Site Characterization of the GetWET Observatory at Colorado State University

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Abstract

The GetWET Observatory on Colorado State University (CSU) property consists of an educational groundwater well field that was drilled in spring 2006. Characterization of the groundwater well field was conducted in order to gain a better understanding of the subsurface material along with groundwater/surface water interactions. Core were collected from the six wells during drilling. Water table elevations of each well were measured in relation to Spring Creek to create a map of the water table and calculate hydraulic properties. The average hydraulic gradient was very low at about 1.25%. It was found, based on the direction of this gradient, that Spring Creek is an influent or losing stream. The thickness of the saturated subsurface aquifer ranges among the six wells from 0.83 m in GW3 to 2.02 m in GW1. This layer consists of mostly medium to coarse sand with some gravel. Groundwater discharge calculation yielded a value of 2.19×10^{-7} m^3/s per one meter length. These data are useful for an initial understanding of groundwater flow patterns and the interaction with Spring Creek. CSU students will continue to evaluate aquifer properties of the site in the coming semesters.

Introduction

The **G**round **W**ater **E**ducation and **T**eaching (GetWET) Observatory (Figure 1a and b) is an educational well field on the CSU campus. Six wells were drilled on April 19th-20th, 2006. The field is a small, relatively flat field immediately adjacent (south) of Spring Creek, which is a perennial stream. There are four wells (GW5, GW1, GW2, and GW3) that run north-south in the field, and two wells (GW4 and GW6) that are oriented east-west. The closest well to Spring Creek is GW3, while the furthest away is GW5 (Figure 2). Each well is about 5.85 m deep, with casing constructed of PVC pipe (Figure 1b). GW4 and GW6 are 16 m apart, while GW5 and GW3 are 15.35 m apart, and GW3 is approximately 5.9 m from the creek. Vegetation on the northwest side of the well field next to the creek consists of a few trees, while the rest of the vegetation is mostly grasses. The observatory was started for the purpose of giving CSU students a hands-on learning experience, and to provide local teachers with training workshops on groundwater. This project's objectives focused on a comprehensive characterization of the well field, including detailed description and analysis of the drilling cores, construction of a cross section of the wells and a water table map, and hydraulic conductivity/groundwater discharge calculations. The results from all of these tasks produced a profile of groundwater-surface water interactions in the well field. As the well field had never before been characterized, the characterization will provide a better understanding of the subsurface, the dominant flow paths for groundwater, and the interaction with surface water within Spring Creek.

Methods

Soil core were collected during drilling in a clear plastic sleeve. The drilling proceeded in 5-foot runs, with varying amounts of soil recovered in each run. A Dremel tool was used to cut open the sleeves lengthwise. Detailed descriptions of the cores involved

documenting details of specific soil color, texture, and saturation (moisture content). Pictures of the core processing are provided in the appendix.

A Munsell soil color chart (GSA, 1991) was used to describe color, and provided specific hue, chroma and saturation descriptors such as 10YR 5/4 (moderate yellowish brown) that were applied to different sections of each core. Texture descriptors used included silty clay, sandy clay, clay surrounded by sand, etc. Gravel content was also included in the texture descriptions. Saturation of the core material was one of the most important aspects of the analysis, along with grain size description. Saturation indicated thickness of the aquifer, while grain size determined the ease with which water flowed through the material.

Water table levels for each well were measured on June 22nd, 2006. They were used to construct the water table map, which yielded some slightly unexpected results.
The water table map was constructed using UTM (Universal Transverse Mercator) coordinates that were entered into a spreadsheet. Contour lines were then drawn at 0.05 m intervals according to water table levels measured at each well. Flow lines were also added in perpendicular orientation to the contour lines. These and the contour lines were used in gradient calculations, the results of which were used in other calculations that eventually yielded groundwater discharge (Q).

The equation used to calculate the hydraulic gradient was the difference in elevation between the two points (Δh, or h_1-h_2) divided by the distance between those two points (Δx, or x_1-x_2). This produced a unit-less number, which was then inserted into an equation that yielded a value for q (specific discharge) in meters per second (m/s):

$$q = K(\Delta h/\Delta x)$$

where K is hydraulic conductivity in m/s. Darcy's law is then solved as follows:

$$Q = Aq$$

where Q is groundwater discharge in m^3/s per meter length and A is the cross-sectional area through which the water flows, calculated by multiplying the length of the cross section (1 m) by the saturated thickness. As stated earlier, q is the value for specific discharge, calculated using the hydraulic gradient ($\Delta h/\Delta x$) multiplied by a chosen hydraulic conductivity (K), selected from Freeze and Cherry (1979) based on type of material through which the water is running.

Results

Results of the well core descriptions yielded some important observations regarding layers that continued across the wells. The first such observed layer was the black clay (Figure 2) that generally appears in the second run of each well, with the exception of GW6, where it appears near the top of the third run (Figure 2); the drilling advanced in 5-foot runs, with varying amounts of soil recovered in each run. This black layer is usually

surrounded by a thin layer of light to moderate brown clay or sand, and is sometimes mixed with that same color of clay. The black clay is often silty as well.

Another very important layer to the characterization of the well field was the sand and gravel that was found in every well (Figure 2). The wells that have gravel are GW5, GW1, GW2, GW3, and GW6. Sand was found in all six wells, always below the black clay. The first occurrence of sand is usually at the beginning of the third run, with the exception of GW5 and GW4. These two wells both show a first occurrence of sand in their second layer. Most of the sand encountered was at least damp, if not saturated, indicating that this is the layer through which more groundwater is flowing. The color of the majority of this material is about 10YR 5/4 (moderate yellowish brown), and the grain size ranges from some fine sand to mostly medium to coarse sand.
The third important layer was the weathered bedrock/bedrock layer (Figure 2). From the characteristics of this layer the bottom boundary of the saturated layer could be determined. If the clay was damp, then it was included in the saturated thickness. If it was drier and indurated, then it was characterized as bedrock. The bedrock is Cretaceous-aged Pierre shale, which most likely provides a good seal for the bottom of the saturated layer.

The water table elevations are listed in Table 1.

Table 1. Well elevations and corresponding water table elevations.

Well number	Elevation at top of casing (m)	Water table elevation (m)
GW5	1521.22	1.69
GW1	1521.29	2.15
GW2	1521.27	2.15
GW3	1521.16	2.15
GW4	1521.35	1.53
GW6	1521.08	2.77

Water table levels plotted on a map of the wells (Figure 3) indicate that the water table slopes gently away from Spring Creek. The average gradient between contours 1519.00 m and 1518.90 m is approximately 1% (Figure 3).

For specific discharge calculation, a K value of 10^{-5} m/s was used, taken from a chart in Freeze and Cherry (1979). This value corresponds with unconsolidated silty/clean sand. This is the material closest to the sandy layers encountered and described in the project. The calculations yielded a specific discharge value of approximately $1x10^{-7}$m/s for the middle flow line (Figure 3).

Groundwater discharge (Q) calculation yielded a value on the same order of magnitude as the specific discharge (q) calculation, because of the very small hydraulic gradient. The Q value calculated that corresponds with the value above for specific discharge is approximately $2x10^{-7}$ m^3/s, per one meter length. The saturated thickness for GW2 (Figure 2), the value used in this calculation, was 1.75 m.

Discussion and Conclusions

The data collected and the descriptions made in this project were the first to be done for the GetWET Observatory on the CSU campus. They allow for a more comprehensive understanding of the area, including the subsurface material, the water table level, and the relationship of these two aspects of the field to the water in the immediately adjacent Spring Creek.

The first and most important relationship observed was that between the sand and gravel layer and the water table. It was observed that the first appearance of sand in each well corresponded closely with the level of the water table in that well. This is logical, as it is known that water flows more easily through material that has larger (and connected) pore spaces, as sand and gravel do because of their larger grain size compared to silt and clay (Fetter 1994).

