The Soils of Pittsburgh and Their Effects on the Development of Land Use in Pittsburgh, Pennsylvania

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A literature review was performed to ascertain how much of an impact the different soil profiles of Pittsburgh affected the development of the city through the 19th, 20th, and 21st centuries. The soils of Pittsburgh owe much of their current form to glacial outwash originating in the late Wisconsinan glaciation event, lacustrine deposits from Lake Monongahela, a lake formed from the blockage of the Monongahela River's paleoflow, and the modern fluvial environments provided by the three rivers of Pittsburgh. These soils are broken into associations dominantly unaltered by urban development that have various characteristics and associations dominantly altered by urban development and are predominantly a silt loam and exhibit a fine to very fine grain size. Urban soils and strip mines, however, are difficult to categorize. Pittsburgh's land use began largely as a small, concentrated town, growing and expanding ever outward as it urbanized, with many different soil profiles overtaken by the city. It was determined that, while soil profiles quite likely played a role in the early development of Pittsburgh, more modern urbanization points to the urbanization dictating what the soil is, instead of the other way around. Finally, predictions were made for what this meant for the remaining unaltered soil associations, if remediation would be possible for urban soils back to some more natural soil, and how this work may apply to other cities around the nation.

Acknowledgments

I would like to acknowledge Dr. Whitenack, without whose help this work would have not been possible, as well as Dr. Miller, whose help in agreeing to be my second reader midway through the work not only aided in allowing me to complete it but, coupled with his historical expertise, was also instrumental in assuring I had a more complete and full work.

Additionally, I would like to thank Margaret Hewitt at the Detre Library and Archive References Desk at the Senator John Heinz History Center in Pittsburgh, whose help in understanding and interpreting maps was indispensable, and who was a pleasure to work with throughout the entirety of the process.

Introduction

Geological Background

The current commonwealth of Pennsylvania has quite a storied geological history when it comes to glaciation, with the climate beginning to cool approximately 16 Ma (million years ago) (Sevon, 1999). As the Earth cooled, water froze into ice, which in turn aided in the further cooling of the Earth. By 1.6 Ma, an ice sheet, named the Laurentide Ice Sheet, covered what is now Canada, and then began moving southward toward what is now the United States (Sevon, 1999). Pennsylvania was only affected by this period of glaciation in what is known as the Wisconsinan glaciation, which is further broken down into its three advances, the early, middle, and late Wisconsinan (Sevon, 1999). While the early and middle Wisconsinan did not reach Pennsylvania, the late Wisconsinan did, between 25 and 21 Ka (thousand years ago), and as such is the one that focus must be given to (Sevon, 1999).

The glaciation did not reach too far into Pennslyvania, as seen in Figure 1 (Braun, 2011), and certainly did not reach Pittsburgh (Braun, 2004). Pittsburgh still bears the mark of the glaciation, though (Adams, 2017). Though there was no direct glacial activity in Pittsburgh, there was glacial outwash, a type of sediment that is transported from glaciers by streams formed by the meltwater at the head of a glacier (Sevon, 1999). Perhaps an even larger player, however, was Lake Monongahela, a large, dendritic,

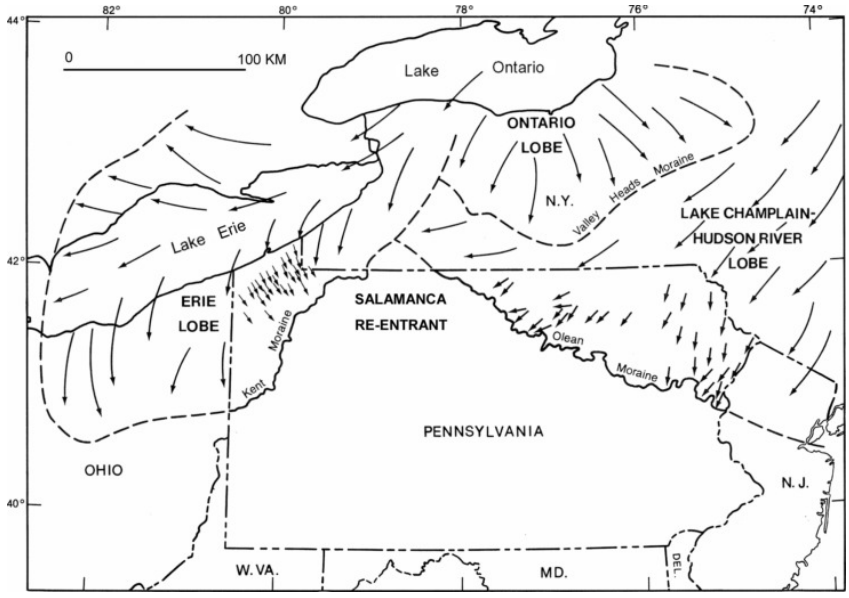


Figure 1: Furthest extent of glaciers in Pennsylvania. (Braun, 2011)



Figure 2: Monongahela Lake with estimated position of Pittsburgh (Modified from: WV Geological and Economic Survey, 2017)

proglacial lake that formed due to the blockage of the paleo-equivalent of the Monongahela River that covered areas in Pennsylvania, Ohio, and West Virginia (Adams, 2017) (See Figure 2). This blockage occurred due to the end moraine of the glacier, where sediments and debris, pushed by the glaciers, form something akin to a ridgeline at the front end of the glacier (Sevon, 1999), blocking the paleo-Monongahela River, which actually flowed north (Adams, 2017). Both the glacial outwash and lacustrine sediments, brought about by the vehicles of meltwater stream and Lake Monongahela respectively, have shaped Pittsburgh's geology, as well as its soils, laying down the bedrock that Pittsburgh's modern rivers, the Monongahela, the Allegheny, and Ohio, have cut through to form what we know today as

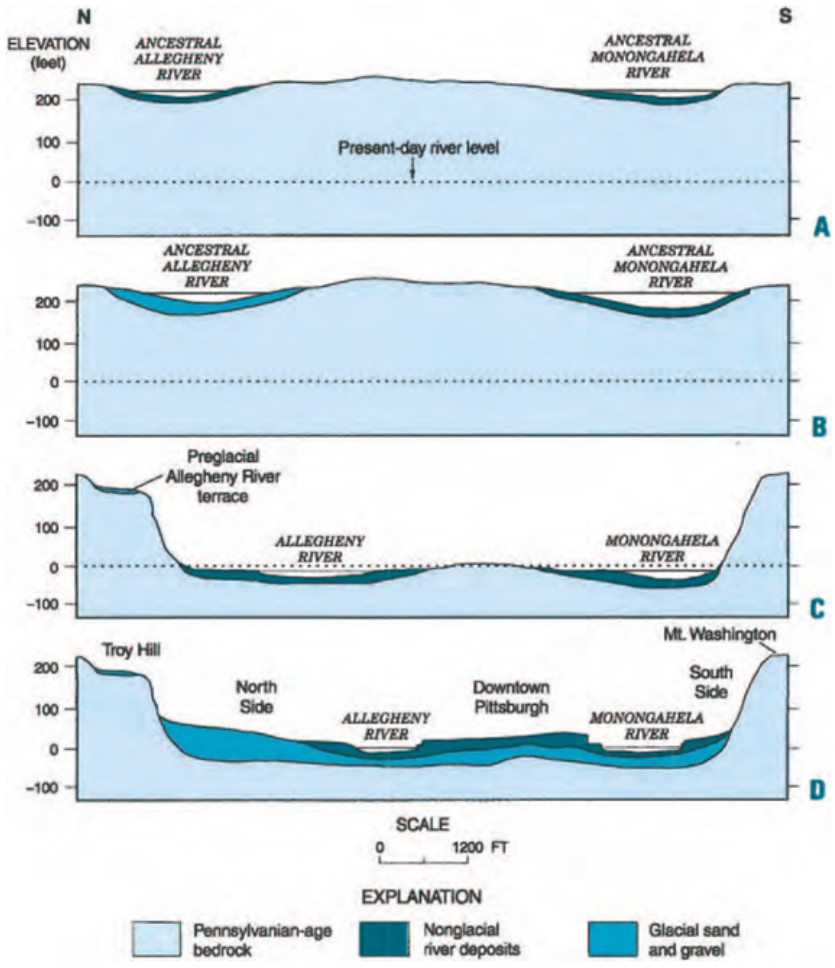


Figure 3: Development of the Monongahela and Allegheny Rivers over the past 1Ma (Gray, 2019)

Pittsburgh, Pennsylvania. Figure 3 (Gray, 2019) shows the development of the Allegheny and Monongahela Rivers over the past 1 Ma, and how modern Pittsburgh lies amongst both glacial and fluvial sediments. It is within this context that modern-day Pittsburgh finds itself.

Historical Settlement of Pittsburgh

The settlement of Pittsburgh also has quite a long history as well. In the general area of Pittsburgh, human settlement can be traced back to anywhere between 12,000-14,000 years ago, as human remains have been found within what has been designated as the Meadowcroft Rockshelter, which is approximately thirty miles southwest of Pittsburgh (Pennsylvania Historical and Museum Commission, 2015). The history of early indigenous settlement between this archeological finding and European settlement is fairly unclear, but it is known that there were, at least, the Adena culture, the Hopewell culture, and the Monongahela peoples at different times throughout this period (Pitt Sustainability, 2021).

As Europe began to look westward for the sake of colonization, Pennsylvania received a mixture of European peoples. Conflicts in southern Germany brought German settlers to Pennsylvania, with the Reformation making various religious groups seek refuge in the New World, with English Quakers, Puritans, and Catholics settling in Pennsylvania, as well as German Pietists, Calvinists from Ireland, and Huguenots from France (PHMC, 2015). Of course, Pennsylvania was not the first part of the current United States to be colonized. As Europeans colonized the eastern seaboard of the modern United States, numerous tribes came to the Pittsburgh area as refugees, who had been displaced by European colonization, including the Delaware, Shawnee, and Haudenosaunee (perhaps more commonly known as the Iroquois) (PHMC, 2015; Pitt Sustainability, 2021).

