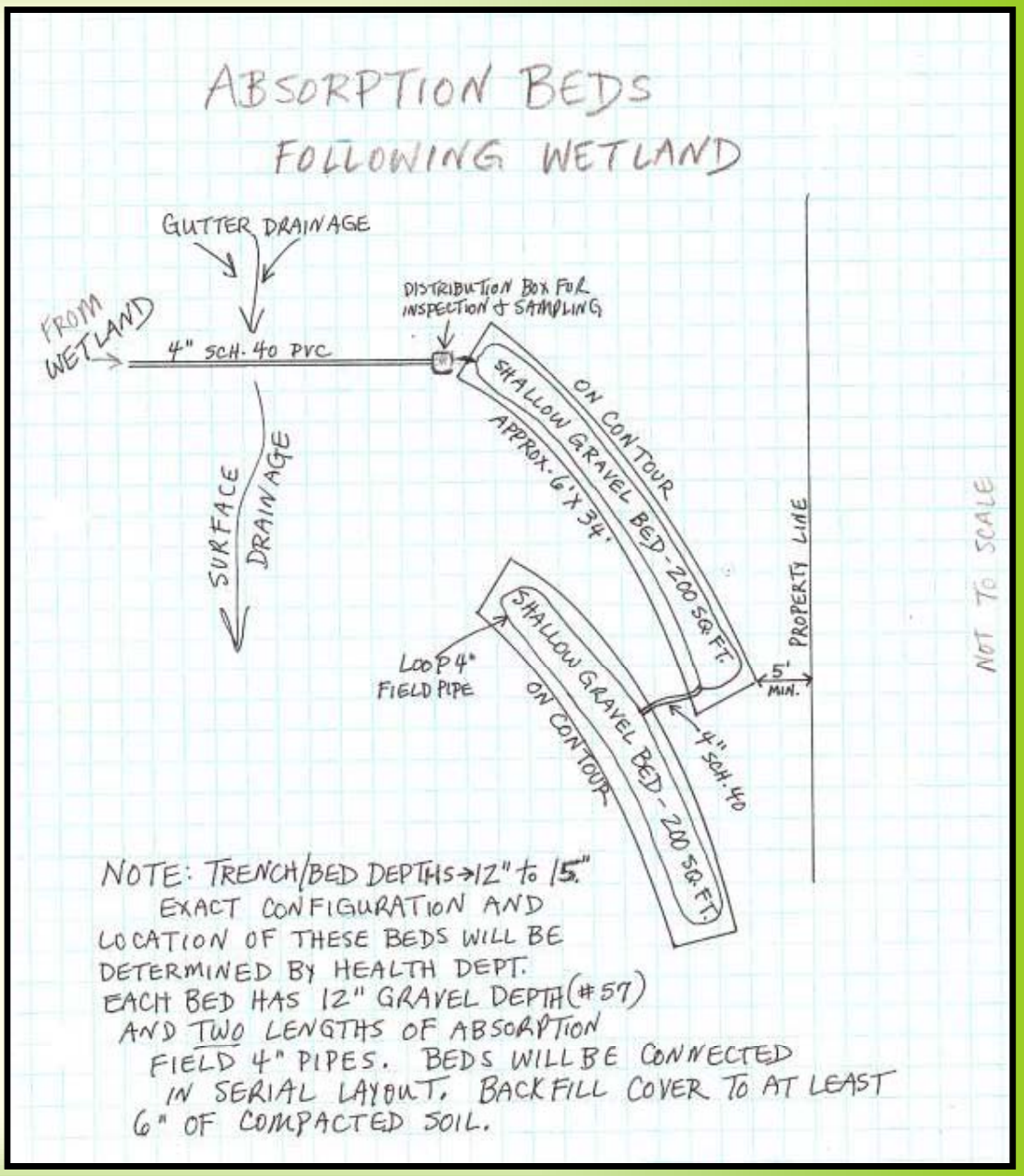


Side Perspective Sand Filter Trench

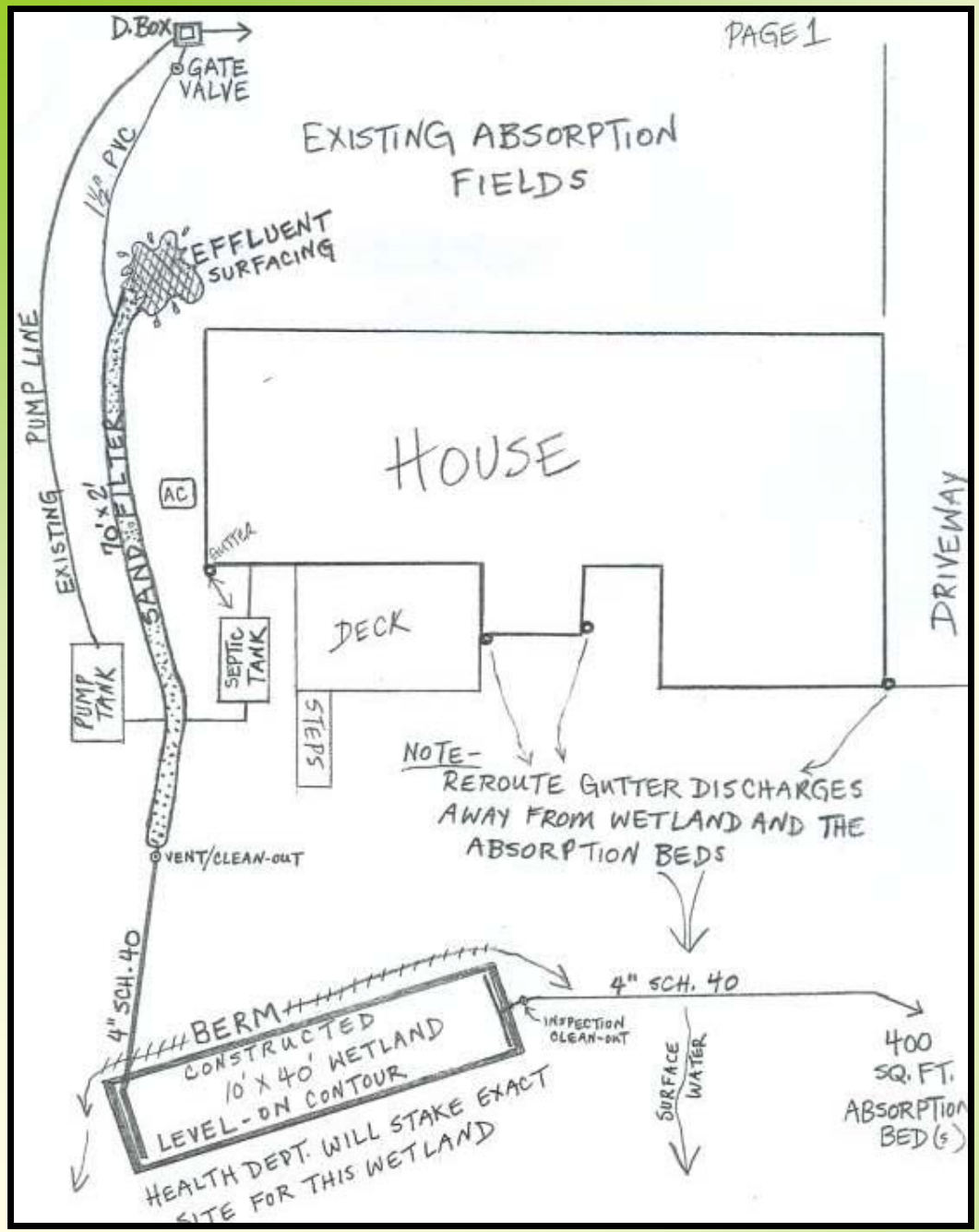
Wetland Cell



Final Disposal in Absorption Beds



Sampling Box after Wetland Cell
Fecal coliform <1/100 ml

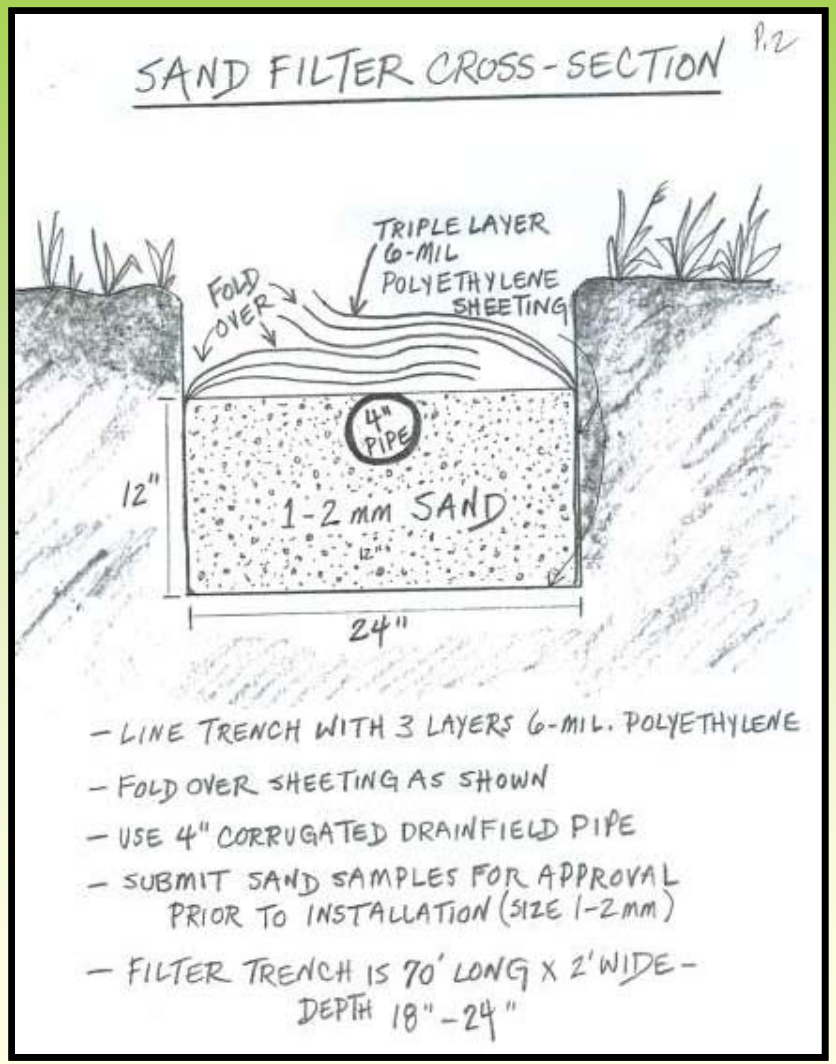


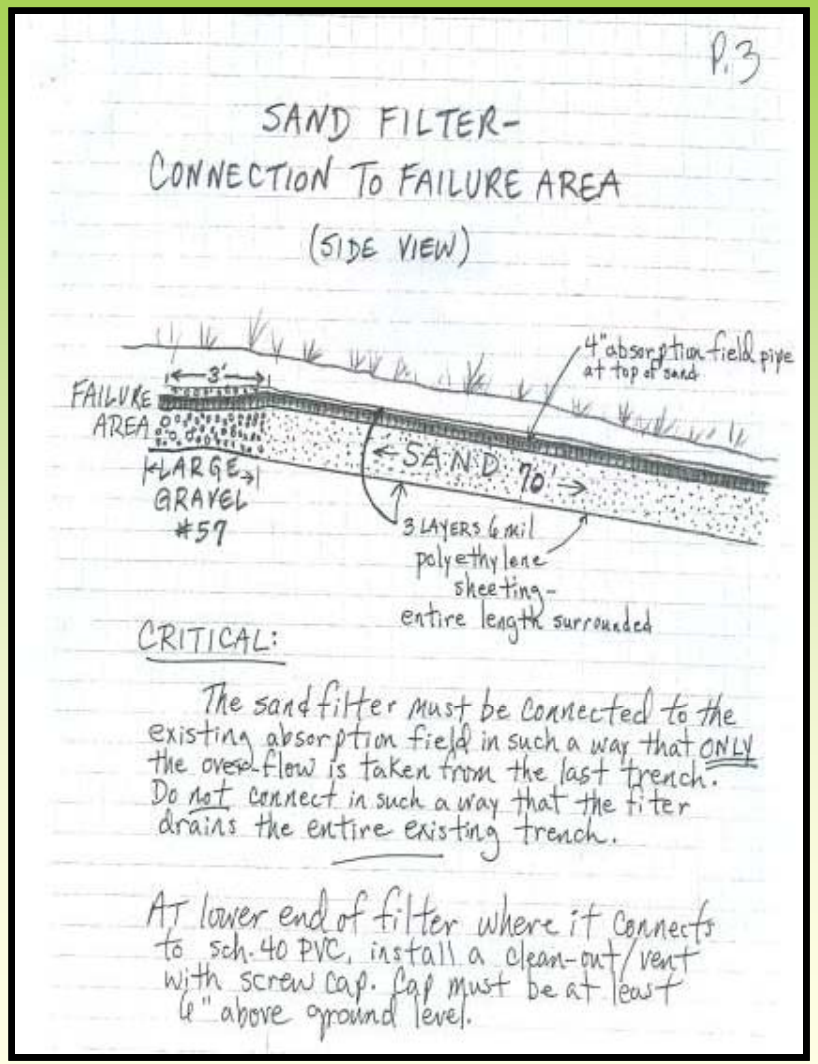
Piney Hills - Design

3 conventional repairs, still failing.
Conasauga Soils