Another observation made was that the black clay generally appeared in the second run (1.23 m to 2.77 m) of each well. It also seemed to appear near the water table most of the time. This could be due to moisture, which may cause weathering and produce a black color. This correlation could also indicate a zone in which alternating processes of reduction and oxidation have occurred, indicates a zone through which the water table level fluctuates.

The last major observation that was made had to do with the bedrock. The first appearance of bedrock in each well tended to be weathered and significantly mottled, and usually with the same colors (olive gray with dusky yellow or similarly colored mottles). This weathering was most likely due to contact with the aquifer. As depth increased, however, the bedrock became less weathered and mottled, as well as less moist (and harder). The color was usually close to olive gray.

The water table levels were most important for hydraulic gradient calculations. They also allow for determination of the interaction between groundwater and surface water, especially whether Spring Creek is influent or effluent. It had been initially assumed that Spring Creek was an effluent stream, meaning water would be flowing into it; this would be indicated by water table elevations that sloped down towards the level of the creek. However, it was discovered that this was not the case. Contrary to initial assumptions, the creek was discovered to be influent, meaning that the water from the creek was flowing into the groundwater. The general topography of the region tends to slope in the same direction as the flow lines and Spring Creek is also receiving irrigation return flows during the period of measurement.

When hydraulic gradient was calculated, it was observed that it is very low, which implies that the water was probably not moving very quickly through the aquifer (sand and gravel); the water table is relatively flat, and subtly mimics the topography of the well field. Specific discharge and groundwater discharge calculations yielded values that confirmed this inference. Indeed, the water is moving at about 15 m/year. It must be

noted that clay (bedrock) layers, if measured, most likely would have had much lower discharge values.

Any error in measurements or calculations in this project was human error. Therefore, some of the values, such as distance between contour lines, may be slightly different if measured again by another scientist.

The GetWET well field characterization produced by this study provides some important information for CSU students and local teachers. Descriptions of the subsurface material allow inferences to be made regarding groundwater activity as well as its interactions with Spring Creek. This could be applied to other measurements during different times of the year. Further research could be done in a different season to see whether or not the state of the stream (influent or effluent) would be different. This would be interesting to study, since the measurements for this project were made during the summer, which has been dry and has followed an exceptionally dry spring season. However, Spring Creek has also been receiving more irrigation water and adding to the groundwater system. More research could also be done to either confirm or refute the results obtained from this project. That is, it would be beneficial to have more data from other times of the year, as well as other years entirely, so determinations could be made as to whether or not there is a pattern with regard to interactions between Spring Creek and the groundwater.

References

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Figures

Figure 1a. An aerial photo of the well field and surrounding area. The well field is the area enclosed by the red circle.

Figure 1b. GetWET Observatory looking northwest. The groundwater wells are encased in steel risers with locking caps.

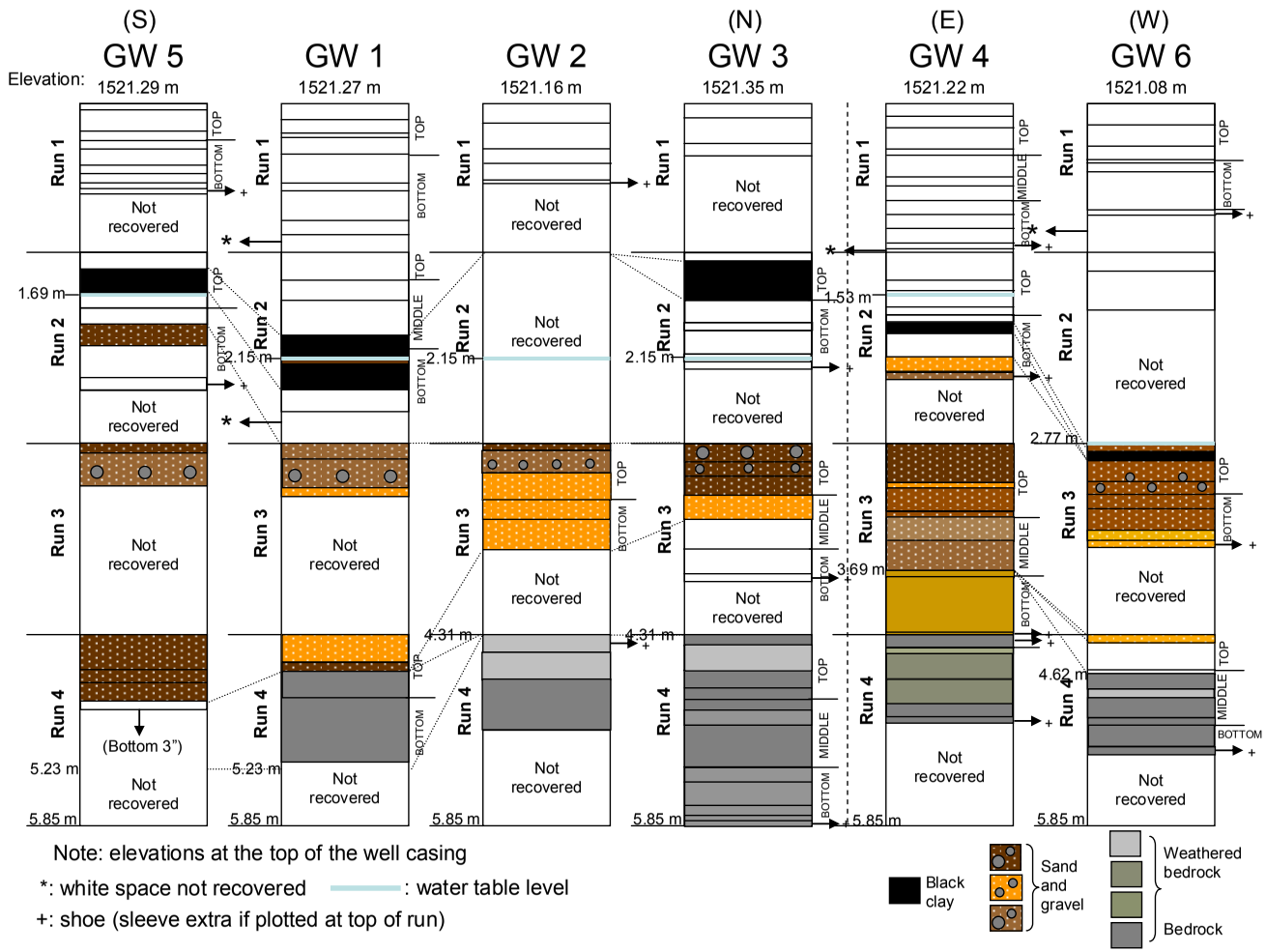

Figure 2. Cross sections of core collected from each well. Layers correlated between wells where possible using dashed lines. Although GW2 does not show a black clay layer (because of lack of recovery in Run 2), the logs taken during drilling indicate that there was a black clay present.

