

INSTALLER BASICS - MATH



Leveling Rods

Two Types are available

- “**Architects**” (graduated in feet, inches and eighths of an inch)
- “**Engineers**” (graduated in feet, tenths, and hundredths of a foot). *Tenths Grade Rod*

Engineers Leveling Rod

(Tenths Rod)

2.50 ft.

2.59 ft.

2.55 ft.



Rod Reading Conversions

Convert Tenths of a Foot to Inches

- **Multiply the (tenths of foot) by 12.**

Example:

The rod reading is 5.25 feet.

Calculation: $0.25 \text{ feet} \times 12 \text{ inches/foot} = 3.0 \text{ inches}$

Converts to 5 feet 3 inches.

Rod Reading Conversions

Convert Inches to Tenths of a Foot

- **Divide the (inches) by 12.**

Example:

The rod reading is 3 feet 6 inches (3'6").

Calculation: 6 inches ÷ 12 inches/foot = 0.50 foot

Converts to 3.50 feet.

Helpful Hints

Inches: 0 3 6 9 12

Divide by 12

Tenths: 0 .25 .50 .75 1.0

HOUSE SEWER LINE

Septic Tank Inlet & Outlet Pipes Must Be
Schedule 40 PVC

Slope On “Inlet” Pipe $\frac{1}{8}$ – $\frac{1}{4}$ Inch Per Foot

4 Inch Cleanout Required

Before Entering Tank

Every 100 Feet

Changes In Direction $> 45^\circ$

Minimum and Maximum Fall Stub-Out to Tank Inlet

If tank inlet is 16 feet from house, what is the minimum and maximum fall allowable in this solids bearing line?

Slope On “Inlet” Pipe $\frac{1}{8}$ – $\frac{1}{4}$ Inch Per Foot

Minimum: $16' \times \frac{1}{8}$ inch/foot = 2”

Maximum: $16' \times \frac{1}{4}$ inch/foot = 4”

Fall between example stub-out to septic tank inlet must be between 2” – 4”

BENCHMARK

The Reference Point For The System

Established By The DR

Shown On Permit

Permanent Location

Either:

Arbitrary Elevation (*Example: Benchmark 100'*)

Actual Ground Elevations

Using a Benchmark

DR and Installer are **NOT** going to set up their laser equipment at the same level → must know how to use the benchmark

Example: DR shoots B.M. rod reading as 4.5',
Installer gets B.M. as 4.0'. What does this mean?

Since the installer's reading is 0.5' lower, the installer will have to subtract 0.5' or 6" from **EVERY** rod reading/elevation on the permit when re-laying out system