Trench Sand Filter

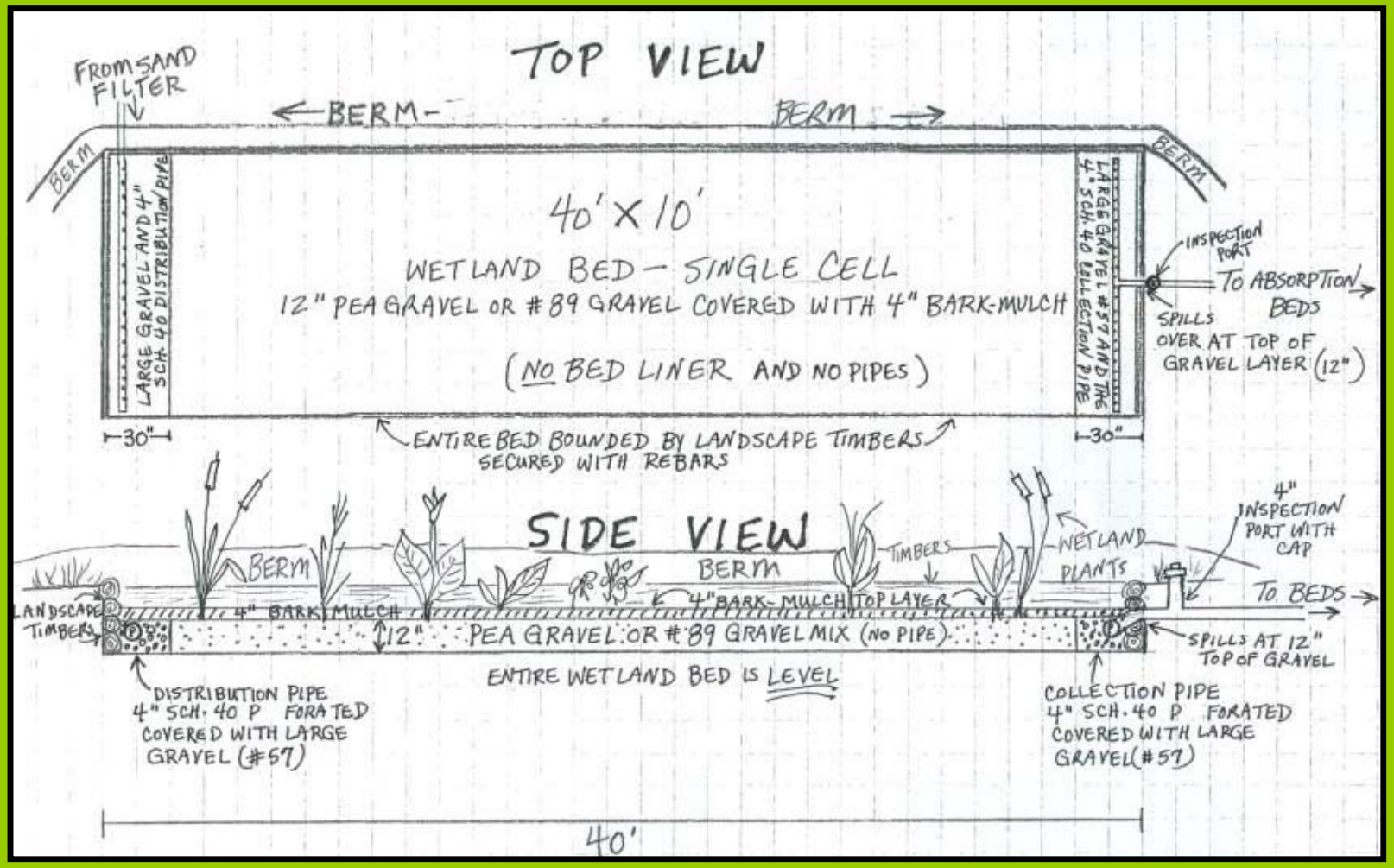
Piney Hills





Wetland Cell Design

Piney Hills



Photos of Piney Hills system

Photos of Piney Hills System

Photos of Piney Hills System

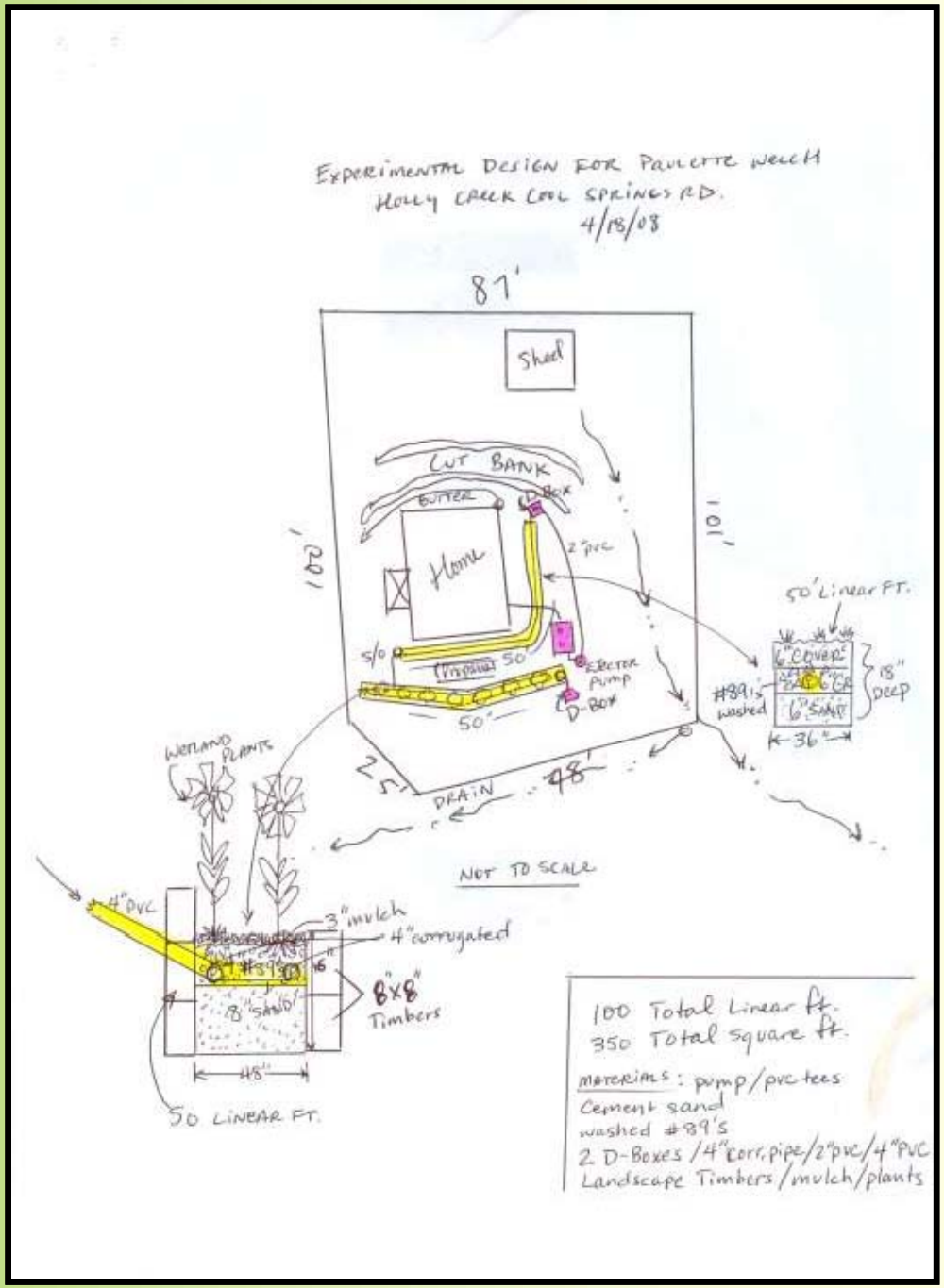
What Was Learned?

1. Wrap sand filter in cases where groundwater or surface water may intrude into filter. Divert gutter water.
2. Wetland Cell probably not necessary.
3. Manufactured sand (crushed granite) worked well but has too many fines.
4. Gravel layer with pipe should be installed over sand filter in trench.

Experimental System – Welch: Or, How Many Problems Can You Fit on One Lot?

- Older home, very small lot
- High groundwater
- Rock
- Springs
- Creeks and temporary streams
- Very bad soils
- Wells
- Failing system with direct discharge