European settlement in Pittsburgh proper began in earnest around 1770, after treaties with the Native Americans of the Ohio Valley allowed for more and more European settlement in the area. In the coming years, there would be great violence between these settlers and the natives in the surrounding areas, with multiple wars being fought between them (Burke, 2020). The city began to grow and continued to do so after the Revolutionary War. The Civil War increased the demand for iron and arms, which proved a boon for Pittsburgh's economy, and shortly after, Andrew Carnegie and Henry Clay Frick would open Carnegie Steel Co., merging it with several other companies in 1901 to form United States Steel Corp. (Pittsburgh History, 2023). Up and through the middle of the 1950s, Pittsburgh was the nation's eighth-largest city and accounted for almost half of the nation's steel production alone. During this time, Pittsburgh swelled to nearly 500 million inhabitants. In the '70s and '80s though, the steel industry would somewhat disappear from Pittsburgh, leaving it to reinvent itself as it is now: a hub for education, small manufacturing, medicine, and research. The spirit of a hard-working, industrial city, however, has certainly not left (Pittsburgh History, 2023).

It is upon this backdrop that I seek to investigate how these two storied histories have interacted. These two pieces of Pittsburgh history are quite intertwined with each other, and as such, I seek to analyze the soils of Pittsburgh that the geologic record, and at times, human activity, has left behind, and discover how these soils may have impacted the development of the great city of Pittsburgh through land use choices.

The Soils of Pittsburgh

For this work, the soils of Pittsburgh are placed into ten general soil associations (see Map 1, pg. 24). These associations are distinct groupings of major and minor soils with their own characteristics and patterns. Soils can certainly stretch between associations, but typically when

this happens, they possess different patterns in the various associations (United States Department of Agriculture, 1981).

Furthermore, the associations themselves are placed into two groups: those areas which have been dominantly altered, whether by urbanization and strip mines, where most of the soil has been somehow anthropogenically changed, and where pockets of undisturbed, natural soils are few and far between and those areas that dominantly have not been altered (USDA, 1981). This elucidates the effects of the development of Pittsburgh on these soils and also allows for speculation into what these soils may have been like before heavy settling and development. Finally, see Table 1 for an overview of all soils discussed.

Areas Dominantly Unaltered

Gilpin-Upshur-Atkins association

The first association is known as the Gilpin-Upshur-Atkins association. It makes up about 15 percent of Allegheny County and usually occurs on steep or very steep valley sides, as well as some flood plains, albeit narrow ones (USDA, 1981). It is comprised of approximately 50% Gilpin soils, 10% Upshur soils, and 5% Atkins soils, with the remaining 35% being split between multiple minor soils.

The Gilpin soils (Figure 4), the most common soil of this association, have as their parent material shales and fine-grained sandstones. Gilpin soils are characterized as ultisols (USDA, 1981), a category of soils that are commonly heavily leeched, possess low native fertility, and typically are found in humid temperate and tropical areas with stable landscapes today (Idaho, 2023) making Pittsburgh's humid, rainy climate a perfect place for the formation of these soils. Gilpin soils have a depth to a shale bedrock of about 31 inches (USDA, 1981). From the surface to about 5 inches deep, the Gilpin is a silt loam, then from five inches down to twenty-three

inches, it presents as a shaly silt loam, and from twenty-three to thirty-one inches depth, it becomes a very shaly loam, before finally hitting the shale bedrock (USDA, 1981).

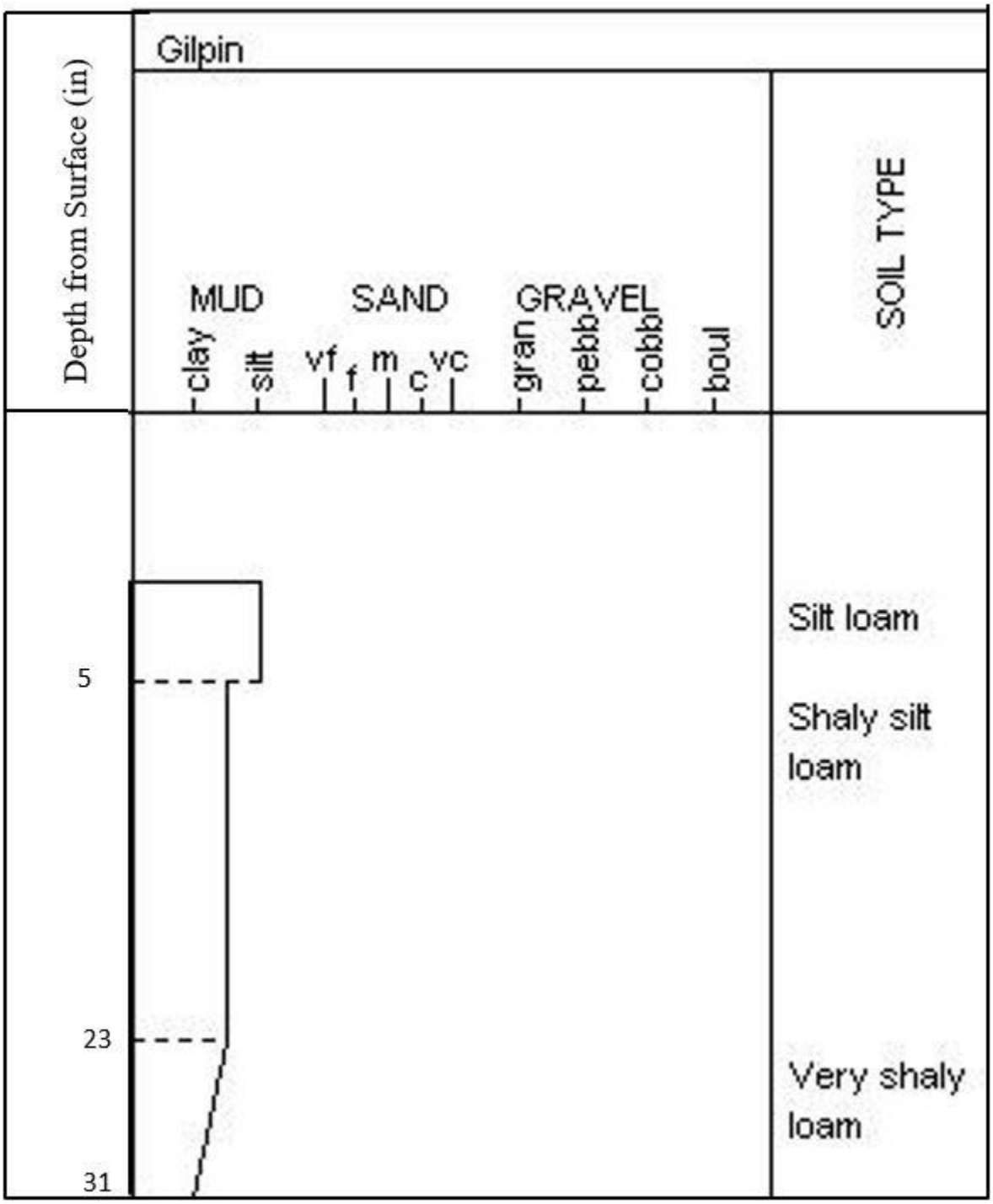


Figure 4: General sedimentary column of Gilpin soils. Built in SedLog and then modified. Abbreviations: vf - very fine, f - fine, m - medium, c - coarse, vc - very coarse, gran - granule, pebb - pebble, cobb - cobble, boul - boulder

Upshur soils (Figure 5) owe their pedogenesis to weathering of red clay shale bedrock and thus are considered alfisols (USDA, 1981). Alfisols are characterized by a zone of subsurface clay accumulation, and a concentration of base cations (Ca2+, Mg2+, K+, and Na+) of at least 35% (Idaho, 2023). Upshur soils are underlain by the shale bedrock at depths of approximately four to six feet, with the first six inches from the surface being a silty clay loam, from six inches to thirty-one inches clay and shaly silty clay, and thirty-one inches to sixty-four inches being shaly silty clay to very shaly silty clay (USDA, 1981).

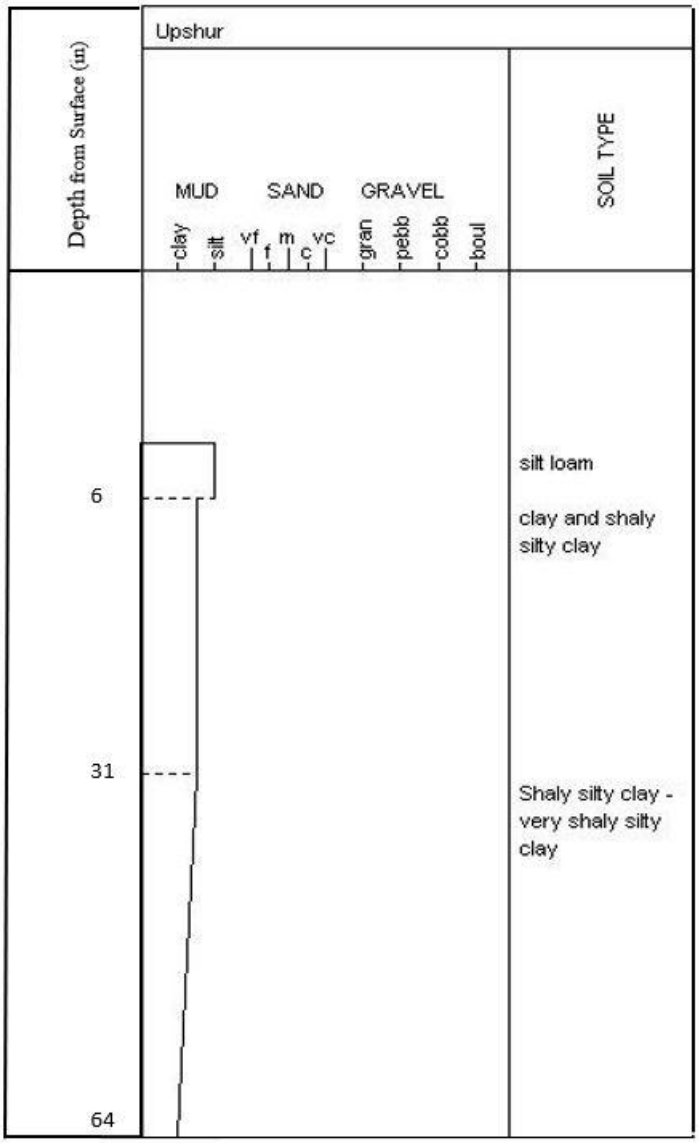


Figure 5: General sedimentary column of Upshur soils. Built in SedLog and then modified. Abbreviations: vf - very fine, f - fine, m - medium, c - coarse, vc - very coarse, gran - granule, pebb - pebble, cobb - cobble, boul - boulder