Using Benchmark to Verify Site Shots

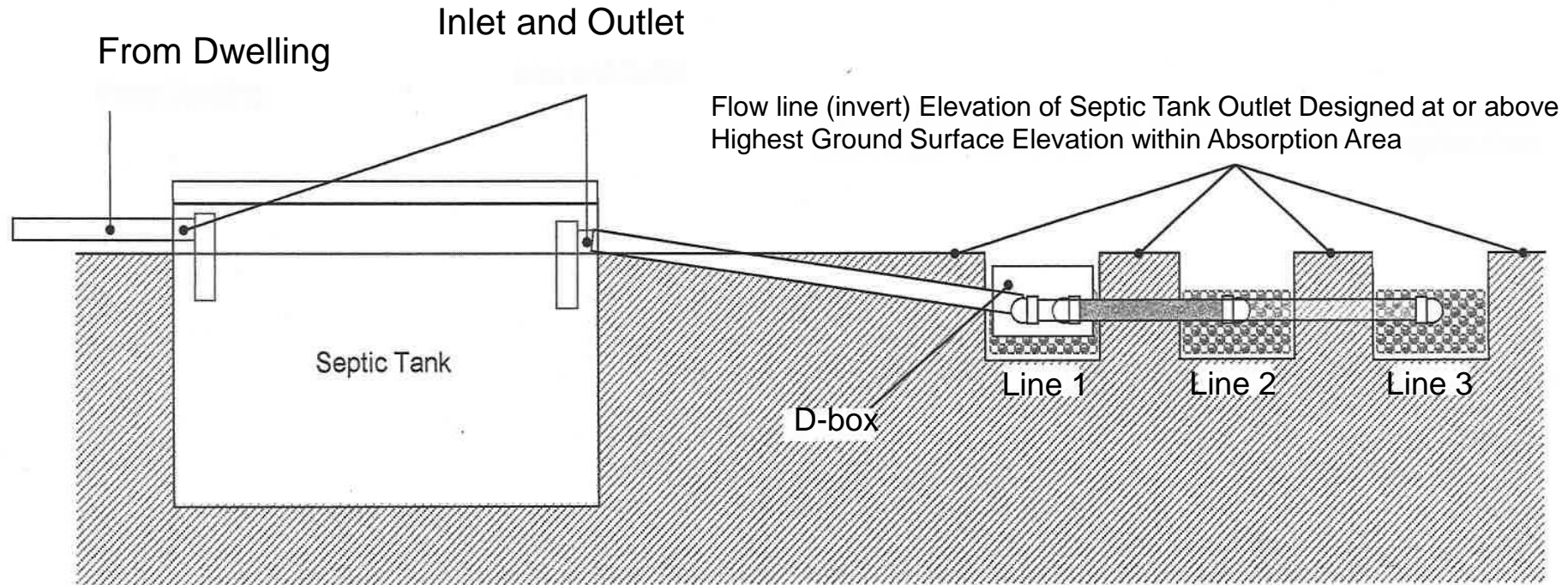
DR shots on permit

	G.E.
S.O.	2' 7"
TANK IN	2' 9"
TANK OUT	2' 11"
D-BOX IN	4' 2"
LINE ONE	5' 0"
BENCHMARK	5' 5"

Installer shots

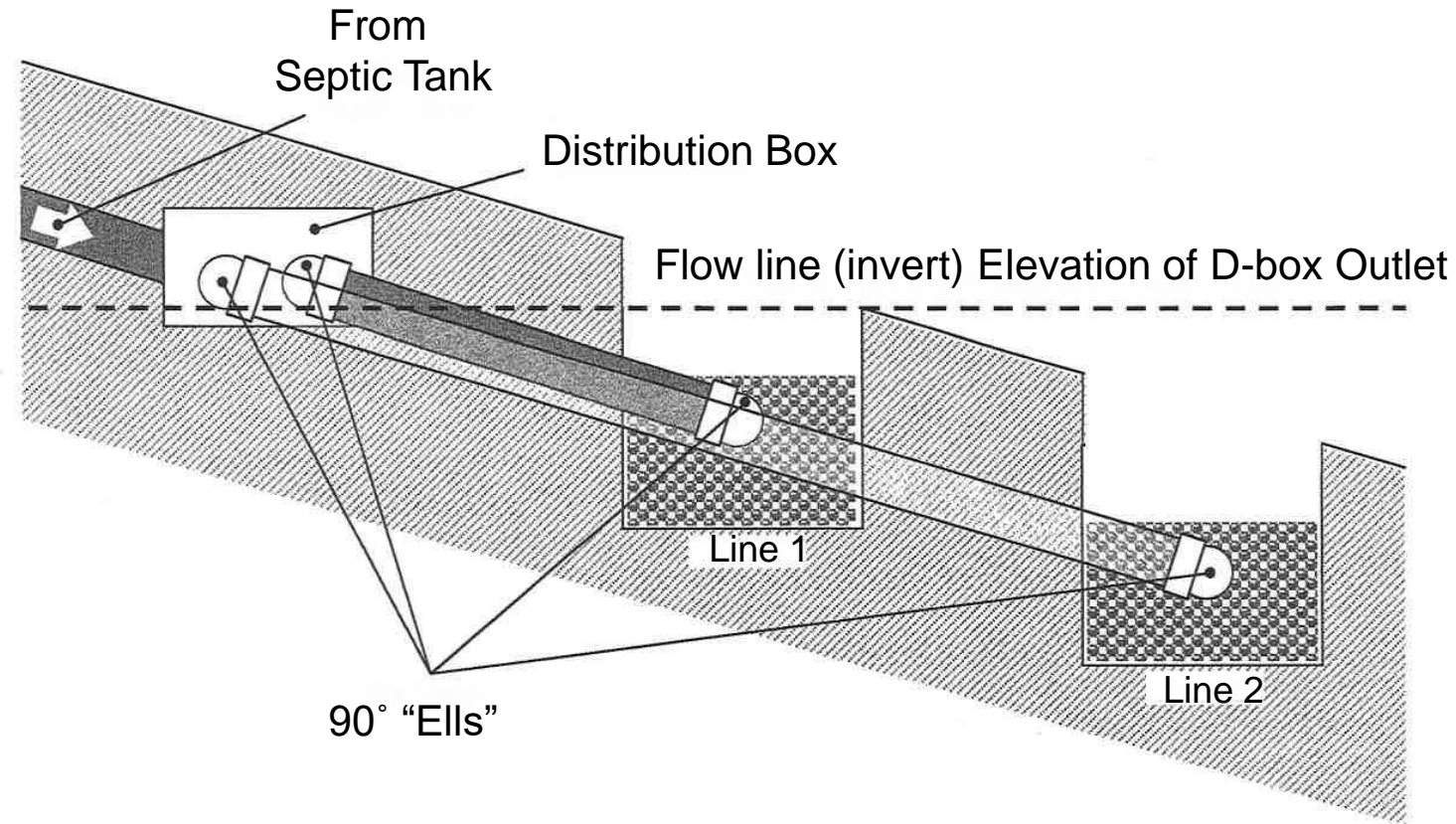
	G.E.
S.O.	1' 11"
TANK IN	2' 1"
TANK OUT	2' 3"
D-BOX IN	3' 6"
LINE ONE	4' 4"
BENCHMARK	4' 9"

Maximum Storage on Flat Ground



- The slope across the drain field starting from line 1 to the last line is < 6 inches.
- The outlet flow line of the septic tank is at or above the highest ground elevation within absorption area.
- Distribution box height is not critical.