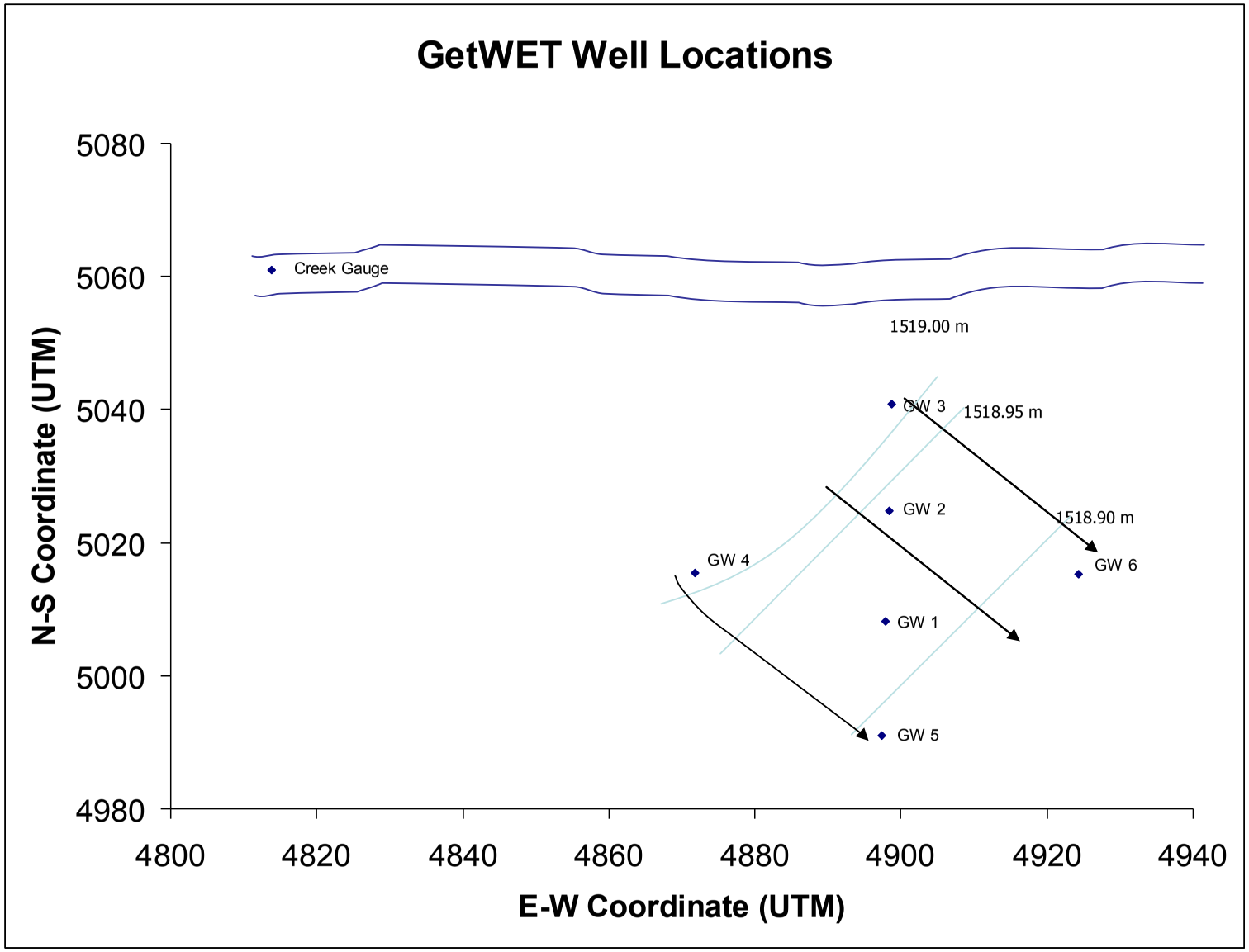

Figure 3. Well locations at the GetWET Observatory. The flow lines are approximated, but have been drawn perpendicular to the contour lines, which have been drawn at 0.05 m intervals based on water table elevations from each well.

Appendix

An example of one of the cores still encased in the sleeve.

The process of cutting open the core's plastic sleeve.

Spring Creek GetWET
Well drilling core descriptions

Drilled April 19-20, 2006
Drillers Engineers, Inc.
8.25" OD
4.25" ID Auger
5 foot increments
Split spoon

GW 1
Run 1 (0-4')

Top

0-8 cm: many roots; mostly small, subangular blocky aggregates (fine-grained when crushed); color: 10YR 4/2 (dark yellowish brown)
8-16 cm: small, angular to subangular blocky aggregates (fine-grained when crushed); color: 10YR 4/2; <10% gravel (mostly ≤1 cm), one larger chunk (~ 3½ cm)
16-28cm: 10YR 5/4 (moderate yellowish brown) with some dark mottling; large chunks (~ 4 cm)- high clay content; <10% gravel; any aggregates (not many) are small to medium, angular to subangular blocky (fine-grained when crushed)
28-33 cm: slightly coarser grains; ~ 10-20% gravel; ~ 10YR 5/4 (moderate yellowish brown); some coarser sand, some silt
33-46 cm: 10YR 6/2 (pale yellowish brown) with some pink (k-spar?); 10R 7/4 (moderate orange pink); <10% gravel; fine- to medium-grained; angular to subangular blocky w a couple of rounded small pebbles

Bottom

0-8 (46-54) cm: aggregates larger (~½ - 2 cm), subangular blocky; one larger cobble (9 cm diameter at widest, 3-3½ cm thick)- gneiss?- dark, finely crystalline rock with small white bands; 10YR 4/2; very little (if any) clay; fine sand and silt; gravel <10%
8-13 (54-59) cm: fine sand and silt, more clay; one large (~ 4 cm thick) aggregate (8-11 cm: 5Y 5/2 light olive gray, 11-13 cm: 10R 6/6 moderate reddish orange); material underneath aggregate similar to 0-8 cm in color, size, etc.
13-16 (59-62) cm: four larger (2½ - - 4½ cm) aggregates, rest of aggregates ≤ 1½ cm, subangular blocky; two colors: 10YR 4/2, 10R 6/6 (oxidization?); very few fine roots; fine sand and silt
16-23 (62-69) cm: same two colors as 13-16 cm, though more of the 10R 6/6; clay; little fine sand/silt (all stuck together); one or two fine roots
23-47 (69-93) cm: 10YR 4/2; clay; almost no fine sand (some silt?); a couple of small 10R 4/6 (medium reddish brown) spots; some black spots
47-59 (93-105) cm: more sand; ≤10% gravel; subangular blocky, small aggregates; ~ 10YR 5/4; some (little) black and pink spots

Shoe Sample
Mottled; some oxidization; two main colors: ~10YR 4/2, 5Y 6/4 (dusky yellow); mostly clay, some fine silt

Run 2 (4-9')

Top
0-21(105-126) cm: mostly clay with some silt and little organic material; 10YR 4/2; a couple of very small oxidized spots and a couple of very small black spots

Middle
0-16 (126-142) cm: clay; some (very little) organic material; some oxidization; 10YR 4/2 (dark yellowish brown); good ribbon
16-40 (142-166) cm: mostly 5YR 6/4 (light brown) on fresh surface, but some 10YR 4/2; clay with very little organic material; good ribbon; unclear boundary
40-50½ (166-176½) cm: black on fresh surfaces, but even deeper mottling (includes black clay and 10YR 5/4 sandy clay) is present; clay (good/decent ribbon formed); slightly different smell than rest; clear boundary

Bottom
0-7 (176½ - 183½) cm: black clay with some silt
7-12 (183½-188½) cm: mostly sand with very little clay; 10YR 4/2; little mottling with black
12-32 (188½-208½) cm: moist- clay gives a little when pressed; very little silt- almost all clay (good ribbon formed); outer layer around black ~½ cm; mixture of two colors: 5YR 6/4 (light brown), ~ 10YR 4/2
32-50½ (208½-227) cm: very clear boundary (color); ~ 10YR 5/4

Shoe Sample
Clay; 10YR 5/4

Run 3 (9-14')

0-9 (227-236) cm: wet; medium coarse sand; <10% gravel; overall color between 5YR 4/4 (medium brown) and 10YR 5/4 (moderate yellowish brown)
9-26 (236-253) cm: ~ 50% gravel; overall color approximately the same as 0-9 cm; some of gravel is pink (k-spar?); some quartz gravel
26-30½ (253-257½) cm: same overall color; slightly finer texture; ~1/3 gravel?
30½-40 (257½-267) cm: finer texture with some clay; <1/3 gravel (10-20%?); 5YR 5/6

Shoe Sample
Sand and gravel with little clay; 10YR 5/4; ≥50% gravel

Run 4 (14-19')

Surface sample
Gravel (average size of ~ 3 cm)

Top
0-21 (267-288) cm: wet; 5YR 5/6 (light brown); fine to medium sand
21-28 (288-295) cm: transition; 10YR 4/2 (dark yellowish brown); almost no gravel (finer texture)
28-48 (295-315) cm: clay; 5Y 3/2 (olive gray); mottles: 5Y 6/4 (dusky yellow)

Bottom
0-45 (315-360) cm: clay; 5Y 3/2 with mottles of 5Y 4/4 (moderate olive brown); firmer than top (less moisture?)