The Atkins soils (Figure 6), the least common major soil of the association, are found alongside streams in floodplains, and trace their genesis back to recent alluvium from these streams. They are categorized as entisols (USDA, 1981). This is a designation that is quite broad, as it largely encompasses more recent soils that are found typically in areas of frequent change, such as floodplains. Because of the volatility of these areas, entisols typically lack significant horizon development, making it difficult to group otherwise

(Idaho, 2023). This lack of diagnostic material occurring in floodplains makes sense, given these are environments where erosion and deposition happen fairly regularly on a geologic timescale. From the surface to about eight inches in the subsurface, Atkins soils are characterized by a silt loam, from eight inches to thirty-four inches it ranges between the silt loam and pure loam, and from thirty-four to sixty inches, it ranges from loam to silty clay loam. These soils also typically have a very high water table (USDA, 1981).

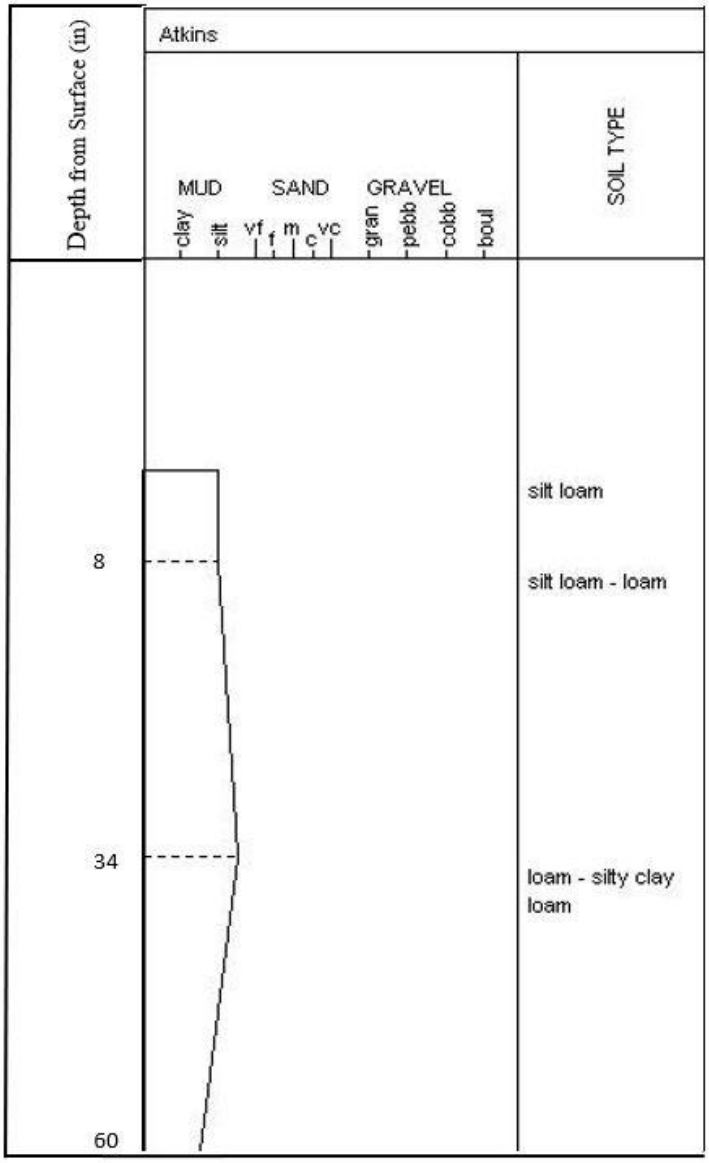


Figure 6: General sedimentary column of Atkins soils. Built in SedLog and then modified. Abbreviations: vf - very fine, f - fine, m - medium, c - coarse, vc - very coarse, gran - granule, pebb - pebble, cobb - cobble, boul - boulder

Gilpin-Weikart-Atkins association

This second association also appears on steep and very steep sides of valleys but also includes near-level flood plains, much like the previous one. It is made up of 50% Gilpin soils, 15% Weikart soils, and 5% Atkins soils, with minor soils making up the difference. This association makes up about 5% of Allegheny County.

Both the Gilpin (see Figure 4) and Atkins soils (see Figure 6) in this association present in much the same way as they did previously, with Gilpin soils being somewhat deep, around two to three feet, to shale bedrock on the valley sides and the Atkins soils being deep, with more than five feet to bedrock, and poorly drained with a high water table, being found in the flood plains of this association (USDA, 1981).

The Weikart soils (Figure 7) derive from shales and fine-grained sandstones and are located on the sides of valleys, similar to the Gilpin soils (USDA, 1981). Weikart soils are defined as inceptisols (USDA, 1981). Inceptisols are slightly more mature than entisols, having somewhat developed a true soil horizon, but still not having the requisite horizon development to be categorized further. Inceptisols are typically found along steep

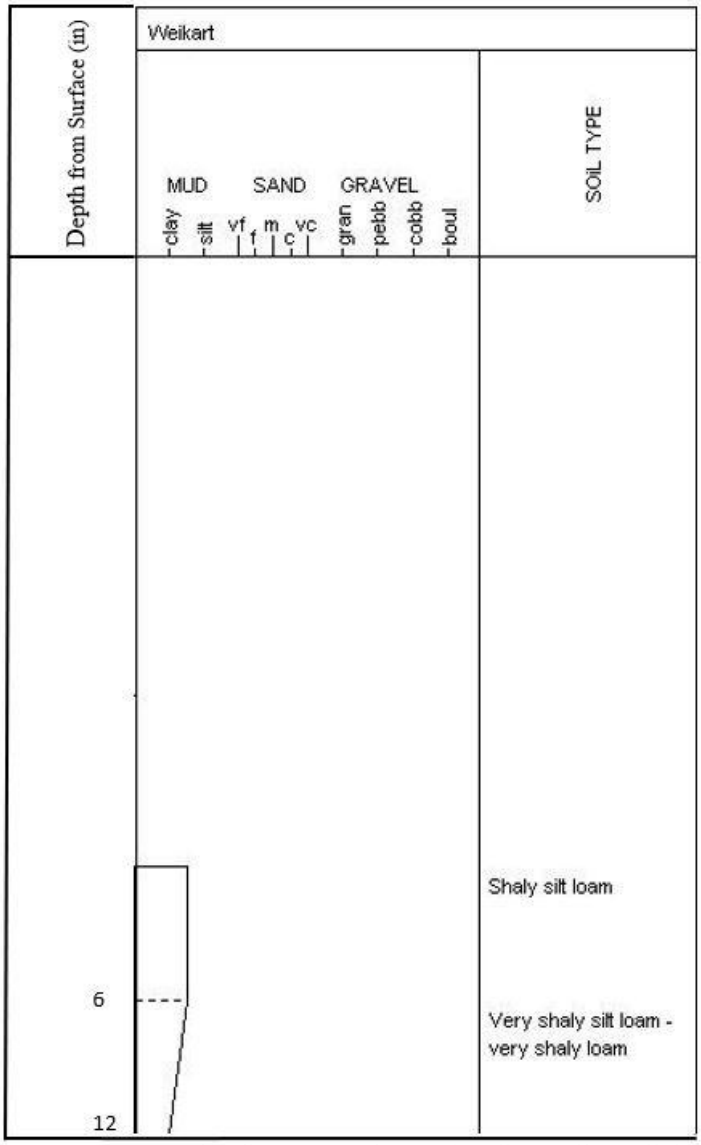


Figure 7: General sedimentary column of Weikart soils. Built in SedLog and then modified. Abbreviations: vf - very fine, f - fine, m - medium, c - coarse, vc - very coarse, gran - granule, pebb - pebble, cobb - cobble, boul - boulder

slopes, mountainous regions, and younger geomorphic structures and as such are not necessarily tied in any way to climate, except that they are typically not found in aridic climates (Idaho, 2023).

The Weikart soils are usually shallow to bedrock, with shale bedrock being at a depth of only fifteen inches. From the surface to about six inches, the Weikart soil presents as a shaly silt loam, and from six inches to bedrock, it varies between very shaly silt loam, and very shaly loam (USDA, 1981).

Culleoka-Weikart-Newark association

This association, much like the last two, is again found on the sides of valleys and flood plains. It is comprised of 50% Culleoka soils, 10% Weikart soils, and 10% Newark soils, with the rest being minor soils. The association comprises about 4% of Allegheny County (USDA, 1981).