Maximum Storage on Sloping Ground



- Elevation change from line 1 to last line is ≥ 6 inches.
- Outlet flow line of D-box is at or above the ground elevation of line 1.

Max Storage Questions

1. What do we use to determine max storage on a flat ground?

Septic tank outlet flowline and GE of line 1

2. What do we use to determine max storage on sloping ground?

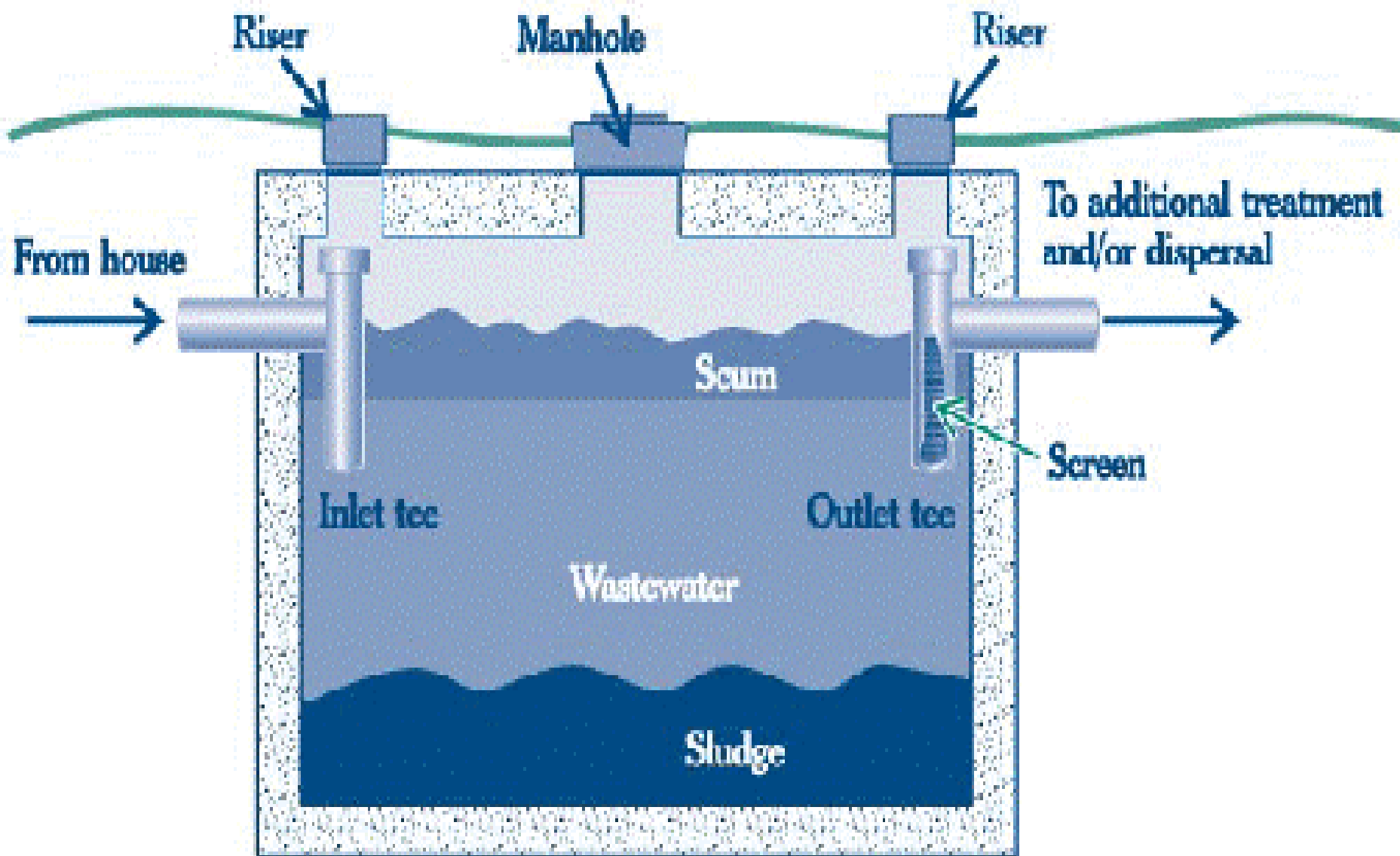
D-box outlet flowline and GE of line 1

3. On sloping ground, if the GE on line 1 is 4.6', what would be an acceptable d-box outlet flowline elevation? 4.4' 4.7'