Welch Design



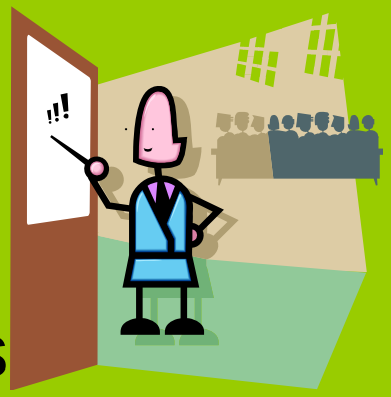
Trench Sand Filter

Wetland Cell

Sampling Box

Finished Wetland Cell

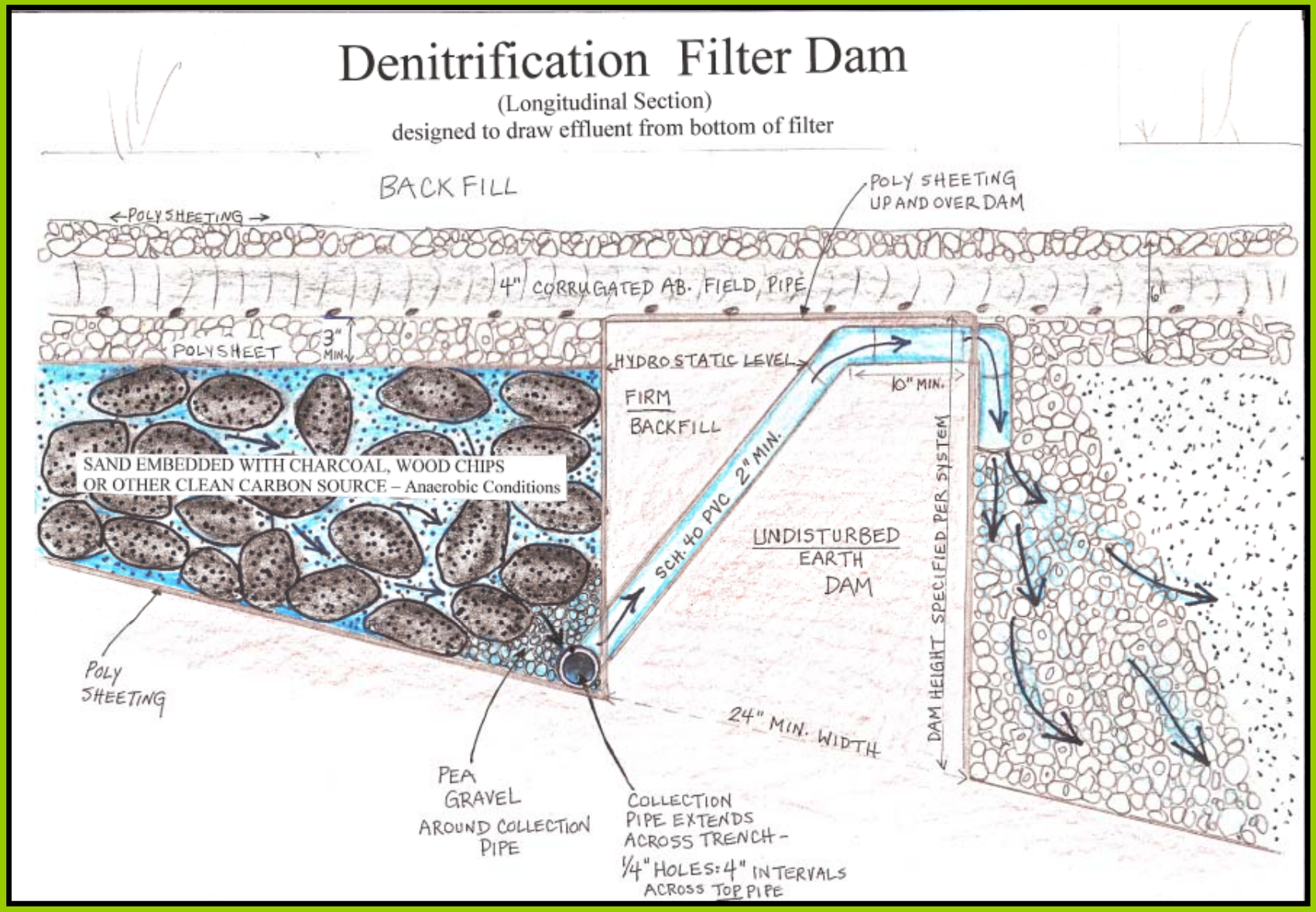
What Was Learned?



1. Wrap the sand filter whenever there is potential for high groundwater or surface water but provide ventilation.
2. In this case the wetland cell was necessary. Discharge from sand filter was anaerobic.
3. Resulting water quality after wetland cell was excellent: <1 fecal coliform/100 ml.
4. This spring the system stayed at discharge point most of the time.