The Culleoka soils (Figure 8) make up the majority of this association and are formed from the weathering of shale, fine-grained sandstone, and limestone bedrock parent materials (USDA, 1981). It is classified as an alfisol (USDA, 1981), much like the previous Upshur soils, meaning it has a zone of clay

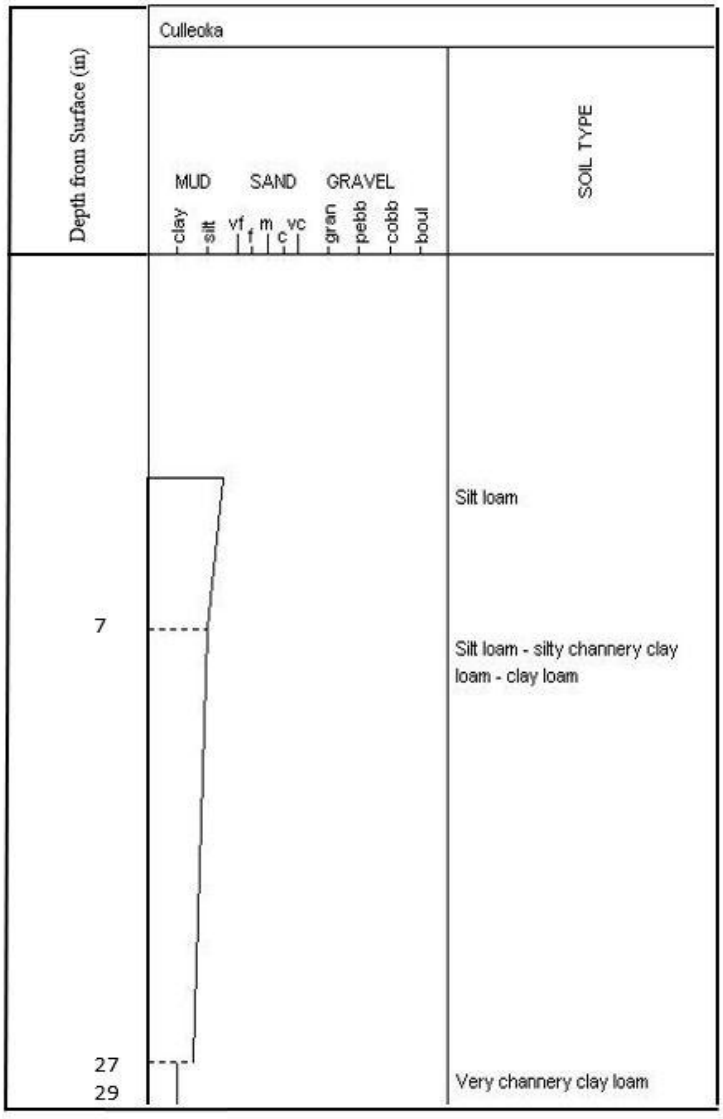


Figure 8: General sedimentary column of Culleoka soils. Built in SedLog and then modified. Abbreviations: vf - very fine, f - fine, m - medium, c - coarse, vc - very coarse, gran - granule, pebb - pebble, cobb - cobble, boul - boulder

accumulation, which becomes clear in the representative profile (Idaho, 2023).

The depth to bedrock of this soil type can be quite variable, given its position on the sloping sides of valleys. A general profile of this soil would be twenty-nine inches to bedrock. From the surface down to a depth of seven inches, it presents as a silt loam, from seven to twenty-seven it varies between silt loam, silty channery clay loam, and clay loam. The final two inches to bedrock are categorized as a very channery clay loam (USDA, 1981).

The Weikart soils (see Figure 7) in this association are very much similar to those in the Gilpin-Weikart-Atkins association previously discussed. They are shallow to a shale or sandstone bedrock and have the same issues with classification (USDA, 1981).

The Newark soils (Figure 9) are very similar to the Atkins soils mentioned above in that they occupy flood plains and are therefore formed by recent alluvium (USDA, 1981) and are classified as entisols, being much too recent and free of categorizable characteristics to be put in any of the more narrow categories (USDA, 1981) (Idaho, 2023). The Newark soils are quite deep to bedrock, with the bedrock typically being at least five feet from the surface. From the surface for the first nine inches, it is silt loam, with the next twenty-five inches, down to a depth of thirty-four inches from

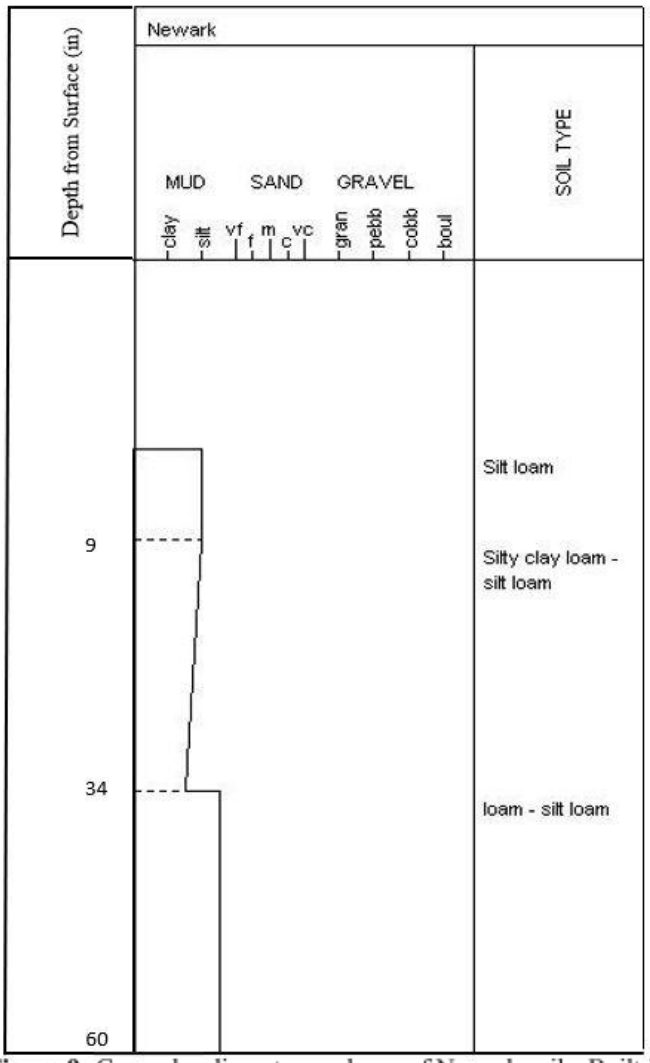


Figure 9: General sedimentary column of Newark soils. Built in SedLog and then modified. Abbreviations: vf - very fine, f - fine, m - medium, c - coarse, vc - very coarse, gran - granule, pebb - pebble, cobb - cobble, boul - boulder

the surface, it differs from silty clay loam and simply silt loam. The final twenty-six inches down to a depth of sixty inches is loam stratified with silt loam (USDA, 1981).

Gilpin-Wharton-Upshur association

This association is found in both undulating and hilly uplands, with long and narrow, gently sloping ridgelines and a scattering of rounded knobs. Small streams and drainage ways dissect this association very often as well (USDA, 1981). This association is the most extensive, being found in northern Allegheny County and making up 32% of the entire county. It is comprised of 35% Gilpin soils, 20% Wharton soils, and 5% Upshur soils, with the difference being made up of various minor soils (USDA, 1981).

The Gilpin (see Figure 4) and Upshur (see Figure 5) soils here are the same as was mentioned previously, with the added detail of Gilpin soils typically occurring on convex slopes, while the Upshur soils, in contrast, typically occur on concave slopes in this association (USDA, 1981), since this association deals with gentler slopes instead of steep valleys as the previous ones did.

The Wharton soils (Figure 10) have formed from the weathering of acidic, gray clay shale (USDA, 1981). They are classified as ultisols, much like the Gilpin soils mentioned above (USDA, 1981) (Idaho, 2023). The

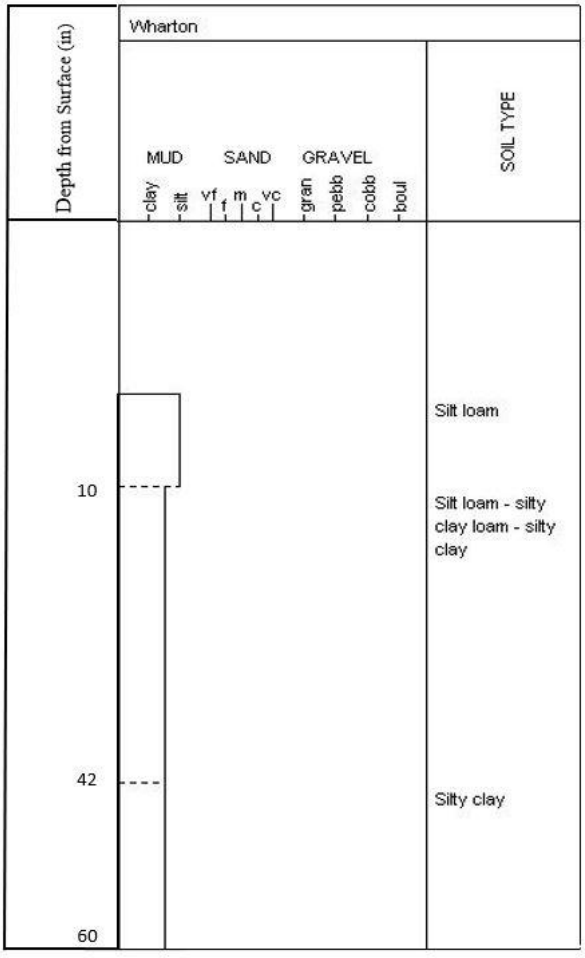


Figure 10: General sedimentary column of Wharton soils. Built in SedLog and then modified. Abbreviations: vf - very fine, f - fine, m - medium, c - coarse, vc - very coarse, gran - granule, pebb - pebble, cobb - cobble, boul - boulder

surface layer of Wharton soils is about ten inches thick and is characterized by a silt loam. The next layer occupies the space from ten inches to forty-two inches below the surface and is made up of a mixture of silt loam, silty clay loam, and silty clay. The final section reaches from forty-two inches to sixty inches and is characterized by silty clay. The bedrock here can be reached at about eight feet and is a gray clay shale, but it seems that soil data were only gathered on the first five feet (USDA, 1981).