4. On flat ground, if the GE on line 1 is 4.6', what would be an acceptable d-box outlet flowline elevation? 4.4' 4.7'

5. On flat ground, if the GE on line 1 is 4.6', what would be an acceptable tank outlet flowline elevation? 4.4' 4.7'

Typical single-compartment septic tank with ground-level inspection risers and screen



CALCULATING INSTALLATION DEPTH

The system design calls for the septic tank outlet to be installed at ground level. The outside dimensions of Ernie's 1000 gallon septic tank are:

Length 103 inches Width 54 inches Height 64 inches

Inlet height 55 inches Outlet height 52 inches

Include the gravel used to bed the tank (example 3 inches).

How deep should the tank hole be?

CALCULATING INSTALLATION DEPTH

$$\begin{array}{r} \text{Outlet height} \quad 52 \text{ inches} \\ \text{Gravel bedding} \quad + \quad 3 \text{ inches} \\ \hline 55 \text{ total inches} \end{array}$$

The tank hole needs to be 55 inches deep

SEPTIC TANK BAFFLES

Inlet & Outlet Baffles Supplied By Manufacturer

Check For Correct Length

Inlet Baffle

Measure Drop between Tank Inlet & Outlet

Add 6 Inches

Outlet Baffle

Measure From Floor of Tank to Bottom of Outlet

Multiply by 0.35 or 0.45

- HINTS:**
- 1. Do All Measurements In Inches**
 - 2. Flow Line Means Bottom of Pipe**

EXAMPLES

Inlet Baffle

3 inch drop across tank + 6 inch baffle length = 9 inches

Outlet Baffle

43 inches floor of tank to outlet X 0.35 = 15.0 inches

OR

43 inches floor of tank to outlet X 0.45 = 19.4 inches

Outlet baffle may be between 15.0 & 19.4 inches

! HINT: Do All Measurements In Inches !

CALCULATING TANK VOLUME

The inside dimensions of Ernie's rectangular septic tank are:

Length 97 in. Width 48 in. Height 59 in.

Inlet height 52 in. Outlet height 50 in.

What is the volume of this entire septic tank?

CALCULATING TANK VOLUME

$$\text{Volume of Water (gallons)} = \frac{\text{Inside Length} \times \text{Inside Width} \times \text{Liquid Depth}}{231 \text{ inches}^3 / \text{gallon}}$$

$$\text{Volume of Water} = \frac{97 \text{ in.} \times 48 \text{ in.} \times 50 \text{ in.}}{231 \text{ in.}^3 / \text{gallon}} = \frac{232,800 \text{ in.}^3}{231 \text{ in.}^3 / \text{gallon}}$$

$$\frac{232,800 \text{ in.}^3}{231 \text{ in.}^3 / \text{gallon}} = 1007.8 \text{ gallons}$$