Shoe Sample
Very fine clay; 5Y 3/2

GW 2

Run 1 (0-4')

0-4 cm: organic material; common fine roots; mostly silt, maybe some clay or very fine sand; 10 YR 5/4 (moderate yellowish brown)
4-14 cm: 10 YR 5/4; some aggregates-angular to subangular blocky, ~ 1 cm on average; <10% gravel; mostly silt; one medium root
14-23 cm: between 5YR 6/4 and 5YR 5/6 (light brown); more solidified (massive) than 0-4 and 4-14 cm; silty, but much more clay; aggregates subangular blocky; <10% gravel
23-34 cm: silty; about same amount of clay as 14-23 cm; 10YR 4/2 (dark yellowish brown); gravel- slightly more, but still <10%; some dark (black) spots, but doesn't look quite like mottling
34-43 cm: more clayey; silt still present; <10% gravel; any aggregates are slightly larger, but mostly massive, subangular blocky; 10YR 5/4
43-51 cm: mostly clay; some white spots; some small pieces of black material, one coarse chunk (coal?); mixture (mottling?) of 10 YR 4/2 and 10YR 5/4; massive
51-57 cm: clay; mottling: spots of ~10YR 5/4 and 10YR 4/2 in (between 10R 6/6 moderate reddish orange and 10R 4/6 moderate reddish brown); massive

Shoe Sample
Massive; clay with mottling (10YR 4/2 with spots of white and 10R 4/6)

Run 2 (4-9')

NO RECOVERY

Run 3 (9-14')

Top
0-5 (57-62) cm: wet; fine to medium sand with some silt and/or clay; some dark spots- gleying??; 10YR 5/4
5-15 (62-72) cm: wet; more clayey- somewhat sticky to the touch; ≤10% gravel; 5YR 6/4 (light brown)

15-23 (72-80) cm: gleying; less clayey than 5-15 cm; ~20-30% gravel; main color 5YR 6/4
23-45 (80- 102) cm: almost all coarse sand with very little clay or silt; 10 YR 6/6 (dark yellowish orange)

Bottom
0-16 (102-118) cm: wet; medium coarse sand (slightly finer than 23-45 cm) with little silt or clay; <10% gravel; 10YR 6/6 with very slight pinkish tint
16-45 (118-147) cm: 10 YR 6/6; wet; medium coarse sand with more clay (a little muddier); ~ 10% gravel

Shoe Sample
Wet; ~ 30% gravel; medium coarse sand; 10 YR 6/6; some (little) clay- slightly muddy

Run 4 (14-19') - soft bedrock
0-2 (118-120) cm: sandy with ~ 10% gravel; 5Y 5/2 clay inside
2-21 (120-139) cm: clay with some sand around outside (brought down from previous section?); clay color 5Y 5/2 (light olive gray) with mottles of 5Y 6/4 (dusky yellow); weathered bedrock
21-45 (139-163) cm: clay; some 5YR 4/4 (medium brown) clay around outside (≤ ~½ cm); 5Y 3/2 (but grayer) with mottles of 5Y 6/4; weathered bedrock
45-63 (163-181) cm: 5Y 3/2 is closest, but clay is slightly darker and grayer; mottles of 5Y 6/4; less weathered than previous layers of run 4

Shoe Sample and Sample Extruded From Sleeve
Mottling: ~5Y5/6 (light olive brown) mottles in clay that's about the same color as 45-63 cm; some oxidization on the end; smaller chunks are grayer, a little lighter

GW 3
Run 1 (0-4')
0-6 cm: 10YR 5/4; some organic material; massive; <10% gravel; piece of metal- reddish, ~ 3 cm at widest; some clay, silt
6-11 cm: small (usually ≤½ cm), subangular blocky aggregates, a few larger (3 cm) ones; silt; less clay; very little fine sand; a little lighter than 10 YR 4/2 (dark yellowish brown)
11-33 cm: some larger (coarse- ≤ 1½ cm) angular to subangular blocky aggregates; mostly massive; <10% gravel; one medium root; some white areas; clay with some silt; 5 YR 5/6 (light brown); looser stuff is close to 10YR 4/2
33-42 cm: ~ 10% gravel; some coarse sand; some coarse (2-3 cm) subangular blocky aggregates; mostly loose granules or smaller aggregates; one 7 cm - wide chunk; overall ~ 10YR 4/2

Sleeve Extra
One 7 cm chunk, one 5½ cm chunk; ~ 10% gravel; rest is subangular blocky and granular aggregates; one medium root; fair amount of clay (especially in aggregates and chunks); some sand; more silt; ~10YR 4/2, but grayer

Run 2 (4-9')

Top
0-8 (42-50) cm: slightly darker than 10YR 4/2; one spot of sand (~ 3 cm wide, slightly more yellow than 10YR 5/4 (moderate yellowish brown); clay with some sand
8-31 (50-73) cm: silty clay with little sand; different smell (like GW 1 Run 2 middle); 10YR 2/2 (dusky yellowish brown) to almost black; ribbon formed; some fine mica flakes; around outside: ~ ¼ cm 10YR 4/2 (but slightly browner) clay with sand
31-42 (73-84) cm: more sandy (sand is a little darker than 10YR 5/4); little organic material; layer outside ~ 1-2 mm (same color as layer on 8-31 cm); rest of clay is 10YR 2/2 to black; ribbon formed

Bottom
0-17 (84-101) cm: ribbon formed; closest to 10YR 2/2 (but grayer); clay with some silt, little sand
17-25 (101-109) cm: much sandier; slightly grayer than 10YR 5/4; 10-20% gravel; still clayey; some (grayer than 10YR 2/2) clay
25-44 (109-128) cm: in between 5YR 5/6 (light brown) and 10YR 5/4 (moderate yellowish brown); clay; some black spots
44-46 (128-130) cm: 10 YR 6/6; clay with some black spots
46-49 (130-133) cm: closest to 5Y 5/2 (light olive gray) but a little grayer (less green); clay with black spots
49-51 (133-135) cm: ~10YR 5/4; clay with a couple pieces of gravel

Shoe Sample
10YR 5/4 with slight pinkish tint; clay with some sand

Run 3 (9-14')

Top
0-15 (135-150) cm: wet; 5YR 4/4 (moderate brown); sandy clay with a couple of cobbles; ~10% gravel
15-25 (150-160) cm: wet; ~30% gravel; rest is very sandy clay; 5YR 4/4
25-41(160-176) cm: sandy clay; 5YR 4/4 but a little pinker; <10% gravel

Middle
0-19 (176-195) cm: ~5YR 5/6 (light brown) but a little more yellow; 20-30% gravel; one cobble ~8 cm; rest is fine to coarse sand with some clay
19-21 (195-197) cm: sandy clay (much more clay); ~5YR 6/4 (light brown)

21-41(197-217) cm: gleying (?); clay- good ribbon; trace of 5YR 6/4 clay around outside; mottled: 10Y 6/2 (pale olive) but slightly grayer, and 5Y 5/6 (light olive brown)

Bottom
0-41(217-258) cm: gleying (?); clay- good/decent ribbon; mottling: 10Y 6/2 (pale olive) but slightly grayer, and 5Y 5/6; trace of 5Y 4/4 (moderate brown) clay around outside

Shoe Sample
Clay- good/decent ribbon; mottling: 5Y 5/6 (light olive brown) and 5Y 5/2 (light olive gray); very little organic material

Run 4 (14-19')

Top
0-8 (258-266) cm: mottles: ~5Y 4/4 (moderate olive brown) but a little browner; 5Y 3/2 but grayer, not quite as dark; clay (weathered bedrock); good ribbon
8-27(266-285) cm: clay (weathered bedrock); slightly more mottling; mottles: 5Y 5/6 (light olive brown) but a little browner; overall color mostly 5Y 5/2 (light olive gray); good ribbon
27-41(285-299) cm: clay (weathered bedrock); good ribbon; mottles 5Y 5/6 but a little browner); overall color 5Y 3/2 (olive gray) but grayer
41-51(299-301) cm: clay (weathered bedrock); good ribbon; less mottling (=less weathered?); mottles: 5Y 4/4 (medium olive brown) but a little browner; overall closest to 5Y 3/2 but grayer and a little darker