Dormont-Guernsey-Culleoka association

This association is very similar to the Gilpin-Wharton-Upshur association in that it occupies uplands and hilly areas as well as being highly dissected by waterways, with the distinction that it is in the southern part of Allegheny County, and only makes up 18% of the county. It is comprised of 35% Dormont soils, 10% Guernsey, and 10% Culleoka (USDA, 1981).

The Dormont soils (Figure 11) formed from a mixture of the weathering of nonacidic shale, clay shale, and limestones (USDA, 1981). They are classified as alfisols like the Upshur and Culleoka soils before, owing to their forested past and relatively temperate climate (USDA, 1981) (Idaho, 2023). The Dormont soils are silt loam from the surface to a depth of seven inches, silt loam to silty

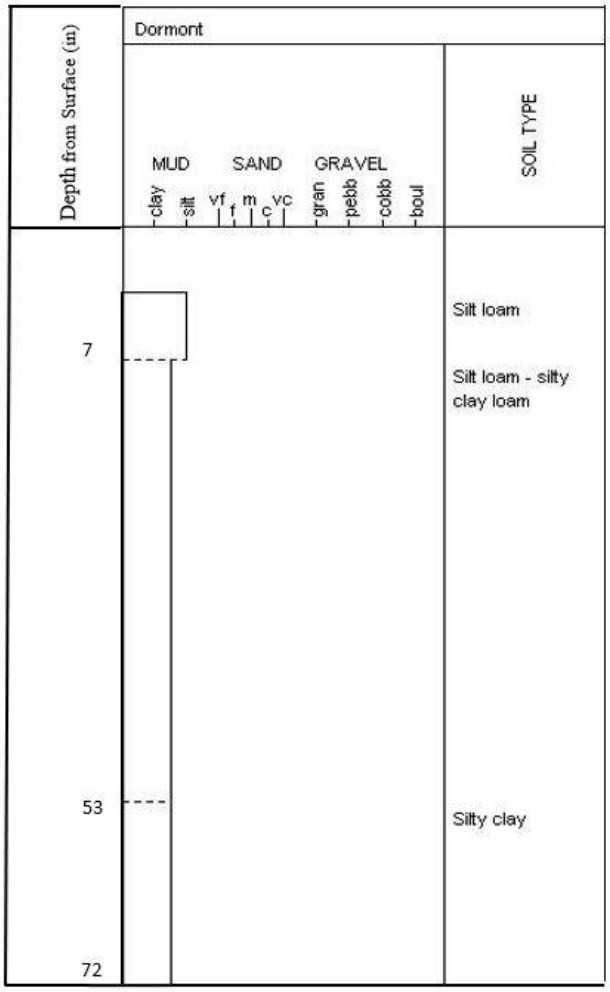


Figure 11: General sedimentary column of Dormont soils. Built in SedLog and then modified. Abbreviations: vf - very fine, f - fine, m - medium, c - coarse, vc - very coarse, gran - granule, pebb - pebble, cobb - cobble, boul - boulder

clay loam from seven inches to fifty-three inches, and from fifty-three to seventy-two inches it is silty clay. The bedrock is shale and limestone that is somewhere beneath the sample area, but data are not available past seventy-two inches (USDA, 1981).

The Guernsey soils (Figure 12) have formed from nonacid clay shale and limestones (USDA, 1981). They are also classified as alfisols (USDA, 1981). The Guernsey soils are made up of silt loam for the first seven inches, and from seven to thirty-eight inches the Guernsey soils are made up of silty clay loam, silty clay, and clay, with the final twelve inches down to a total of fifty inches is a shaly silt loam. The bedrock for this soil group is limestone and clay shale and is located at least eight feet beneath the surface, but data below the sample area are unavailable (USDA, 1981).

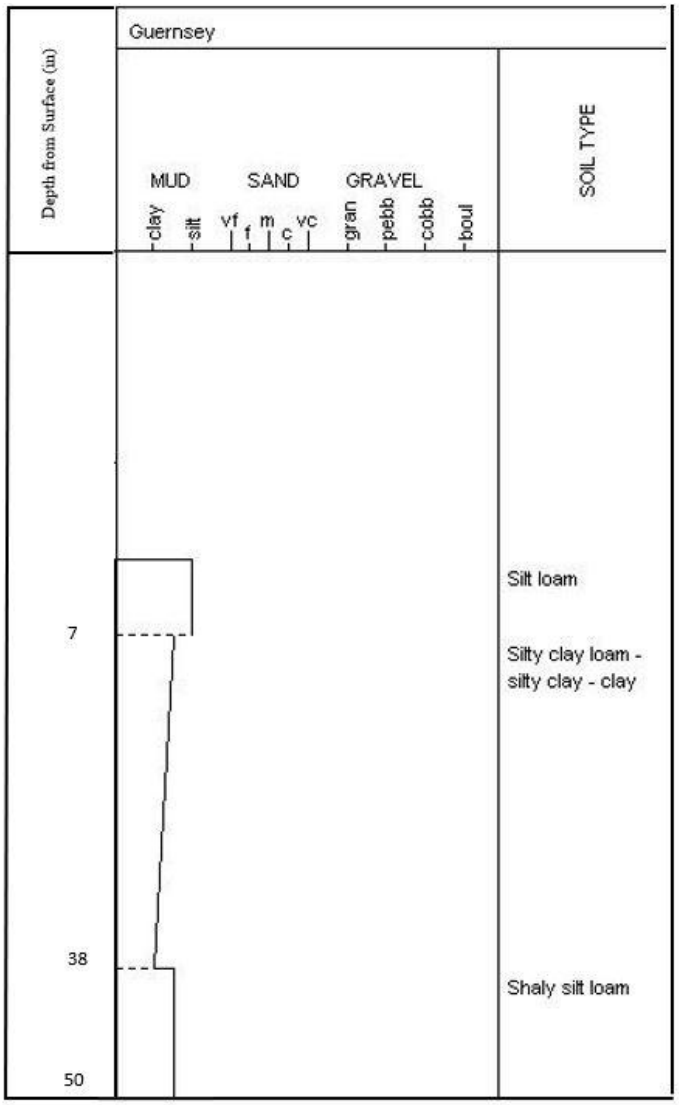


Figure 12: General sedimentary column of Guernsey soils. Built in SedLog and then modified. Abbreviations: vf - very fine, f - fine, m - medium, c - coarse, vc - very coarse, gran - granule, pebb - pebble, cobb - cobble, boul - boulder

The Colleuka soils (see Figure 8) here are the same as mentioned above, except for the slopes being much shallower, owing to the location of this association being undulating uplands while the previous association was found along steep valley slopes (USDA, 1981).

Areas Dominantly Altered

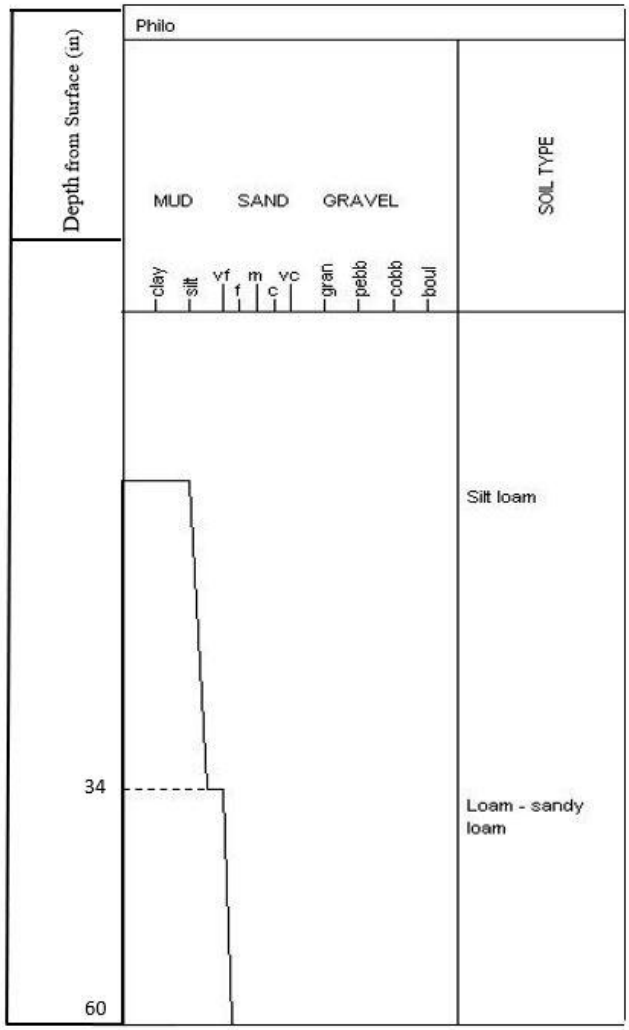
Urban land-Philo-Rainsboro association

This association, the first of the associations where the soils have been dominantly altered by either urbanization or strip mines, makes up about 6% of Allegheny County. It is found primarily on bottomlands adjacent to major waterways. It is comprised of 70% urban land, 10% Philo soils, and 10% Rainsboro soils, with the remaining 10% being various minor soils (USDA, 1981).

Urban land or urban soil is the name largely given to any piece of land or profile of soil that has been sufficiently altered by efforts of urbanization (USDA, 1981). For a while, this category was not very well understood, but recent work (Hermann et al., 2020) has been done in multiple cities across the United States to see if some model could be made for how these soils form and what characteristics they might have. Regardless of pre-urban parent materials and heterogeneity, urban soils seemed to uniformly converge inward to a single soil type. This is a fine-grained soil with comparatively lower carbon content from pre-urban conditions (Herrmann et al., 2020). It has been observed that urban soils overall take what soils preexisted urban conditions and move them toward an intermediate value between all constituent parts. This is favorable for urbanization, construction, and the support of buildings, along with other urban uses, but puts a strain on the soil to perform any of the normal ecosystem services it usually would (Herrmann et al., 2020).