Stratified Filter within Septic Tank

Denitrification Design



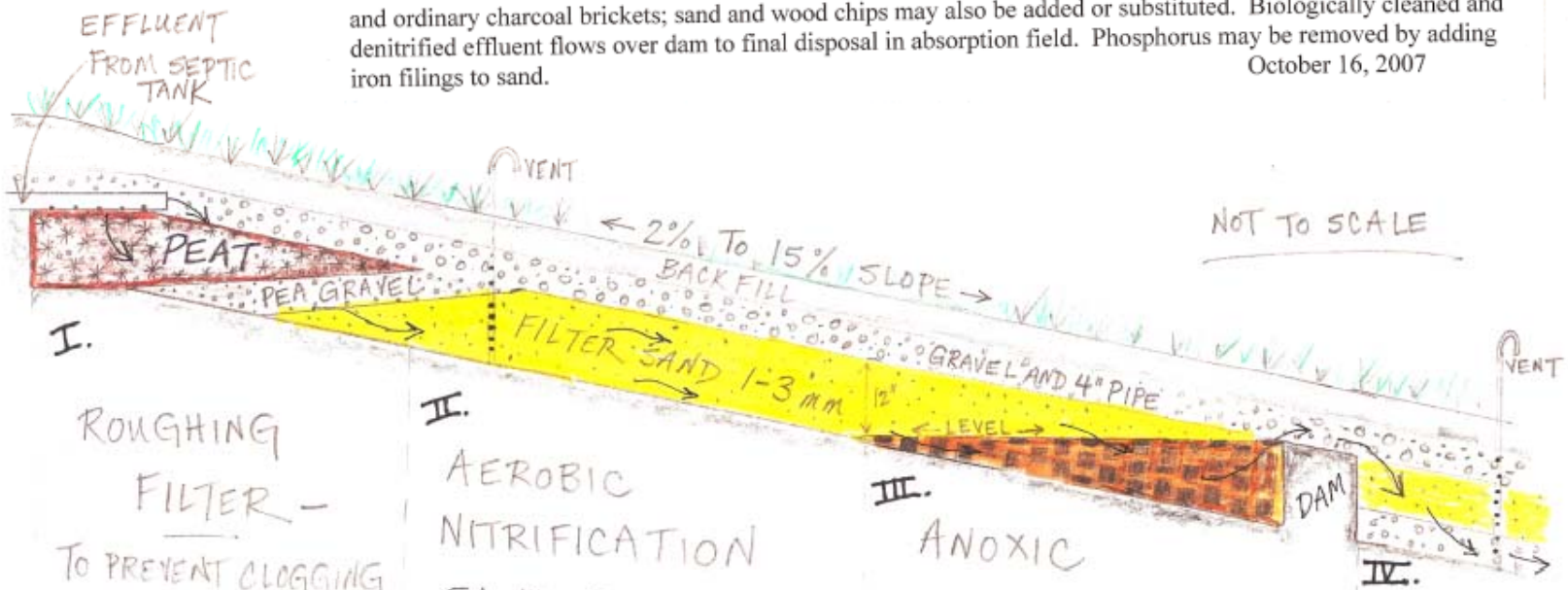
Template for Stratified Treatment

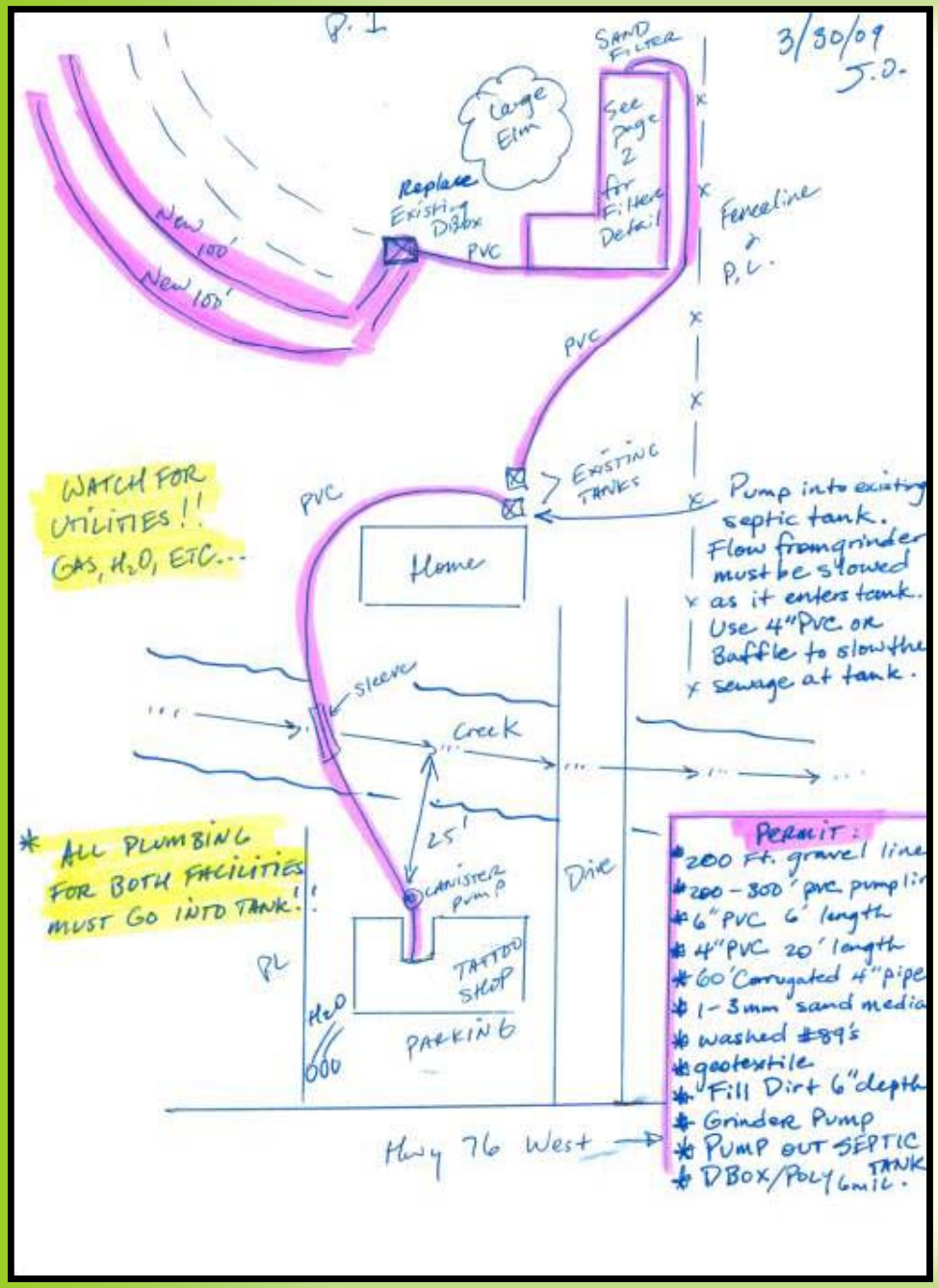
R. King

DRAFT TEMPLATE FOR LATERALLY SLOPING STRATIFIED TRENCH SAND FILTER

This illustration shows a longitudinal view of a sloping trench sewage effluent treatment filter with stratified components for nitrification and denitrification. Effluent exits septic tank and enters roughing filter composed of peat and pea gravel. Roughing filter precludes clogging of sand surface in next component, aerobic nitrification sand filter. Roughing filter and aerobic sand filter provide biological treatment and convert ammonium nitrogen to nitrate (nitrification). To convert nitrate into nitrogen gas (denitrification) an anaerobic environment is needed with rich source of carbon. This environment is created by damming trench and constructing a filter made of sand and ordinary charcoal brickets; sand and wood chips may also be added or substituted. Biologically cleaned and denitrified effluent flows over dam to final disposal in absorption field. Phosphorus may be removed by adding iron filings to sand.