CALCULATING ROUND TANK VOLUME

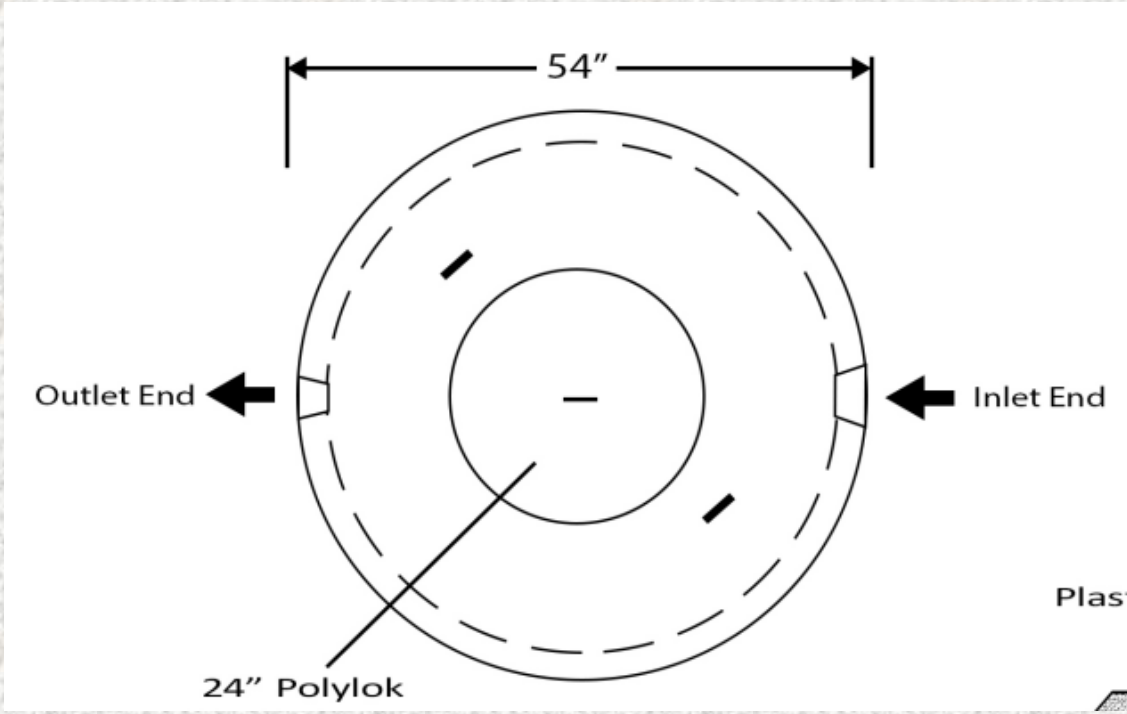
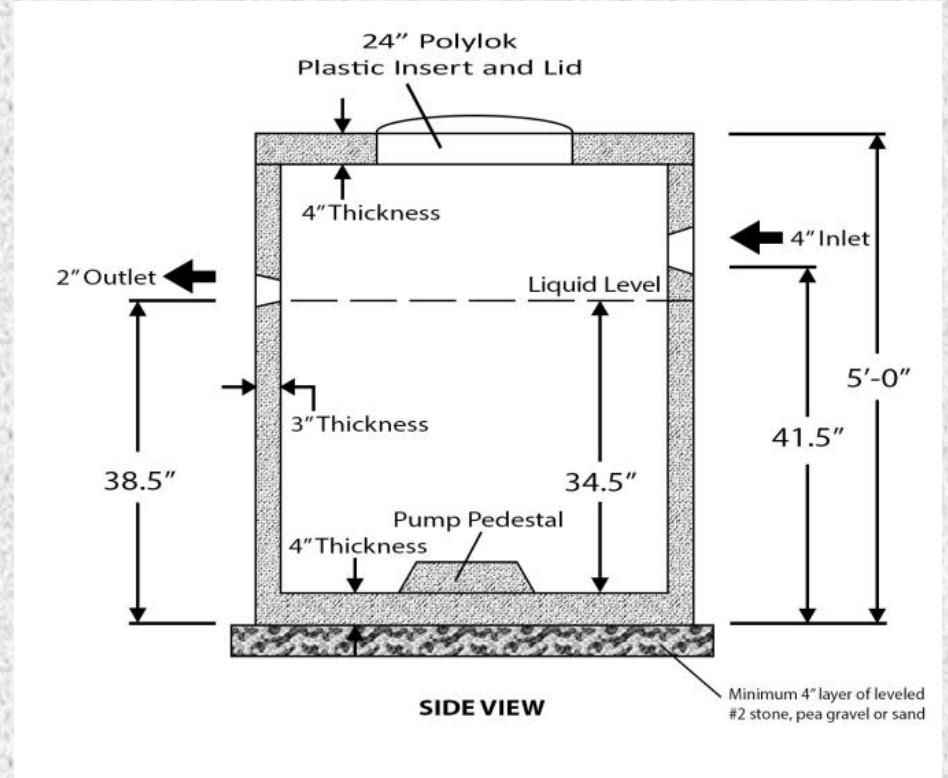
The inside dimensions of Ernie's round dose tank are:

Diameter: 54"

Height 52"

Inlet height 38"

Outlet height 35"



CALCULATING ROUND TANK VOLUME

$$\text{Volume of Water (gallons)} = \frac{\pi (\text{pi}) \times \text{radius}^2 \times \text{Liquid Depth}}{231 \text{ inches}^3 / \text{gallon}}$$

$$\text{Radius} = \frac{1}{2} \text{ diameter or } r = 27'' \quad \pi \approx 3.14$$

$$\begin{aligned} \text{Volume of Water} &= \frac{3.14 \times 27^2 \text{ in.} \times 35 \text{ in.}}{231 \text{ in.}^3 / \text{gallon}} = \frac{80,117 \text{ in.}^3}{231 \text{ in.}^3 / \text{gallon}} \\ &= \frac{80.117 \text{ in.}^3}{231 \text{ in.}^3 / \text{gallon}} = 346.8 \text{ gallons} \end{aligned}$$

CALCULATING WATER DEPTH

The inside dimensions of Ernie's 1000- gallon rectangular septic tank are:

Length 97 in. Width 48 in. Height 59 in.

Inlet height 52 in. Outlet height 50 in.