In Pittsburgh in particular, these urban soils present differently than they might in other cities in terms of trace metals left behind from the huge industrial history Pittsburgh has. The most studied trace metal in these soils is lead, but there also exist trace amounts of arsenic, cadmium, copper, and zinc (Maxim, 2022). Interestingly, it seems that dominant modern wind

channels as well as paleochannels play a role in deciding where trace metals are concentrated, being areas of atmospheric temperature inversions, that, as a result, concentrate air contaminants and transfer them into the soil (Maxim, 2022). In fact, the differences in trace metal concentrations can be used to infer what use that land may have had in the past, with areas enriched with cadmium relative to zinc predominantly being located around historical coking operations, a process that essentially refines raw coal into coke, an essential piece of the steel production process, by expelling impurities (West Cumbria Mining, 2023), and areas enriched with lead relative to zinc being located around secondary lead smelters. This approach is not perfect, however, as at times construction projects can move soils to and from areas, making nailing down the genesis of contaminants difficult at times, as it is unclear if they are original to the area or have been disturbed and moved (Maxim, 2022).



For the sake of brevity, any reference to urban soils will be referred back to these paragraphs to avoid repetition. Additionally, due to a lack of stratigraphic data, a representative sedimentary column of urban land could not be constructed.

As this association is found along waterways, Philo soils (Figure 13) are found in floodplains typically adjacent to streams and as

such owe their genesis to recent alluvium (USDA, 1981). They are classified as inceptisols (USDA, 1981), much like the Weikart soils before, meaning they are new and have some small definitional characteristics beginning to form, but not enough yet to allow them to be more fully classified (Idaho, 2023). From the surface, Philo soils exhibit about thirty-four inches of silt loam, with thirty-four to sixty inches being loam or sandy loam. Data on the bedrock underlying these Philo soils is unavailable, but it is further below the surface than the five-foot interval for which soil data are available (USDA, 1981).

Figure 13: General sedimentary column of Philo soils. Built in SedLog and then modified. Abbreviations: vf - very fine, f - fine, m - medium, c - coarse, vc - very coarse, gran - granule, pebb - pebble, cobb - cobble, boul - boulder

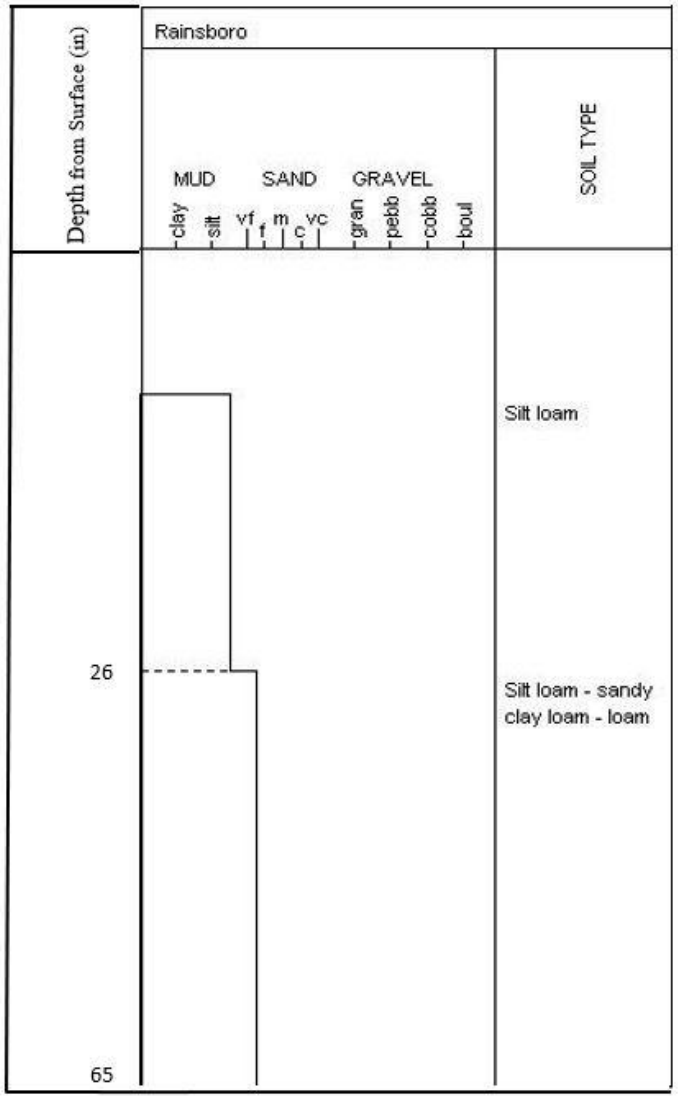


Figure 14: General sedimentary column of Rainsboro soils. Built in SedLog and then modified. Abbreviations: vf - very fine, f - fine, m - medium, c - coarse, vc - very coarse, gran - granule, pebb - pebble, cobb - cobble, boul - boulder

The Rainsboro soils of this association trace their beginnings to old acid alluvium (USDA, 1981). Rainsboro soils are alfisols (USDA, 1981), and, similar to those before, do contain clay horizons (Idaho, 2023). From the surface, Rainsboro soils have twenty-six inches of silt loam, which gives way to thirty-nine inches of silt loam, sandy clay loam, and loam (USDA, 1981.) The bedrock data are again unavailable but it is some distance yet below these soil data which

are more closely underlain by terrace materials (USDA, 1981).

Urban land-Rainsboro-Allegheny variant association

This association is found on terraces that range from level to rolling a couple of hundred feet above major streams and rivers. It makes up just 3% of the county and is 55% urban land, 25% Rainsboro soils, and 10% Allegheny variant soils, with the final 10% being minor soils (USDA, 1981).

The urban land and soils here are very similar to those mentioned before (see Urban land-Philo-Rainsboro association) and the Rainsboro soils (see Figure 14) are very similar as well (USDA, 1981).

The Allegheny variant soils (Figure 15) are formed in old acid alluvium, the name given to particularly old alluvial soils with a pH lower than 5.5 (Food and Agriculture Organization, 2023). It is likely that this acidity is due to the prevalence of trace metals in the soil. The Allegheny variant soils are underlain by stratified terrace materials (USDA, 1981). They are classified as ultisols, similar to the Gilpin and Wharton soils mentioned previously (USDA, 1981). From the surface to a depth of eight

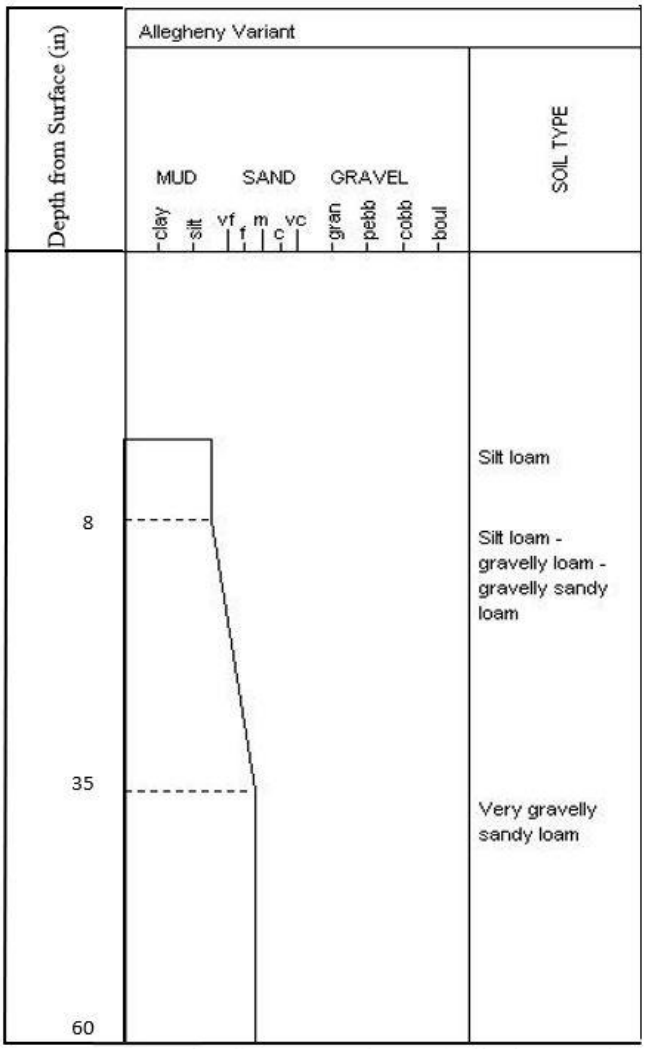


Figure 15: General sedimentary column of Allegheny Variant soils. Built in SedLog and then modified. Abbreviations: vf - very fine, f - fine, m - medium, c - coarse, vc - very coarse, gran - granule, pebb - pebble, cobb - cobble, boul - boulder

inches, the Allegheny variant soils present as silt loam, with eight inches to thirty-five inches being silt loam, gravelly loam, and gravelly sandy loam. Between thirty-five inches and sixty inches, it presents as very gravelly loamy sand (USDA, 1981).

Urban land-Wharton-Gilpin association

This association is in the northern half of the county and makes up about 3% of the county. It is comprised of mainly urban land (see Urban land-Philo-Rainsboro association), Wharton soils (see Figure 10), and Gilpin soils (see Figure 4). It shares many characteristics with the Gilpin-Wharton-Upshur association as it manifests in similar hilly areas and is also dissected by waterways and drainage. The significant difference between the two is the extensive urbanization that has taken place in these areas (USDA, 1981). All soils in this association are similar to the ones mentioned before. (USDA, 1981).