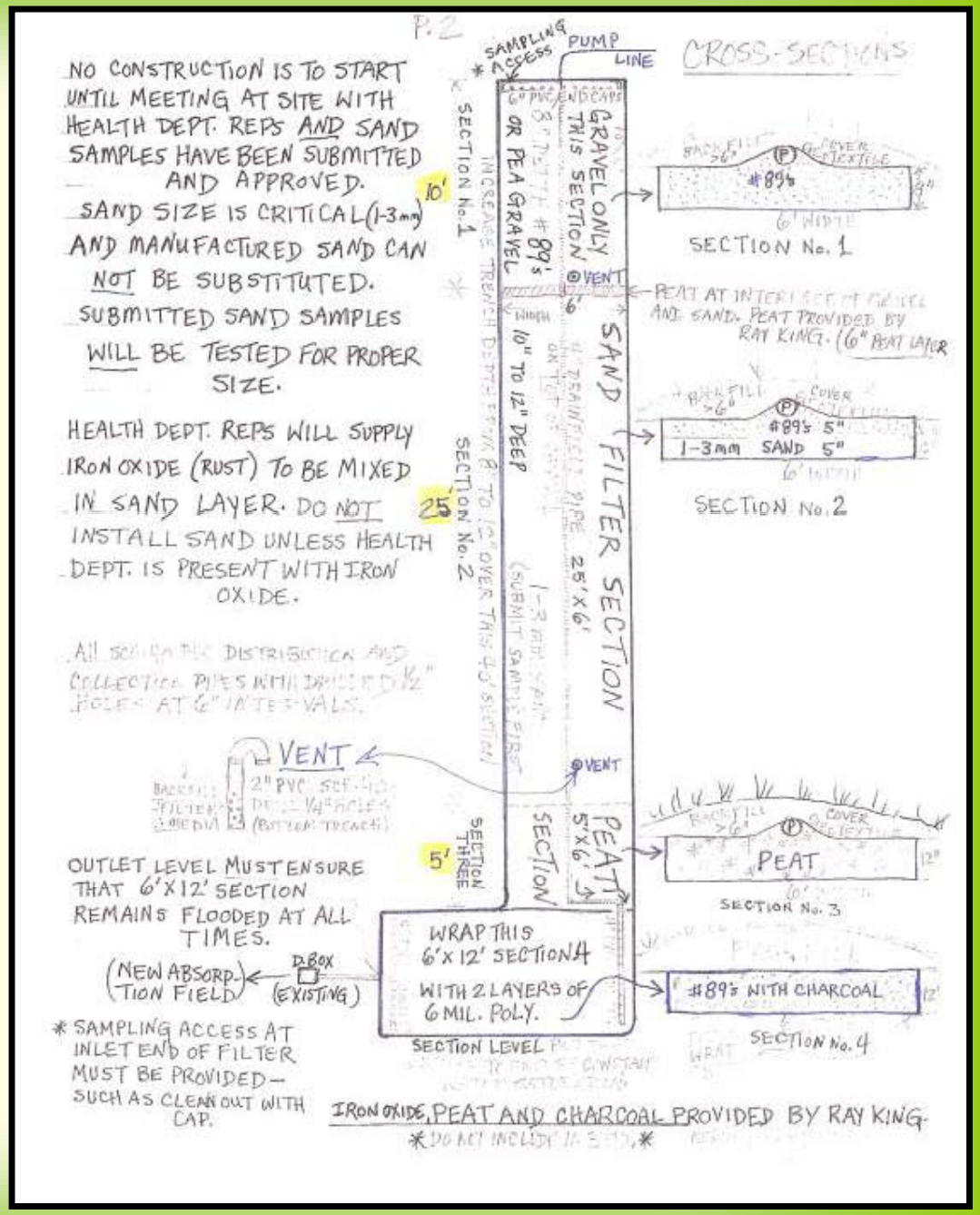
October 16, 2007





Design for Tattoo Studio and Residence System

Specifications for Stratified Filter – Tattoo/Residence

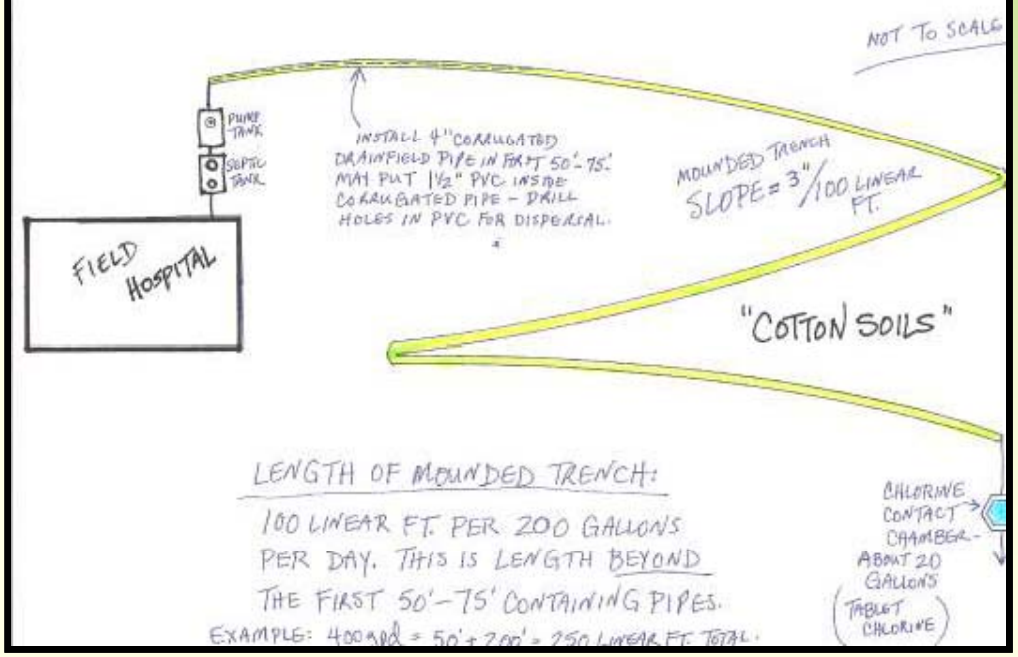