The installation instructions provided with the tank indicate a minimum of 350 gallons of water is needed as a ballast (*In case of a rain event or high seasonal water tables, prevents the tank from "floating"*).

What is the minimum depth of water needed to meet this requirement (in inches)?

CALCULATING WATER DEPTH

$$\text{Volume of 1 inch of Water (gallons)} = \frac{\text{Inside Length} \times \text{Inside Width} \times \text{Depth}}{231 \text{ inches}^3 / \text{gallon}}$$

$$1 \text{ Inch of volume} = \frac{97 \text{ in.} \times 48 \text{ in.} \times 1 \text{ in.}}{231 \text{ in.}^3 / \text{gallon}} = 20.2 \text{ gal.}$$

$$\frac{350 \text{ gallons}}{20.2 \text{ gal.} / \text{in}} = \underline{17.3 \text{ in. depth}}$$

DOSE DRAWDOWN CALCULATIONS

(Rectangular tank) – Calculating water volume in 1” depth

Tank dimension (inside): 60 in. (long) X 36 in. (wide) X 44 in. (deep)

$$1'' \text{ of water volume} = 60 \text{ in.} \times 36 \text{ in.} \times 1 \text{ in.} = 2160 \text{ in}^3$$

$$2160 \text{ in}^3 \div 231 \text{ in}^3 / \text{gallon}$$

$$1 \text{ inch} = 9.35 \text{ gallons per inch}$$

If dose volume is 30 gallons, how many inches should drawdown be each dose cycle?

$$30 \text{ gal (dose)} \div 9.4 \text{ gal/in} = 3 \text{ inch drawdown}$$

HINT: Do All Measurements In Inches

DOSE DRAWDOWN CALCULATIONS

(Round tank) – Calculating water volume in 1” depth

Tank dimension (inside): 50” in diameter x 44 in. (deep)

