Examine the attached drilling log and answer the following questions.

1. Determine the following:

   A. Surface elevation at the top of the well: 1161.37 ft
   B. Total depth of the boring: 55 ft
   C. Borehole diameter: 7 3/8" 4"
   D. Well assembly diameter: 4.37 ft
   E. Elevation at the base of the boring: 1153.37 ft
   F. Elevation at the base of the Pittsburgh Coal: 35.5 ft
   G. Depth at which groundwater was first encountered during drilling: 38 ft
   H. Depth of the static water level in the well on 6/23/89: 1125.87
   I. Drilling method: Air rotary
   J. Elevation at which groundwater was first encountered during drilling: 1135.37 ft
   K. Elevation of the static water level in the well on 6/23/89: 1121.97 ft
   L. Elevation of the bottom of the well screen: 1121.67 ft
   M. Elevation of the top of the well screen: 3.2 ft
   N. Composition of material packed around well screen: Course sand
   O. How far above the top of the well screen does the screen pack rise?: 3.2 ft
   P. Composition of material surrounding the solid PVC riser pipe: Cement/Cement Grout

2. Based on the drilling log, what lithostratigraphic unit likely serves as the aquifer providing water to the monitoring well? Gray Limestone @ 25 ft depth

3. Examine the position of the static water level vs. the encountered ground water level.

   A. What hydrostatic conditions are implied by this relationship? Confined / Artesian
   B. What type of aquifer condition exists? Is it unconfined / confined? What are the likely aquitards / aquifers? Confined, Gray Shale = Aquitard, Coal / Limestone = Aquifer

4. What is the relative porosity and permeability of the following lithostratigraphic units (describe as either "low" or "high" for each characteristic, refer to notes as needed).

<table>
<thead>
<tr>
<th></th>
<th>Porosity</th>
<th>Permeability</th>
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<tbody>
<tr>
<td>Pittsburgh Coal</td>
<td>High</td>
<td>Low</td>
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<tr>
<td>Upper Pgh Limestone</td>
<td>High</td>
<td>(Saturated)</td>
</tr>
<tr>
<td>Gray Shale below Pgh LS</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>L. Pgh Coal</td>
<td>Low</td>
<td>(Saturated)</td>
</tr>
<tr>
<td>Lower Pgh LS</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>
5. Examine the location of the screened interval in relation to the lithostratigraphy. In terms of ground water chemistry, would you think the well water to be on the alkaline or acidic side?

\[
\text{Acidic} \rightarrow \text{Ca}^2+ + \text{Fe}^3+ \left(\text{Pyrite}\right) + 3 \text{H}_2\text{O} \rightarrow \text{H}_2\text{S} + \text{Acid mine} + \text{H}_2\text{O}
\]

6. What type of groundwater chemistry would you expect in relation to the Pittsburgh Coal - alkaline or acidic?

Acidic

7. What would happen to the groundwater chemistry of the well (screened interval), if the cement-bentonite grout seal leaked around the solid PVC riser pipe?

Grout = Cement = High pH = Alkaline

8. What is cement made out of?? Would this material render water alkaline or acidic? What would be an extreme pH of the well water if some of the cement-bentonite grout leaked into the well screen during installation (by mistake)? What would be the easiest way to check for grout contamination in the field?

Lime-free, Alkaline, pH = 12-14, USE A pH meter

9. Common well construction calculations:

Some base expenses:

Drilling = $11.30 / linear ft; 4" PVC slotted screen = $5.00 / linear ft; 4" PVC riser = $3.00 / linear ft; cement-bentonite grout mix = $8.35 / 50# bag; bentonite pellets = $15.00 / 50# bucket; coarse sand = $7.50 / 50# bag; fine sand = $5.45 / 50# bag; 10" steel casing = $23.50 / linear ft.

Assume the following in your calculations:

i. 50# bag of cement-bentonite grout mix fills 0.5 ft³ of volume
ii. 50# bucket of bentonite pellets fills 0.8 ft³ of volume
iii. 50# bag of coarse sand fills 0.3 ft³ of volume
iv. 50# bag of find sand fills 0.2 ft³ of volume

Some preliminary questions and hints:

i. Does a drill hole most resemble a cube, sphere, cone, trapezoid, or cylinder? Cylindrical

ii. What is the equation to calculate the volume of the object in i. above? \( V = \pi r^2 h \) (hint look at beginning of notes)

iii. What is the diameter of the annular space between the walls of the bore hole and the outside of the PVC well assembly? Is it constant or variable throughout the assembly?

\[ D = 8 \text{ ft, } D_{\text{min}} = 9.875 \text{ in} \left(\frac{3}{12}\text{ in} \right) = \frac{0.822}{12} \text{ ft, } D_{\text{max}} = 7.875 \text{ in} \left(\frac{12}{12}\text{ in} \right) = \frac{0.66}{12} \text{ ft} \]

iv. How would you determine the volume of the annular space between the outside of the borehole and the outside of the PVC well assembly? Write a generalized equation.

\[ \text{Outer Diameter} - \text{Well Diameter} = \text{Annular Space} \]

\[ \frac{\text{Outer Diameter}}{2} \times \frac{1}{12} \text{ ft} \times \frac{1}{12} \text{ in} \]
Determine the following itemized construction costs for drilling and installing the monitoring well (refer to drilling / construction log). (Remember: when calculating volumes, make sure to use consistent length units)

A. Borehole drilling $L \times 50 \text{ ft} \times 23.5 \text{ ft} / \text{ft}$
B. 10" steel casing $L \times 8.9 \times 13.5 \text{ ft} / \text{ft}$
C. Solid PVC riser $L \times 52.00 \text{ ft} / \text{ft}$
D. Slotted PVC screen $L \times 0.25 \text{ ft} \times 11 \text{ ft} = 2.64 \text{ ft}^3$
E. Cement-Bentonite Grout in the 6" borehole at base of well $L \times \text{vol
**FORM 6**

**Borehole Number:** 11W-10-88

**Surface Elevation (F/MSL):** 1161.37

**Hole Diameter:** 7-7/8 inches, From 0 To 55.0 inches, From ____ To ____

**Total Depth:** 55.0

**Depth to Static Ground Water Level (SWL):** 26.5 (ft)

**Date SWL Measured:** 8/6/23

**Drilling Method:** Air Rotary (Injection Water at 40.0)

**Date Drilled:** 8/6/23 (yy/mm/dd)

**Drilled By:** Mark Duncan (Duncan Bros. Drilling)

**Logged By:** Karen Poosky (Murray Associates, Inc.)

**County:** Fayette County

**Township or Municipality:** German Township

<table>
<thead>
<tr>
<th>Depth (Ft)</th>
<th>Lithologic Description</th>
<th>Plot</th>
<th>Ground Water Observations</th>
<th>Samples</th>
<th>Recvr Alt</th>
<th>Comments</th>
<th>Well/Perforation Construction</th>
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<td>0.0</td>
<td>Brown Silty Clay</td>
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* * Encountered Ground Water  ▼ Composite Static Water Level  ** Recovered/Attempted

Use additional sheets with this format as necessary