System for Refugee Hospital - Southern Sudan

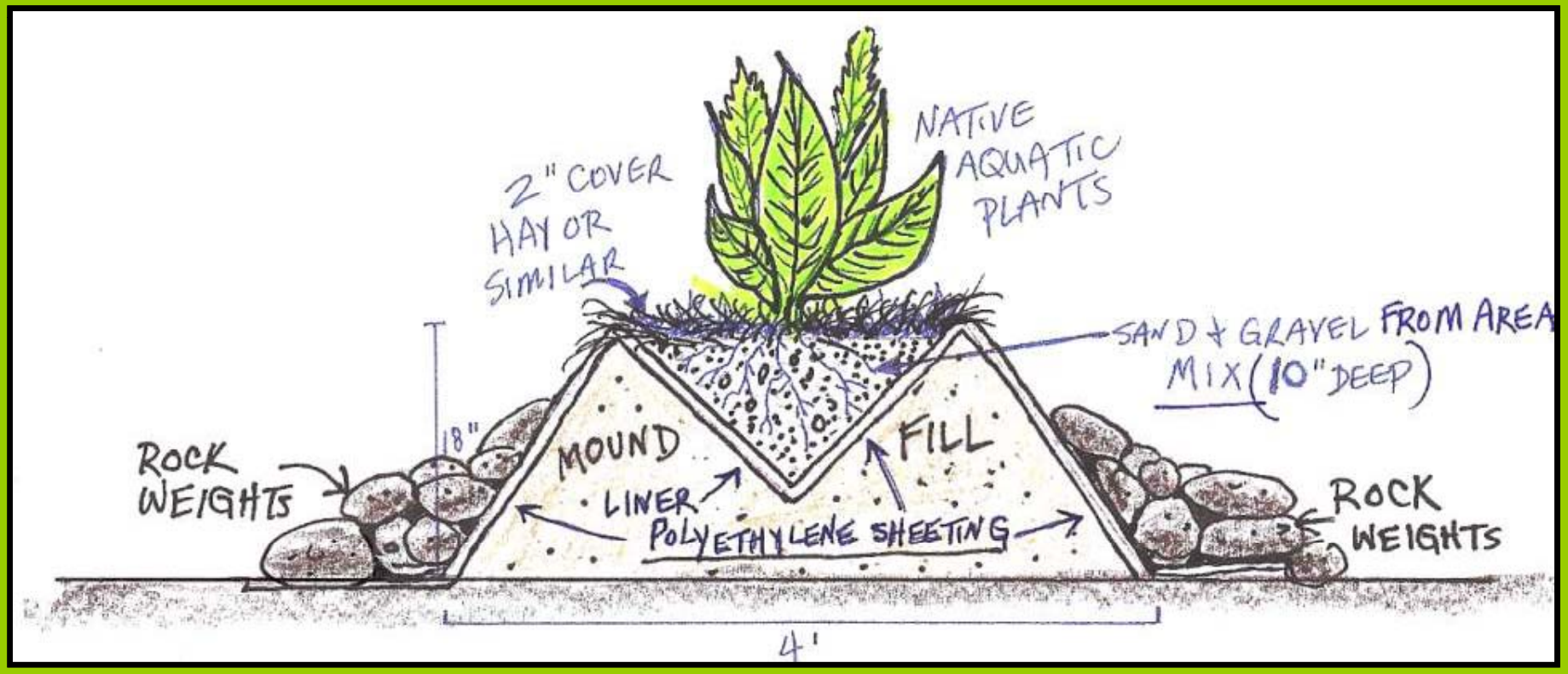
SLOPING GRAVEL-SAND & NATIVE PLANTS MOUNDED TREATMENT TRENCH FOR SMALL HOSPITAL FOR REFUGEES