Urban land-Dormont-Culleoka association

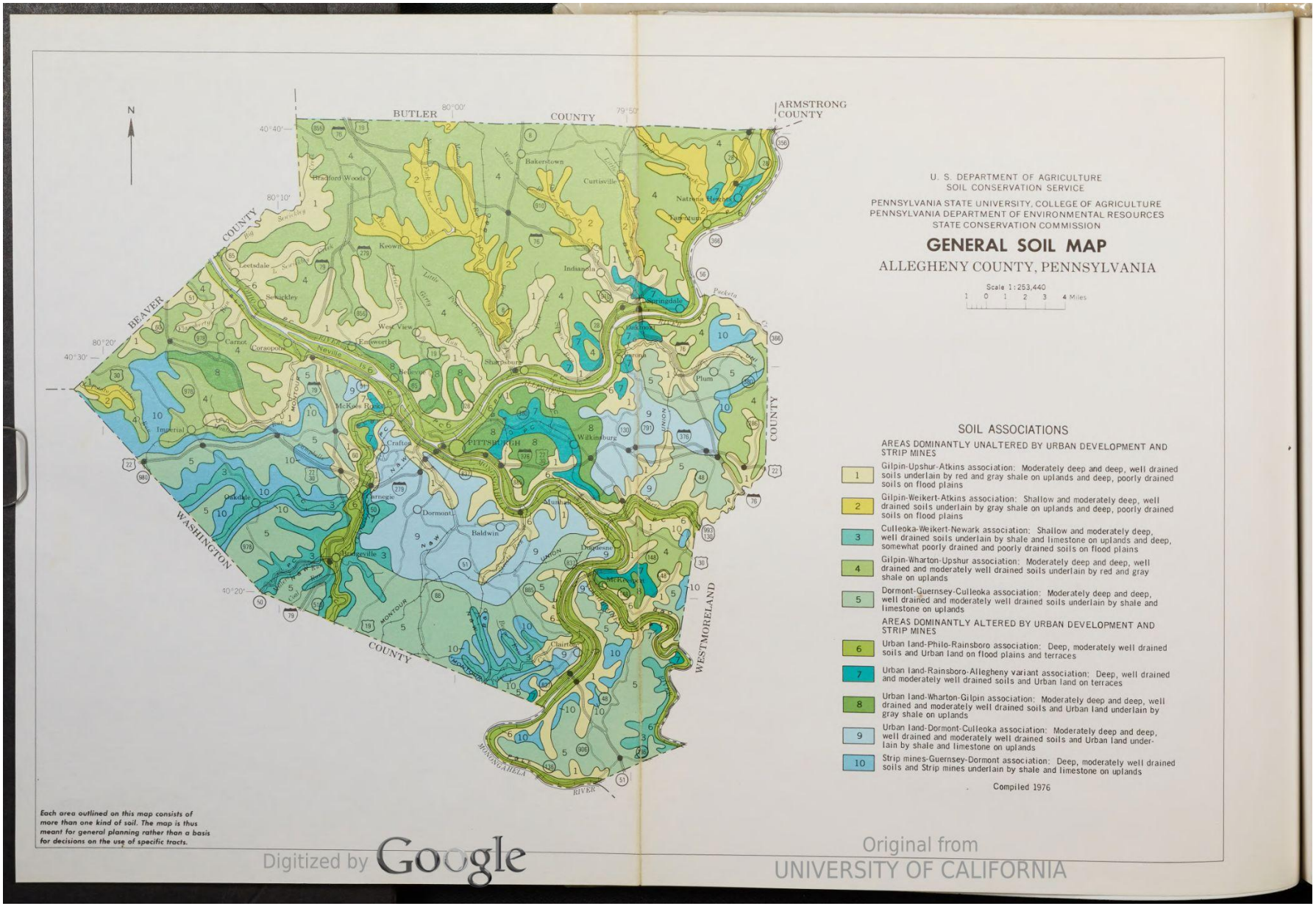
This association makes up 9% of Allegheny County and is the southern counterpart of the Urban land-Wharton-Gilpin association mentioned above, just as the Wharton-Guernsey-Culleoka association is the southern counterpart to the Gilpin-Wharton-Upshur association. This association is similarly found along level to hilly uplands and is dissected by many streams. It comprises approximately 60% urban land (see Urban land-Philo-Rainsboro association), 10% Dormont soils (see Figure 11), and 10% Culleoka soils (see Figure 8), with the last 20% being minor soils. Every soil in this association is the same as has been mentioned before, with the significant caveat of the large portion of urban soils (USDA, 1981).

Strip mines-Guernsey-Dormont association

This association varies from those dominantly altered associations that precede it as it does not include urban land and soils, but instead the areas that have been strip-mined. It comprises about 5% of Allegheny County and is found in the southern half of it. It is made up of 70% strip mines, 10% Guernsey soils, and 10% Dormont soils, with the remaining 10% being various minor soils (USDA, 1981).

The Guernsey (see Figure 12) and Dormont (see Figure 11) soils in this association are similar to those found in others, but the strip mines in this association are unique. Strip mine soils usually simply consist of variable spoil types leftover from coal mining. These can range from mixed soils to broken fragments of limestone, sandstone, shale, and coal, with coarse material making up 30-65% of the volume (USDA, 1981). Similar to urban land, a sedimentary column could not be constructed due to a lack of stratigraphic data.

Spoil is the name given to the overburden, or soil and rock, that overlay the coal seam that must be removed in order to actually access the coal bed for mining (Brant, 1964). These spoils, when cast aside, begin chemically weathering almost immediately (Struthers, 1964). It can take soil about a thousand years to mature into even an inch of topsoil, but this perception of gradual, linear change is deceiving, as change begins to slow incrementally as the soil gains maturity. The beginning acidic chemical weathering these spoils undergo is quite dramatic (Struthers, 1964). This, combined with the fact that only isolated pockets of the strip mine land in this association have been reclaimed (USDA, 1981) could potentially explain the general coarsely-grained mixture, given the nature of strip mine spoils.



Map 1: General Soil Map, Allegheny County Pennsylvania (USDA, 1981).

Table 1: Overall Soils Table

Soil groups are organized by order mentioned in **The Soils of Pittsburgh**. Depths from surface list multiple depths to give a full picture of the representative profiles, but also to potentially aid in the reading of the sedimentary columns. Data from USDA, 1981. -Sol classification follows classifications from USDA, 1981.

light red indicates soil groups that are in both dominantly altered and unaltered associations

darker red indicates soil groups that are solely in dominantly altered associations

boxes left white indicate soil groups that are solely in unaltered associations

Soil Group	Depth from Surface (in)	Primary Soil Type	-Sol classification (USDA, 1981)
Gilpin	5 23 31	Silt loam Shaly silt loam Very shaly loam	Ultisols
Upshur	6 31 64	Silt loam Clay Silty clay	Alfisols
Atkins	8 34 60	Silt loam Silt loam Loam	Entisols
Weikart	6 12	Shaly silt loam Very shaly silt loam	Inceptisols
Culleoka	7 27 29	Silt loam Silt loam Very channery clay loam	Alfisols
Newark	9 34 60	Silt loam Silty clay loam Loam	Entisols
Wharton	10 42 60	Silt loam Silt loam Silty clay	Ultisols
Dormont	7 53 72	Silt loam Silt loam Silty clay	Alfisols
Guernsey	7 38 50	Silt loam Silty clay loam Shaly silt loam	Alfisols
Philo	34 60	Silt loam Loam	Inceptisols

Rainsboro	26 65	Silt loam Silt loam	Alfisols
Allegheny Variant	8 35 60	Silt loam Silt loam Very gravelly sandy loam	Ultisols
Urban Soils	-	Fine-grained, homogenous mixture	-
Strip Mines	-	Mix of clasts and conglomerates	-

Pittsburgh Soils and Land Use

Ascertaining land use as Pittsburgh has developed is difficult. The majority of the maps from the early years of the city are fire insurance maps from the Sanborn company that I accessed through the Senator Heinz Historical Center Archives in Pittsburgh. Additional maps come from a handful of other publishers and Google Earth. These maps were digitized and placed into an ArcGIS program by the University of Pittsburgh (University of Pittsburgh, 2023), and I used this ArcGIS program to analyze these maps for this section. The main issue with such maps is that they do not always catalog the whole of Pittsburgh throughout all of the years (for more, see Discussion: Data Caveats). These maps are then cross-referenced to the map of the soil associations (see Map 1).

Gilpin-Upshur-Atkins association

In the early years of Pittsburgh's settlement, this association would have likely been one of the first that people began to develop upon, given its general proximity to the rivers (Fang & Jawitz, 2019). At the confluence (a geographical landmark that will be utilized to aid in

understanding the spatial relations in this section), this quickly became high-density residential developments alongside industry and commercial sectors as well. By 1872, modern downtown Pittsburgh would have been fairly well-developed already, as the surrounding areas, further from the confluence and modern downtown were more sparsely populated and closer to low-density residential areas (Sanborn Map Company, 1872; University of Pittsburgh, 2013). These trends of mixed-use continued into the new millennium, with 1903-1906 maps showing the continuing development of the city. Neighborhoods grew denser and industries grew larger (Sanborn Map Company, 1903-1906).

In the modern day, much of the land occupied by the Gilpin-Upshur-Atkins association is quite varied in use. Its general position along waterways and rivers has given it versatility, in that it is currently situated under commercial districts near the confluence of the three rivers, with the commercial sectors giving way to low, medium, and high-density residential areas as well as heavy industrial areas as the distance from the confluence increases. Further out, beyond these, forests dominate the association (County of Allegheny, 2015). Overall, this soil association seems quite varied in use and does not have a solid, definite use either in historic Pittsburgh or current Pittsburgh (University of Pittsburgh, 2013).

Gilpin-Weikart-Atkins association & Culleoka-Weikart-Newark association

These associations are grouped because their similarities in their depositional environment also correlate to their similarities in land use. They are both found along steep slopes alongside rivers and in the floodplains around them (USDA, 1981). For this reason, development has been different for these associations.