Middle
0-10 (301-311) cm: clay (weathered bedrock); good ribbon; small amount of fine sand ~10YR 5/4 (moderate yellowish brown); mottles: ~5Y 5/6 (light olive brown); overall color: 5Y 3/2 but a little lighter
10-18½(311-319½) cm: clay (weathered bedrock); good ribbon; between 5Y 5/2 (light olive gray) and 5Y 3/2 (olive gray) but a little browner; mottles: ~5Y5/6; trace of ~10YR 5/4 clay around outside
18½-52(319½-353) cm: 5Y 3/2 but a little lighter and grayer; mottles ~5Y 5/6 but slightly browner; clay (weathered bedrock); good/decent ribbon

Bottom
0-5 (353-358) cm: clay (weathered bedrock); good/decent ribbon; small amount of fine sand (10YR 5/4- moderate yellowish brown) on outside; mottles: 5Y 5/6; between 5Y 5/2 and 5Y 3/2
5-11 (358-364) cm: clay (weathered bedrock); good/decent ribbon; mottles: 5Y 5/6; 5Y 3/2 but a little lighter and grayer
11-31 (364-384) cm: clay (weathered bedrock); slightly more mottling- 5Y 5/6 but browner; 5Y 3/2 but grayer; good/decent ribbon

31-40 (384-393) cm: clay (weathered bedrock); good/decent ribbon; almost no mottling; any mottles are small, 5Y 4/4 (moderate olive brown)- hard to tell because of faintness and size
40-47 (393-400) cm: clay (weathered bedrock); good ribbon; more mottling: 5Y 5/6 but a little browner
47-52 (400-405) cm: almost no mottling; clay (weathered bedrock); good ribbon; any mottles close to 5Y 6/4 (dusky yellow) but hard to tell because of faintness and size; 5Y 3/2 but a little grayer

Shoe Sample
Mottles ~5Y 4/4; 5Y 3/2 but slightly grayer; clay (weathered bedrock); good/decent ribbon

GW 4
Run 1 (0-4')

Top
0-10 cm: some organic material (few medium roots, few fine roots); closest to 10YR 6/2 (pale yellowish brown); <10% gravel; fine to coarse angular to subangular blocky; silt and clay, not much sand
10-18 cm: massive; 10YR 5/4 (moderate yellowish brown) with some 5YR 6/4 (light brown); slightly more sand (?)
18-33 cm: mostly massive (any aggregates fine, subangular blocky); overall color closest to 10YR 4/2 (dark yellowish brown); other colors: spots of black, white material, a few 10R 6/6 (moderate reddish orange) spots, a couple of slight 5Y 6/4 (dusky yellow) streaks; ~10% gravel (rest is about same composition as 10-18 cm)
33-38½ cm: overall color 10YR 4/2 (dark yellowish brown); 10-20% gravel;silty clay with some sand; a couple of 5 YR 6/4 (light brown) spots, etc.

Middle
0-5 (38½-43½) cm: <10% gravel; 10YR 4/2; silty clay with some sand; mostly fine angular to subangular blocky; some larger chunks (3-5 cm); one 4-cm piece of gravel
5-8 (43½-46½) cm: massive; mostly clay (silty with little sand); 10YR 5/4;
8-17 (46½-55½) cm: dominantly 10R 6/6 (moderate reddish orange); a couple of 10YR 4/2 spots; massive; about same composition as 5-8 cm
17-25 (55½-63½) cm: 10YR 4/2; massive; slightly more clay; silty clay; a couple of 10R 6/6 spots
25-31 (63½-69½): dominantly 10R 6/6 with some 10YR 4/2 (mottling?); massive; slightly more clay; silty clay
31-36 (69½-74½) cm: massive; 10YR 4/2; silty clay; a couple of small white spots

Bottom

0-5 (74½-79½) cm: silty clay; decent ribbon; massive; 10YR 4/2; one medium fine root
5-9 (79½-83½) cm: silty clay; <10% gravel; 5YR 5/6 (light brown) but a little darker and yellower (oxidization), and 10YR 4/2; massive, but partially granular
9-12 (83½-86½) cm: silty clay; <10% gravel; mostly massive but partially granular; 10Y 7/4 (moderate greenish yellow)- gleying, 10R 6/6, 10YR 4/2; good/decent ribbon
12-22 (86½-96½) cm: massive; good/decent ribbon; <10% gravel; between 10R 6/6 and 10R 4/6 (moderate reddish brown), some white spots, a couple of 10Y 7/4 spots, 10YR 4/2 but a little browner, small amount of 10YR 2/2 (dusky yellowish brown)
22-28 (96½-102½) cm: mottling: 5Y 6/4 (dusky yellow) but a little browner, 10YR 4/2; silty clay, but slightly more clay; good ribbon
28-30 (102½-104½) cm: massive; silty clay; good ribbon; 10YR 4/2 but a little lighter and yellower; a few spots of 10R 6/6
30-36 (104½-110½) cm: 10YR 4/2, faint mottles of 5Y 6/4 (but a little browner); massive; silty clay; good ribbon

Shoe Sample
Cobble- brick? (~10R 4/6- moderate reddish brown, but slightly lighter); traces of (brick?);clay; good ribbon; <10% gravel; 10YR 4/2 with small spots of 10YR 6/6 (dark yellowish orange)

Run 2 (4-9')
Top
0-21½ (110½-132) cm: some brick residue, a few chunks (pebbles/cobbles) of brick (10R 4/6); some organic material; 5Y 3/2 but a little lighter and much grayer, some ~5Y 6/4; non-brick material is clay with little clay
21½-27 (132-137½) cm: silty clay with some sand; good ribbon; between 10YR 4/2 and 10YR 2/2
27-41½ (137½-152) cm: ~10YR 2/2; clay; good ribbon
41½-48 (152-158½) cm: ≤10% gravel; ~10YR 2/2; a couple of small 10YR 7/4 (grayish orange), ~10R 6/6 spots

Bottom
0-5 (158½-163½) cm: sandy clay; poor ribbon; 10-20% fine gravel/coarse sand; 10YR 4/2 with some black
5-16 (163½-174½) cm: mostly black with ~½ cm of 10 YR 4/2 around outside; sandy clay (but a little less sand) different smell; poor ribbon
16-22 (174½-180½) cm: sandy clay; dominantly 10YR 4/2 with some black (mottling?)
22-37 (180½-195½) cm: between 10YR 4/2 and 10YR 2/2; mostly clay with little or no silt; good ribbon
37-43 (195½-201½) cm: mostly fine to medium sand with some clay; 10YR 5/4 but slightly grayer

43-47 (201½-205½) cm: still mostly sand, but more clay; damp; <10% gravel; ~ ¼ -½ cm 10YR 4/2 clay around outside; 10YR 6/6 (dark yellowish orange) but a little darker (sandy portion)

<u>*Shoe Sample*</u>
Wet fine to medium sand with some clay sticking it together; between 10YR 6/6 and 10YR 5/4

Run 3 (9-14')

<u>*Top*</u>
0-10½ cm: saturated, very clayey fine to medium sand; 10YR 5/4 but a little grayer
10½- 31 cm: 10YR 4/2 but a little lighter; saturated fine to medium sandy clay; one spot 10YR 6/6(dark yellowish orange) but a little more orange
31-36.3 cm: ~10YR 6/6 mostly, but with some of same color from 0-10½ cm and 10½ -31: saturated fine to medium sand (slightly clayey)
36.3-47 cm: (like 10½ -31); more clay; saturated fine to medium sandy clay; 10YR 4/2 but a little lighter
47-53½ cm: saturated, very clayey sand (finer sand); 10YR 5/4 but a little darker
53½ -58 cm: saturated clayey fine to medium sand (less clay); 10YR 5/4 but a little darker

<u>*Middle*</u>
0-17½ (58-75½) cm: saturated fine to coarse sand with little clay; ~10% gravel; 10YR 5/4
17½-25 (75½-83) cm: 10YR 6/2 (pale yellow brown) but a little darker; fine to coarse sand, but less of the coarse sand; saturated with almost no clay
25-42½ (83-99½) cm: fine to coarse sand (saturated); 10-20% gravel; almost no clay; ~10YR 5/4
42½-47 (99½-104) cm: moist clay with very little (if any) sand; good ribbon; 5Y 5/6 (light olive brown); weathered bedrock?