$$\text{Volume} = \pi r^2h$$

$$V = 3.14 \times 25^2 \times 1$$

$$V = 3.14 \times 625 \times 1$$

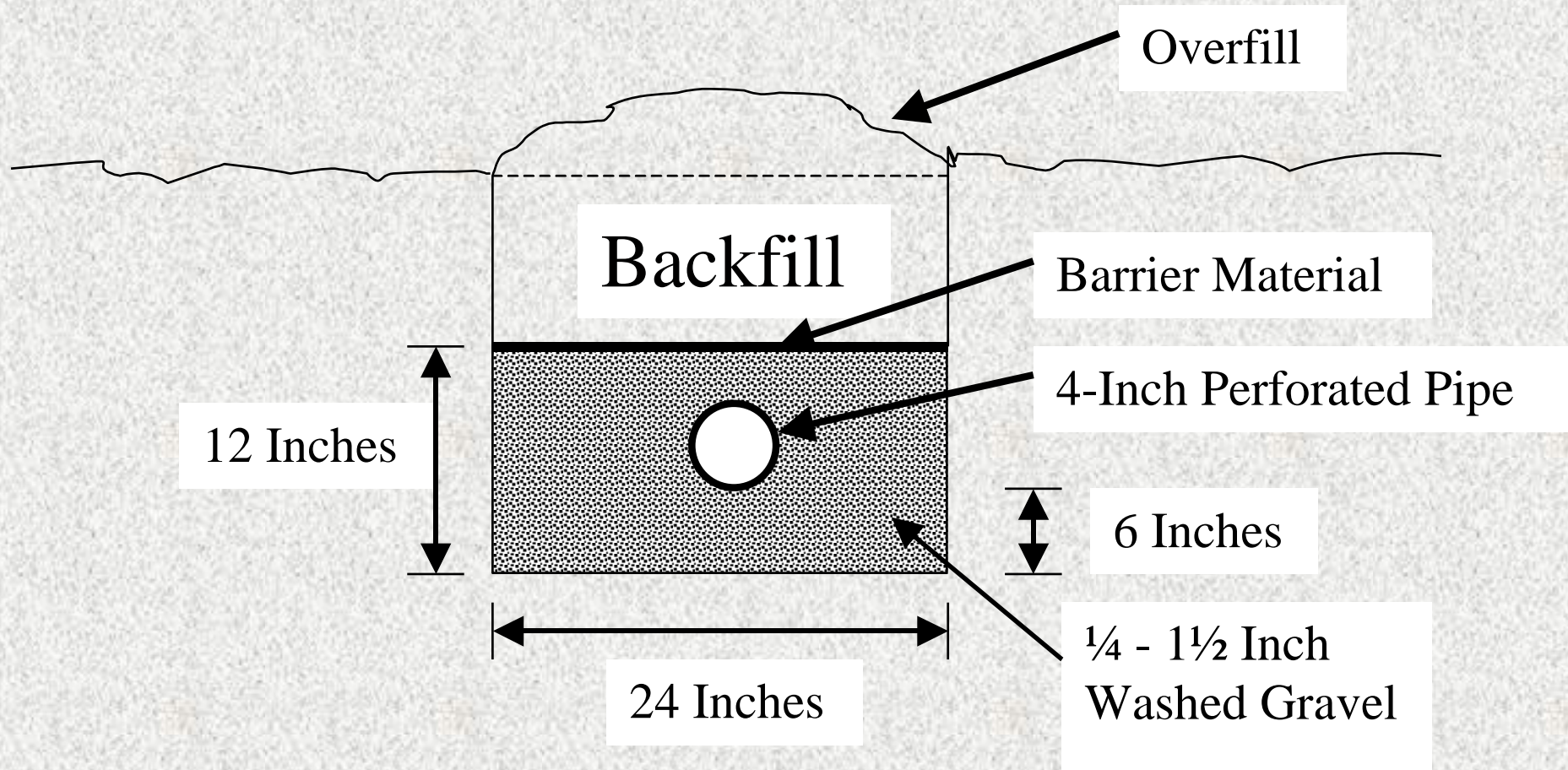
$$V = 1962.5 \text{ in}^3$$

$$V = 1963 \text{ in}^3 \div 231 \text{ in}^3 / \text{gal} = 8.49 \text{ gal} / \text{inch}$$

If dose volume is 30 gallons, how many inches should drawdown be each dose cycle?

$$30 \text{ gal dose} \div 8.5 \text{ g} / \text{in} = \mathbf{3.5 \text{ inch drawdown}}$$

ABSORPTION TRENCH CROSS-SECTION



TRENCH GRAVEL VOLUME

$$\begin{array}{ccccccc} \text{Number of} & \times & \text{Length in} & \times & 2 \text{ ft.} & \times & 1 \text{ ft.} & = & \text{Volume in} \\ \text{Trenches} & & \text{ft. of} & & \text{trench} & & \text{gravel} & & \text{Cubic} \\ & & \text{Trenches} & & \text{width} & & \text{depth} & & \text{Feet (ft}^3\text{)} \end{array}$$

$$\begin{array}{ccccccc} \text{Volume in} & & & & & & \text{Minimum} \\ \text{Cubic} & \div & 27 \text{ ft}^3 / \text{Yard} & = & & & \text{Required} \\ \text{Feet} & & & & & & \text{Number of} \\ & & & & & & \text{Yards} \end{array}$$

EXAMPLE

Design States 4 Absorption Trenches @ 100 Feet Long

$$4 \text{ trenches} \times 100\text{ft} \times 2\text{ft} \times 1\text{ft} = 800 \text{ ft}^3$$

$$800 \text{ ft}^3 \div 27 \text{ ft}^3/\text{yd} = 29.6 \text{ yards}$$

This Is The Minimum Amount, Get Extra For:

Spillage

Bedding Tank(s)

Math Worksheet Problems

MATH WORK SHEET

(Be able to work these types of problems for the math section of the exam)

(Answers on the following page)

Note: *Formulas will be provided for exam.*

Septic Tank Dimensions

Inside of Tank

Length 102"

Width 57"

Inside bottom of tank to outlet flow line 44"

Outside of Tank

Length 108"

Width 63"

Height 66"

Bottom of tank to inlet flow line 51"

Bottom of tank to outlet flow line 48"

D-Box Dimensions (Distribution Box)

Outside of D-Box

Depth 15"

Bottom of D-Box to inlet flow line 6"

Bottom of D-Box to outlet flow lines 4"

Absorption Trench Dimensions

Rock and Pipe Configuration

24" Wide x 18" Deep

Inlet Tee - a.k.a. Sanitary Tee or Baffle

Outlet Tee - a.k.a. Sanitary Tee or Baffle

***All "elevation" references are to be considered "rod readings".**

1. What is the depth, in inches, of a septic tank hole, if the top of the tank is to be at ground level?

Note: On this tank hole, you will have to add 2" of gravel for bedding the tank.

2. What is the depth, in inches, of the septic tank hole, if the outlet flow line is at ground level?

Note: On this tank hole, you must add 1" of gravel for bedding the tank.

3. What is the minimum inlet tee's length? (Measured from the tee's flow line)

***Remember the inlet tee should extend at least 6 inches below the liquid level in the tank.**

4. What would be the range (minimum/maximum) for outlet tee lengths? (Measured from the tee's flow line) ***Remember outlet tees should extend to a distance below the surface 35 to 45 percent of the liquid depth of the tank.**

5. What is the liquid volume in gallons of this septic tank?

6. If the liquid level in this tank drops one inch, how many gallons are lost?

7. The ground elevation at Field Line 1 is 3.25 feet, what is the trench bottom elevation in tenths?

8. In order to obtain maximum storage for field line 1 referenced in problem 7, what is the minimum elevation for the outlet of the D-Box flow line? **Note: The field line site is on a 10% slope.**

9. The elevation of the sewer stub-out flow line is 1'10" (1 foot 10 inches), what is the maximum allowable elevation reading at the septic tank inlet flow line with the tank being 10 feet from the stub-out?