Southern Sudan

"Cotton" soils subject to monsoon rains and periods of extreme drought. During dry season an absorption field can be used, but during monsoons soils are saturated and may have several inches of rain above ground so treated effluent must go through chlorine contact chamber; final disposal during monsoons to creek, pond or other body of water. Expected flow rate about 200 to gal/day (3 to 5 medical personnel, three sinks, one bathroom, liquid medical wastes).

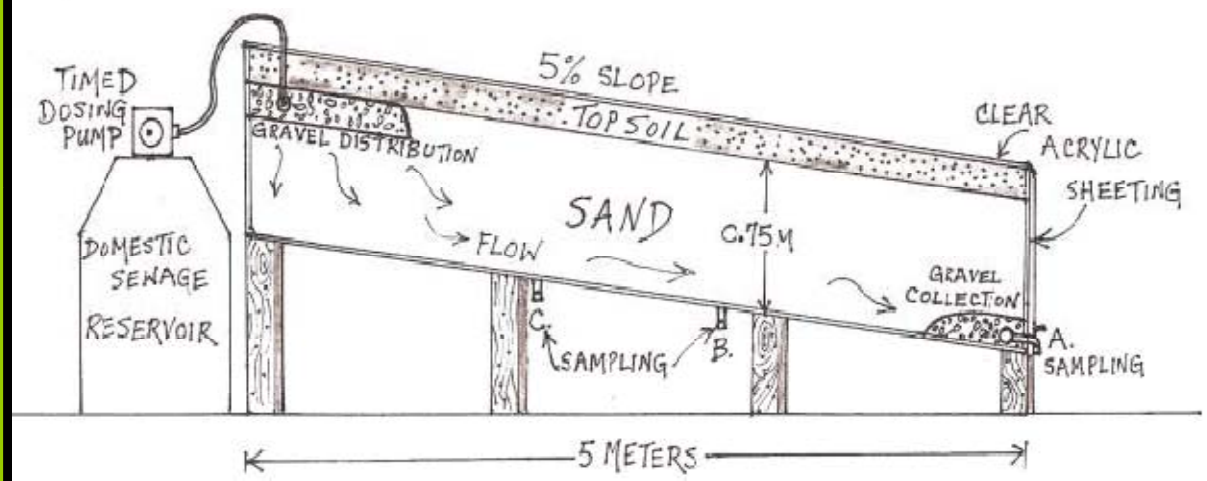


SLOPING GRAVEL-SAND & NATIVE PLANTS TREATMENT TRENCH
Cross Section



Sketch of Laboratory Model

This laboratory model of CWRS laterally sloping slow sand filter was constructed of plywood and acrylic sheeting, representing a slice through the filter in the direction of flow (downslope length). Model contained sampling points and tensiometers. Sand was covered with soil to simulate field conditions. Septic tank effluent was obtained from local households and dosed into models at timed intervals.



Designed to copy field installations as specified by **Centre for Water Resources Studies**

AFTER CHECK, et. al

NOT TO SCALE

Laboratory Models

CURRENT LABORATORY MODEL

STRATIFIED TREATMENTS FOR NUTRIENT REMOVAL

1	CONTROL – sand only	
2	roughing filter, iron oxide, anaerobic section	
3	CONTROL – sand only	
4	CONTROL – sand only	
5	– roughing filter, iron oxide, anaerobic section	
6	– roughing filter, iron oxide, anaerobic section	

4 FEET X 16 FEET RUNS

Summary

- Laterally sloping trench sand filters may be a simple and inexpensive method of effluent treatment for repairs or perhaps new installations. Requires little or no continuing costs or maintenance.
- Proper sand size is absolutely critical (1 to 3 mm.)
- Where groundwater or surface water intrusion is possible, trench sand filters must be wrapped in several layers of poly-sheets and then properly vented.
- Polishing by wetlands after trench sand filters is not necessary in most circumstances.

- Treatment of effluent using this method greatly enhances the probability of successful system repairs while protecting surface and groundwater by reducing fecal coliform counts.
- This method has the potential for significant nutrient removal using stratified treatments within sand filter trenches. Laboratory models and field tests will be required (more testing.)
- Standardization of design and materials will be difficult, but sand has been overlooked as a proven method of improving effluent quality and success rate of on-site systems.

ULTIMATE GOAL

Questions?

Raymond R. King

Director of Environmental Health

North Georgia Health District 1-2

100 W. Walnut Ave., Ste. 92

Dalton, GA 30720

(706) 272-2342, ext. 312

rrking@dhr.state.ga.us