<u>*Bottom*</u>
0-47 (104-151) cm: clay (drier- indurated?); good/decent ribbon; trace of 10YR 5/4 clay around outside; mottling: 5Y 5/6 but a little browner, and ~5Y 5/2 (light olive gray)

<u>*Shoe Sample*</u>
Similar (same) texture to bottom section; 5Y 5/6 and ~5Y 5/2 (mottling); trace of 5Y 4/4 (moderate brown) clay around outside; mostly large chunks with some smaller pieces/aggregates

Run 4 (14-19')

0-5½ (151-156½) cm: small amount of 5YR 4/4 (moderate brown) clay and fine sand around outside; inside is clay (good ribbon); 5Y 5/2 (light olive gray)

5½-26 (156½-177) cm: more fine sand around outside (2-3mm)- 5YR 4/4; mottled clay (weathered bedrock): 5Y 5/6 but slightly more yellow, and ~5Y 5/2 but very slightly darker and browner; good/decent ribbon
26-43½ (177-194½) cm: same coloring (mottling) as 5½-26 cm; no sand; clay (weathered bedrock); good/decent ribbon (same texture as 5½-26 cm)
43½-56 (194½-205) cm: clay (weathered bedrock) with very slightly more moisture; 5Y 3/2 but slightly darker and grayer, mottled with 5Y 5/6 but browner; *less mottling*

Sleeve Extra
0-5 (205-210) cm: almost no mottling; clay; good/decent ribbon; 5Y 6/4 mottles? Hard to tell because of faintness; ~5Y3/2
5-10 (210-215) cm: mottling- lots: 5Y 5/6 but slightly browner, with ~5Y 3/2; same texture as 0-5 cm

Shoe Sample
Harder clay (slightly less weathered bedrock?); hard to make ribbon (dry); 5Y 6/4; with ~5Y 3/2; 5Y 4/4 on top (lots of spots)

GW 5
Run 1 (0-4')
Top
0-1 cm: organic material
1-5 cm: dry silty clay; good ribbon formed when damp; massive, but partially very fine granular when crushed (easily crushed); few fine roots; 10YR 6/2 with pinkish tint
5-22 cm: mostly massive with a few fine to medium angular to subangular blocky aggregates; silty clay (dry, less easily crushed); <10% gravel; few white spots; dominantly 5YR 6/4; a couple of 5Y 6/4 spots; some 10YR 6/2 mixed in with 5YR 6/4; one or two fine roots
22-29 cm: one or two fine roots; very fine granular and some fine to medium subangular blocky aggregates; ~10% fine gravel; silty clay; 5YR 6/4 (similar coloring to 5-22 cm)

Bottom
0-7 (22-29) cm: silt clay (lots of clay); massive; a couple pieces of organic material; kind of hard to crush (very firm); 5YR 6/4 with 5Y 6/4 but slightly darker
7-10 (29-32) cm: one large white spot; predominantly 5YR 6/4 (light brown); mostly massive, but some fine granular aggregates
10-18½ (32-40½) cm: silty clay (more clay); mostly massive, with some fine to (a few) coarse angular to subangular blocky aggregates; mostly 1YR 5/4 with a few spots of 10YR 2/2 (mottling?) and 5YR 6/4
18½-25½ (40½-47½) cm: 5Y 6/4 and 5YR 6/4 with a couple spots of ~10YR 2/2; massive; silty clay; hard

25½-32 (47½-54) cm: 10R 4/6 but a little lighter with ~2 cm spot of white and fine muscovite crystals; <5% gravel; silty clay (mostly clay- hard, dry)
32-37 (54-59) cm: ~10YR 4/2 but a little darker; mostly clay with some silt; <10% gravel; some 10R 6/6, a couple of white spots

<u>*Shoe Sample*</u>
Very little (one or two pieces) organic material; 10YR 4/2 with a few spots of 5Y 5/6; silty clay; some fine granular aggregates; some coarse subangular blocky chunks, one larger chunk

Run 2 (4-9')

<u>*Top*</u>
0-8½ (59-67½) cm: somewhat moist clay; one or two pieces organic material; good/decent ribbon; 10YR 4/2
8½-13 (67½-72) cm: mostly clay; good ribbon; 10YR 4/2 with a slight pinkish tint
13-31½ (72-90½) cm: black clay, 10YR 4/2 (but a little lighter) clay; a couple of 5YR 5/6 spots; moist- good ribbon
31½-34½ (90½-93½) cm: moist clay; good ribbon; a couple of small gravel pieces; ~10YR 5/4 (moderate yellow brown)
34½-48 (93½-107) cm: moist clay; good ribbon; 10YR 4/2 with a couple of black spots; faint black streak

<u>*Bottom (had to dig ~2 cm to get to darker middle)*</u>
0-13 (107-120) cm: moist clay; good ribbon; 10YR 6/2 with faint streaks of 10YR 4/2; a couple of small chunks of ~5Y 6/4 (but lighter) rock (gravel)
13-30 (120-137) cm: ~10YR 5/4 with darker middle (10YR 4/2 with some black); moist clay; good ribbon; somewhat defined rim of ½-1 cm 10YR 5/4
30-51 (137-158) cm: moist clay; good ribbon; 10YR 5/4 with streaks of 10YR 4/2 to 10YR 2/2
51-55½ (158-162½) cm: 10YR 5/4 but a little lighter; moist clay; good ribbon; a couple of black spots

<u>*Shoe Sample*</u>
Clay; gleying (a couple spots of 5GY 7/4- moderate yellowish green mixed with 5G 5/6- moderate green); mostly 10YR 5/4 with a little 5YR 5/6 on same end as green spots; good ribbon; some 10YR 8/2 (very pale orange) spots

Run 3

0-3½ (162½-166) cm: sandy clay; <u>wet</u>; some black and 5YR 5/6, but mostly 10YR 5/4
3½-7 (166-169½) cm: sandy clay, but a little less moisture; 10YR 4/2
7-32½ (169½-195) cm: saturated sand (fine to medium); 10YR 5/4 but a little lighter (between 10YR 5/4 and 10YR 6/6); coarse gravel at bottom (overall <10%)

<u>*Shoe Sample*</u>

~20% coarse gravel; saturated sand (fine to medium); between 10YR 6/6 and 10YR 5/4)

Run 4

<u>*Top*</u>
0-27(195-222) cm: damp, fine to medium-coarse sand; overall color predominantly 10YR 5/4

<u>*Bottom*</u>
0-10½ (222-232½) cm: fine to coarse damp sand; a few small pieces of gravel (≤10%) and a few larger ones (deeper); 10YR 5/4)
10½-24 (232½-246) cm: 10YR 5/4; damp, fine to medium sand (overall finer than 0-10½) with some small pieces of gravel and a couple of larger ones (overall ≤10% gravel); one spot 10R 4/6 but slightly lighter

<u>*Bottom 3" recovery*</u>
Clay surrounded by sand and gravel; clay: 5Y 3/2 but a little grayer and darker (slightly weathered bedrock)- 7-7½ cm before broken; good/decent ribbon; ≥20% gravel (fine to very coarse); sand: 10YR 6/6 (moderate yellowish orange)- mostly fine with some medium

<u>*Shoe Sample*</u>
Clay broken into large chunks; hard to make a ribbon (dry); slightly weathered bedrock; 5Y 3/2 but slightly grayer and darker

<u>GW 6</u>

Run 1 (0-4')