10. What is the total liquid capacity of a round, cylinder-shaped dose tank that has a 72" liquid depth and diameter of 40"?

	Ground Elevation	Flow Line Elevation Require for Max Storage
Benchmark:	2' 3"	XXXXXXXXXXXXXXXXXX
Stub-Out:	3' 1"	2' 10" (assuming fall)
Tank Inlet	3' 3"	3'
Tank Outlet	3' 3"	3' 4"
D-Box	3' 4"	3' 10" (can vary)
Line 1	3' 4"	4' 10"
Line 2	3' 4"	4' 10"

1. Is system flat or sloping ground?

2. Tank outlet or d-box outlet determine max storage?

System specs:
 18" trench depth
 Trench bottom = flow-line
 2" fall across d-box
 4" fall across tank

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10. What is the total liquid capacity of a round, cylinder-shaped dose tank that has a 72" liquid depth and diameter of 40"?

Answers to Math Work Sheet problems:

1. 68"
2. 49"
3. 9"
4. 15.4 inches to 19.8 inches or 15 3/8 inches to 19 7/8 inches
5. 1107.43 gallons
6. 25.17 gallons
7. 4.75 feet
8. 3.25 feet
9. 2' 1/2" (2 feet 1/2 inch)
10. 391.48 gallons

To solve:

Problem 1, Use Outside of Tank, Height 66" + 2" of gravel = 68"

Problem 2, Use Outside of Tank, Bottom of tank to Outlet flow line 48" + 1" of gravel = 49"

Problem 3, Use Outside of Tank, Bottom of tank to Inlet flow line and Outlet flow line 51" - 48" = 3" difference. Add the require 6" into liquid level 6" + 3" = 9"

Problem 4, Use **Inside** of Tank, Bottom of tank to Outlet flow line 44"

Convert 35% to decimal form 35/100 = 0.35 Next Step, 44" x 0.35 = 15.4"

Convert 45% to decimal form 45/100 = 0.45 Next Step, 44" x 0.45 = 19.8"

Outlet tee length range (15.4" to 19.8"), as an example, an outlet tee 17" long, would be acceptable.

Problem 5, Use **Inside** Tank Length, Width and Liquid Depth

$$\frac{102'' \times 57'' \times 44''}{231 \text{ in}^3/\text{gallon}} = \frac{255816 \text{ in}^3}{231 \text{ in}^3/\text{gallon}} = 1107.43 \text{ gallons}$$

Problem 6, Use **Inside** Tank Length, Width and Depth of 1"

$$\frac{102'' \times 57'' \times 44''}{231 \text{ in}^3/\text{gallon}} = \frac{5814 \text{ in}^3}{231 \text{ in}^3/\text{gallon}} = 25.17 \text{ gallons}$$

Problem 7, Convert 18" (Trench Depth) into tenths 18 ÷ 12 = 1.5

Add to 3.25 (Ground Elevation of line 1) 3.25 + 1.5 = 4.75

Problem 8,

On sloping ground to achieve maximum storage for line 1, the outlet flow line of the Distribution box must be at or above the ground elevation of line 1. The ground elevation of line 1 is 3.25 feet.

Problem 9, Using 4-inch Schedule 40 solid pipe, follow the 1/8 to 1/4 inch fall per foot from the sewer stub-out to the inlet of the septic tank.

Convert 1/4" to decimal form (1 ÷ 4 = 0.25"); Multiply 0.25 by 10 feet (distance tank is from house)

0.25" x 10 = 2.5"; Add to 1'10" (Stub-Out flow line elevation) 1'10" + 2.5" = 2' 1/2"

Problem 10, Note: $(\pi \times r^2 \times h) / 231 \text{ in}^3 \text{ per gallon}$ is volume equation; r is the radius or half the diameter, h is height or liquid depth (72"), and $\pi \approx 3.14$. Radius (r) = 1/2 the diameter or r = 20.

$$\frac{\pi \times \text{radius}^2 \times \text{height}}{231 \text{ in}^3/\text{gallon}} = \frac{(3.14) \times (20 \text{ in})^2 \times 72''}{231 \text{ in}^3/\text{gallon}} = \frac{3.14 \times 400'' \times 72''}{231 \text{ in}^3/\text{gallon}} = \frac{90,432 \text{ in}^3}{231 \text{ in}^3/\text{gallon}} = 391.48 \text{ gallons}$$