<u>*Top*</u>
0-2 cm: organic material
2-18½ cm: massive; silt with clay; a few pieces of small gravel; 10YR 5/4
18½-24 cm: mostly massive with some angular to subangular blocky (fine) aggregates; <10% small gravel; 10YR 5/4 but a little darker
24-35 cm: 10YR 5/4 but a little darker; massive with some broken pieces; silt with clay; one small bug
35-45 cm: massive; silt with clay (slightly more?); one 10YR 8/2 (very pale orange) spot; a few small pieces of gravel

<u>*Bottom*</u>
0-4 (45-49) cm: silty clay; good/decent ribbon (dry); ~10YR 5/4 and 10YR 4/2 (10YR 4/2 is more clayey); massive
4-11 (49-56) cm: massive; clay; good/decent ribbon; a few small white spots; mostly ~10YR 2/2 with a little 10YR 5/4 (streaks) at the top
11-41 (56-86) cm: some small white spots; massive; clay- very slightly mottled (mostly 5R 4/4 , some 10YR 2/2at the top); good/decent ribbon

Shoe Sample
Clay; massive; ~5½ cm; a few pieces of organic material at the rounded end; moister; good ribbon; very slightly mottled (5YR 4/4 but slightly lighter)

Run 2 (4-9')

**don't see "alternating black layers" noted in field notes for this run*
0-4 (86-90) cm: a few pieces of medium gravel; clay; massive; good ribbon; 10YR 5/4 but slightly darker
4-13½ (90-99½) cm: clay; massive; 10YR 5/4 but slightly darker with some faint 10YR 4/2 streaks and 10YR 7/4 (grayish orange) but slightly lighter spots; good ribbon
13½-22 (99½-108) cm: clay; massive; good ribbon; streaky: 10YR 5/4 but a little lighter and some faint 10YR 4/2
22-28 (108-114) cm: mostly 10YR 6/6 but slightly darker and browner; faint streaks of ~10YR 5/4; clay; massive; good ribbon
28-44 (114-130) cm: clay; massive; good ribbon; 10YR 6/6 but slightly browner; a few 10YR 2/2 to black spots; a few ~10YR 7/4 spots
44-45 (130-131) cm: sandy (fine) clay with a few small pieces of gravel; ~10YR 6/6

Shoe Sample
Fine sand with some clay; sand sticks when pressed together; a few pieces of gravel; 10YR 5/4 but more yellow

Run 3

Top
0-5 (131-136) cm: wet, slightly clayey fine sand (thin layer of clay on top); closes to 10YR 5/4
5-9 (136-140) cm: 1-2 cm of fine, wet sand on sides (same color as 0-5 cm); black, saturated, very sandy clay in the middle
9-21 (140-152) cm: slightly clayey sand; a couple of black spots; a few (<10%) pieces of coarse sand/fine gravel; ~10YR 5/4; one glob of clay (~5YR 5/6)
21-26 (152-157) cm: ~10YR 5/4, but very slightly darker than 9-21 cm; fine to coarse sand (wet); one or two clay globs (10YR 5/4); a couple of black spots
26-30 (157-161) cm: one large (~4 cm) glob of sandy clay- 5YR 5/6 but a bit lighter; 10-20% gravel; rest is fine to coarse wet sand; ~10YR 5/4
30-36 (161-167) cm: 10-20% gravel; one cobble (6 cm); rest is fine to coarse wet sand- 10YR 5/4

Bottom
0-12½ (167-179½) cm: fine to coarse wet sand with clay and <10% gravel; ~10YR 5/4
12½-32 (179½-199) cm: fine to medium wet sand (overall finer texture than 0-12½ cm); less clay; <10% gravel; ~10YR 5/4
32-35 (199-202) cm: fine to medium wet sand with more clay; one large chunk of gravel (~3 cm); dominantly 5Y 5/6 but slightly browner

35-40½ (202-207½) cm: moist clay; good ribbon; 5Y 4/4 ad 5Y 3/2 (spots)

<u>*Shoe Sample*</u>
10YR 6/6 but a little more yellow, and 5Y 3/2 (mottling); clay; massive; drier, but still good ribbon

Run 4

<u>*Top*</u>
0-7½ (207½-215) cm: very fine sand with some clay (thin layer of clay on top); 10YR 6/6 but a little darker
7½-26½ (215-234) cm: mottled clay (same colors as Run 3 shoe, but fewer 10YR 6/6 mottles); moist; good ribbon; fine sand around outside (10YR 6/6 but a little darker)

<u>*Middle*</u>
0-5 (234-239) cm: ~5Y 5/6 and 5Y 5/2 but a little darker; good ribbon; thin layer (trace) of 10YR 5/4 clay around outside
5-16½ (239-250½) cm: thin layer (trace) of 10YR 5/4 clay around outside with some fine sand; clay (very slightly less moisture); good/decent ribbon; weathered bedrock (less?); 5Y 3/2 but grayer
16½-23½ (250½-257½) cm: mottled clay: 5Y 5/6 and between 5Y 5/2 and 5Y 3/2; slightly moister; good ribbon; same trace clay around outside
23½-27½ (257½-261½) cm: (same as 5-16½ cm)
27½-38 (261½-272) cm: trace clay and fine sand around outside (same color); mottled clay: 5Y 5/6 but darker and browner, and 5Y 3/2 but darker and grayer; good/decent ribbon
38-46 (272-280) cm: trace clay and sand (same color); good ribbon; 5Y 3/2 but grayer and darker; a couple of faint (5Y 5/6) mottles

<u>*Bottom (weathered bedrock)*</u>
0-16 (280-296) cm: trace 5Y 4/4 clay on outside; mottled clay: 5Y 4/4 but slightly browner, and 5Y 3/2 but darker and grayer; good/decent ribbon
16-46 (296-326) cm: 5Y 6/4 and 5Y 3/2 but darker and grayer (fainter mottling); good/decent ribbon

<u>*Shoe Sample*</u>
Same coloring (mottling) as 16-46 cm with some small white spots; good/decent ribbon

***parenthetical depths given are amounts of recovery (w/o shoe samples), not necessarily actual depth in the hole. Most of the time, recovery was less than five feet for each run.

Well cross section (Figure 2) notes

The blue lines represent the water table level. Notice that the wells that are closer to the creek had slightly higher water table levels than the others. This indicates that Spring Creek is currently an effluent stream, meaning it is feeding water into the ground around it.

The dotted lines were place in order to emphasize the continuity of each layer across the wells. GW3 is not connected to GW4 because of its different orientation (GW3 is part of the N-S line whereas GW4 is part of the E-W line).

The black layer represented on this plot went across all six wells. The reason it does not show up in GW2 is that there was no recovery in run 2, the run that contained the black layer. The layer was mostly clay with some silt, and in some cases was mixed with a brown color. It also had a different smell than the rest of the material.

The brown layers on the graph represent the location of the sandy layer that ran across the wells. Gravel was also present in some of these layers. Of particular interest is the fact that the sand layer seems to follow the level of the water table very closely. This is most likely because of the coarser grain size (in comparison with the clay and silt layers), which would allow the water to pass through more easily.

The gray (and similarly colored) layers represent, for the most part, bedrock. Many of those layers had mottling, varying between a few different colors. Most of these layers were fairly hard with little moisture.

Notes for plotted non-colored layers

GW5
Run 1

Top: The first portion of this section was massive, dry silty clay with some organic material (closest to pale yellowish brown). The second portion was also massive, but had some fine to medium angular to subangular blocky aggregates, as well as a few white spots, and was dominantly light brown. The third portion was less massive (had more aggregates) and had some fine gravel as well, and was silty clay.

Bottom: The first portion of this section was silty clay (very high clay content) and massive, very firm, and mostly light brown with some dusky yellow. The second portion was mostly light brown to moderate yellowish brown, silty clay, massive, and had a few spots of possible mottling. The third portion was very hard silty clay, massive, and mostly light brown and dusky yellow. The fourth portion was moderate reddish brown and seemed to have some fine muscovite crystals present. The last portion was mostly dark yellowish brown but slightly darker, was mostly clay (with some silt), and had some moderate reddish orange and white spots, and a small amount of gravel.

Shoe: The shoe was mostly dark yellowish brown with some spots of light olive brown, and had varying sizes of aggregates.

Run 2

Top: The first portion of this section was slightly moist clay, and was dark yellowish brown. The third (last) portion was about the same, with a couple of faint black spots and a faint black streak.

Bottom: The first portion of this section was moist pale yellowish brown clay with a couple small chunks of gravel and dark yellowish brown streaks. The last portion was moderate yellowish brown moist clay with a couple of dark to dusky yellowish brown streaks and a couple of black spots.

Shoe: The shoe showed signs of gleying. There were a couple spots of moderate yellowish green mixed with moderate green, but it was mostly moderate yellowish brown with a little moderate brown and very pale orange.

<u>GW1</u>

Run 1

Top: This section was mostly dry, silty soil, with a clay content that increased in the second and third portions. The second portion also had more gravel than either the first, second, or fourth portions.

Bottom: This section had a relatively large cobble at the top, which was assumed to be gneiss. Some of the aggregates in the first portion were fairly large, and contained fine sand and silt. The color in the following portions stayed similar, but included some spots (pink, reddish brown and black) that were not present in the previous portion. The last portion had slightly more sand.

Run 2

Top: This section was mostly clay with some silt, and a little organic material. There were also a couple of very small black spots present.

Middle: The first two portions of this section (before black was encountered) were mostly clay of a couple of different brown shades.

Black clay was encountered in the third portion of this section and continued through the second portion of the bottom section.

Bottom: The third portion of this section was moderate yellowish brown clay.

Shoe: Same description as third portion of bottom section.

**Hit bedrock at 17 feet

<u>GW2</u>

Run 1

The first portion of this run was again mostly dry silty soil, moderate yellowish brown, possibly with some sand and/or clay. It also had some organic material.

The second portion was light brown to dark yellowish brown and more massive than the first portion.

The third portion was more clayey, moderate yellowish brown, and had very slightly more gravel than the previous portions, but all still had less than 10%. The last portion was mostly clay, with some silt and about the same amount of gravel. The color ranged from dark to moderate yellowish brown, with some moderate reddish brown spots.

Shoe: massive mottled clay (dark yellowish brown with white and moderate reddish brown spots)

Run 2

NO RECOVERY, but a black silty layer was noted, which fits in with the black layers found in the other wells.

*Hit bedrock at 14 feet

GW3

Run 1

The first portion of this run was moderate yellowish brown dry silty soil with some clay and organic material (also a small amount of gravel). A piece of reddish metal was also present.

The second portion had some larger aggregates but was mostly massive, light brown silty clay with a small amount of gravel and some white areas. Some of the looser material was darker (dark yellowish brown).

The third portion had slightly more gravel (~ 10%) and some larger aggregates, and was mostly loose granules or smaller aggregates with one large chunk/cobble. Overall color was about dark yellowish brown.

Run 2

Top: The top portion of this section was a little darker than moderate yellowish brown, and was mostly clay with one lighter spot of sand.

Bottom: The first portion of this section was closest to dusky yellowish brown, but was slightly grayer, and was silty clay with little sand.

The second portion of this section was much sandier than the first, and was also lighter (moderate yellowish brown but slightly grayer) and had a higher gravel percentage (10-20%). Some dusky yellowish brown clay was present.

The third portion was between light brown and moderate yellowish brown, and was clay with some black spots present.

The last portion was clay with some black spots. Major color ranged from dark yellowish orange to moderate yellowish brown to light olive gray.

Shoe: moderate yellowish brown, sandy clay

Run 3

Middle: The last portion of this section was mottled clay (pale olive but slightly grayer and light olive brown) and had a trace of light brown clay around the outside.

Bottom: mottled clay (same coloring as bottom portion of middle with trace of moderate brown clay around outside)

Shoe: mottled clay (light olive brown and light olive gray)

GW4 (pasted in from well descriptions and edited)

Run 1

Top: First portion had some organic material (few medium roots, few fine roots) was closest to pale yellowish brown; <10% gravel; fine to coarse angular to subangular blocky; silt and clay, not much sand. Second portion was massive, moderate yellowish brown with some light brown and possibly slightly more sand. The third portion was mostly massive (any aggregates fine, subangular blocky); overall color closest to dark yellowish brown, other colors were spots of black, white material, a few moderate reddish orange spots, a couple of slight dusky yellow streaks; ~10% gravel (rest is about same composition as previous portion). Fourth portion had an overall color of dark

yellowish brown, 10-20% gravel, silty clay with some sand; a couple of light brown spots, etc.

Middle: First portion had <10% gravel, was dark yellowish brown silty clay with some sand; mostly fine angular to subangular blocky; some larger chunks (3-5 cm); one 4-cm piece of gravel, partially massive, some moderate yellowish brown, part was mostly moderate reddish orange with a couple of dark yellowish brown spots. Second portion was massive; mostly dark yellowish brown silty clay with a couple of moderate reddish orange spots. Third portion was moderate reddish orange and dark yellowish brown silty clay with a couple of white spots.

Bottom: First portion silty clay with some gravel (<10%), some possible oxidization, gleying- moderate greenish yellow in light brown to dark yellowish brown with some moderate reddish orange. Second portion massive clay, <10% gravel, between moderate reddish orange and moderate reddish brown, some white spots, a couple of moderate greenish yellow spots, and some dark to dusky yellowish brown. Last portion mottled, massive silty clay- dusky yellow and dark yellowish brown with a few moderate reddish orange spots

Shoe: cobble- brick? (about moderate reddish brown), clay, <10% gravel, dark yellowish brown with a few small spots of dark yellowish orange

Run 2

Top: First portion had some brick residue, a few chunks of brick and some organic material, olive gray but a little lighter and much grayer, some dusky yellow, clay with very little silt. Second portion was silty clay with some sand, between dark yellowish brown and dusky yellowish brown. Third portion was dusky yellowish brown clay. Last portion was dusky yellowish brown clay with ≤ 10% gravel and a couple of small grayish orange and moderate reddish orange spots.

Bottom: First portion had *some* black, but was mostly dark yellowish brown sandy (coarse sand to fine gravel) clay. Third portion was sandy and slightly silty clay, mostly dark to dusky yellowish brown with a little bit of black.

Run 4

Bottom 3": slightly weathered bedrock surrounded by moderate yellowish orange fine to medium sand, clay was about olive gray, had 10-20% gravel.

<u>GW6</u>

Run 1

Top: First portion massive silt with clay and some organic material at the top and some gravel, moderate yellowish brown. Second portion massive silt with clay, with some broken pieces/aggregates and gravel. Third portion massive silt with clay (possibly slightly more) and a few pieces of gravel, and one very pale orange spot.

Bottom: First portion moderate and dark yellowish brown massive dry clay. Second portion massive dark yellowish brown clay with a few small white spots and a few moderate yellowish brown streaks at the top. Third portion massive, very slightly mottled clay (mostly moderate brown with some dusky yellowish brown at the top), some white spots.

Shoe: massive clay, about 5 ½ cm, a few pieces of organic material, moister, very slightly mottled moderate brown but slightly lighter).

Run 2

First portion massive clay with some gravel, about moderate yellowish brown with some faint dark yellowish brown streaks and grayish orange spots. Second portion massive clay, streaky, moderate yellowish brown and some faint dark yellowish brown, also dark yellowish orange with a few dusky yellowish brown to black and grayish orange spots.

Run 4

Top: Second portion mottled clay (dark yellowish orange and olive gray), fine dark yellowish orange sand around outside.

Middle: First portion about light olive brown and light olive gray moist clay with a trace of moderate yellowish brown clay around the outside.

Mottling notes for bedrock/clay layers

It is important to note that many of the bedrock layers were weathered with significant mottling. The coloring for each was similar, with the main color being close to olive gray, and the mottles being close to dusky yellow or moderate olive brown.