The Gilpin-Weikart-Atkins association escapes most available maps, as it is north of the Allegheny River, where many of the maps in the ArcGIS program do not have data. However, the 1862 and 1872 maps do show the areas that this association covers, and depict a quite rural, sparse area in these years (Beers, 1862; Sanborn Map Company, 1872). In modern-day Pittsburgh, interestingly, this association still follows waterways in areas, including Pine Creek, Bull Creek, and Deer Creek, but is also used for transportation, with multiple highways cutting through this soil association, with the unused land largely being forested (USDA, 1981; County of Allegheny, 2015; Google Earth, 2023; University of Pittsburgh, 2023).

The Culleoka-Weikart-Newark is the GIlpin-Weikart-Atkins association's counterpart in the southern half of Allegheny County, south of the Allegheny and Monongahela. This association also lacks data for a significant portion of its history, but comparing 1862, 1872, and modern imagery, this association seems to have always held relatively rural, sparsely populated areas, with a couple of clusters of low-density residential areas (Beers, 1862; Sanborn Map Company, 1872; USDA, 1981; County of Allegheny, 2015; Google Earth, 2023; University of Pittsburgh, 2023).

Gilpin-Wharton-Upshur association & Dormont-Guernsey-Culleoka association

Similar to the last grouping of the Gilpin-Weikart-Atkins association & Culleoka-Weikart-Newark association, these two associations are also counterparts that represent the northern, Gilpin-Wharton-Upshur, and the southern, Dormont-Guernsey-Culleoka, halves of the county. These associations are the most extensive of the ten, and, as such, have a quite varied land-use history (USDA, 1981).

The Gilpin-Wharton-Upshur association here has the same issues with data availability as the previous Gilpin-Weikart-Atkins does. Because this is mainly part of the northern half of the county, many of the early maps do not show much of this association, if any at all. Once again, data is taken from 1862, 1872, and more modern imagery. The 1862 and 1872 maps show this association being a very rural area. Many of the forests you may see in other, smaller associations have been cut down to make room for agricultural land (Beers, 1862) (Sanborn Map Company, 1872). The more modern imagery reveals that this rural, agricultural use is now a figment of the past, as much of the land has shifted to use in suburban development, with minor pieces being used for recreational purposes ((USDA, 1981; County of Allegheny, 2015; Google Earth, 2023; University of Pittsburgh, 2023).

The Dormont-Guernsey-Culleoka association has much the same story in the southern half of the county. The 1862 map shows this association being incredibly sparse, with inhabitants mainly living near various creeks and other small waterways throughout the association (Beers, 1862). In 1872, the association became a hair more lively, with some more farmhouses popping up throughout, as well as a handful of communities that are small but substantial, especially when compared to the rest of the association. The 1923 Sanborn map shows this association beginning to suburbanize, as more and more developments start to fill up what used to be farmland or simply idle fields (Sanborn Map Company, 1923). By the mid-1900s, this association was more or less fully suburbanized, with some areas being left for recreational use, agriculture, or simply left idle. Modern-day Pittsburgh continues in much the same way, continuing to develop as urban sprawl demands more and more land (USDA, 1981; County of Allegheny, 2015; Google Earth, 2023; University of Pittsburgh, 2023).

Urban land-Philo-Rainsboro association

The first of the dominantly altered associations, this association is located along the rivers in and around Pittsburgh, including, most importantly, the Ohio, Allegheny, and Monongahela. This, alongside the Gilpin-Upshur-Atkins association, would likely be the very first association that was settled in the early days of Pittsburgh. A 1796 engraving shows a very early plan for the development of Pittsburgh, and focuses on the confluence of the Ohio, Allegheny, and Monongahela, showing a small community between the rivers and a few farms outside them (Collot, 1796). An 1830 map shows the development of this plan, with a much higher-density residential community beginning to form between the Allegheny and Monongahela, the place the original plan sought to focus its development. Outside of the rivers though, development also continued. Small, but growing, communities overtook the farms that were planned outside the rivers as the city began to expand (Barbeau, 1830). By the turn of the 20th century, the communities along riverbanks had given way to industrial plants that lined the rivers in Pittsburgh and took up a decent amount of space, however, some smaller industrial factories and plants did leave room for higher-density residential areas behind them. Additionally, there were quite often railways or other such methods of transport immediately between the factories and the rivers (Sanborn Map Company, 1903-1906). By the late 20th century, much of the old steel industry was out of downtown Pittsburgh, and as such land use became more residential and commercial. In the modern-day, these areas are further developed, with uses ranging from light to heavy industrial, commercial, variable-density residential, and even some forests in areas that could not support a building, such as steep hillsides. These areas are also highly used for transportation, via train, highway, or other such means (USDA, 1981; County of Allegheny, 2015; Google Earth, 2023; University of Pittsburgh, 2023).

Urban land-Rainsboro-Allegheny variant association

This association is quite a small one and mainly is found along river terraces. The map from 1862 shows this association mainly being the site of developing communities, and the map from 1872 sees this trend continuing as the communities continue to grow, growing into denser and denser residential areas (Beers, 1862; Sanborn Map Company, 1872). By 1923, these areas had grown significantly (Sanborn Map Company, 1923), and by modern-day, these areas remain largely places of urban and suburban sprawl, perhaps being the next area on the chopping block of urbanization (County of Allegheny, 2015; Google Earth, 2023; University of Pittsburgh, 2023). Some of the deposits of the Allegheny Variant soil group have additionally been used as sand and gravel mines (USDA, 1981).

Urban land-Wharton-Gilpin association

This association is another rather small one. It is largely located at the Point, between the Allegheny and Monongahela Rivers, and as such shares much history with the previous Urban land-Philo-Rainsboro association, with the caveat that where the Urban land-Philo-Rainsboro association is located on or at least quite near to the river banks, this association is further from the bank and thus more central on the Point. Here too would have shared the journey from the residential plan (Collot, 1796) to higher density residential (Barbeau, 1830) to eventually becoming more and more commercial as time went on, until the modern day where it houses a mixture of commercial and residential (Sanborn Map Company, 1923) (USDA, 1981; County of Allegheny, 2015; Google Earth, 2023; University of Pittsburgh, 2023).

Urban land-Dormont-Culleoka association

The 1862 map shows this association being fairly densely populated for the time, with most of the homes concentrated along main roads as development began to spread (Beers, 1862). By 1872, some sizable communities had begun to take shape (Sanborn Map Company, 1872). As the years progressed, these areas became more and more developed, and thus more densely populated. By 1923, the areas were fully urbanized, with high-density residential areas, a couple of parks, and one or two large property lots that belonged to different people (Sanborn Map Company, 1923). In modern-day Pittsburgh, these areas are mainly used for urban development, with the predominant use case being residential areas of variable densities (USDA, 1981; County of Allegheny, 2015; Google Earth, 2023; University of Pittsburgh, 2023).

Strip mines-Guernsey-Dormont association

Finally, this association is different from the rest if for no other reason than the presence of the strip mines. This land was sparsely populated early on, much like other areas (Beers, 1862; Sanborn Map Company, 1872), but unlike other areas, a large part of this association never truly got the chance to develop in a similar vein to all the rest because of the strip mining that occurred on it. In modern times, very little of this land has been reclaimed. Much of it sits idle, and any depressions in or around old strip mines fill with acid water, complicating remediation attempts (USDA, 1981; County of Allegheny, 2015).

Discussion

Overall, this review has shown that the soil profiles of Allegheny County did and do have - admittedly to varying degrees - an impact on how certain land areas were used. However, in the

case of the dominantly altered associations, interestingly, it is quite often the reverse: land use in fact determines the soil type (Herrmann et al., 2020; Maxim, 2022). Some associations proved more influential than others early on, such as the Gilpin-Wharton-Upshur association and the Dormont-Guernsey-Culleoka association, which proved to be excellent areas for early agriculture, allowing Pittsburgh to get off the ground, so to speak (Beers, 1862; Sanborn Map Company, 1872), but as the city developed more, it seemed that the expansion occurred regardless of the soil. In the modern-day, urbanization is occurring at a rate such that significant portions of the various soil associations are now being used for residential, commercial, or industrial purposes regardless of their characteristics (University of Pittsburgh, 2013).

This dynamic between land use and soil characteristics provides an interesting tool for use in predicting what unaltered soils might look like if they were to undergo urbanization. I suspect, in this particular case, there are some soils which this will never be very likely for, namely the Gilpin-Weikart-Atkins and Culleoka-Weikart-Newark associations, due to their topographical locations on steep slopes and hillsides dissuading any serious development. Other than those, though, I could see most, if not all, of these unaltered soils one day entering into the realm of the homogenized, fine-grained, low-carbon soils that urban land creates (Herrmann et al., 2020).

Additionally, I predict that soils reverting from urban land to another, newer, more defined soil type, while possible, would require a timeline free of interference that very few cities would be willing to give. This is without mentioning all the work humans would likely do to either mitigate erosion or halt it altogether, which would further complicate the process of erosion and the formation of a new soil type. While parks and other areas where soils are somewhat freer in these regards may show some promise in terms of this kind of remediation, I

suspect that such areas would still have their soils monitored and kept to a certain stasis. In this way, it may be possible to prevent the urbanization of the soil if the soil is still natural when the park is instated, but it seems rather more difficult to me to take an area of soil that has been urbanized and revert it without opening the area to natural erosion processes that would be wholly disruptive to a typical urban setting.

These data are very likely not unique to Pittsburgh either Urban soils are spread throughout the nation's cities (Herrmann et al., 2020) and I think these same conclusions can likely be drawn with other cities that share similar industrial pasts, such as nearby Cleveland or Cincinnati, or even perhaps manufacturing cities such as Saint Louis, Missouri. Although obviously, the details of each case would be different, it would seem to me that other cities likely share these patterns, and, as such, analyses like these can be an aid in not only understanding how it is that we have arrived here but also what we have waiting for us if we were to continue on our current path.

Data Caveats

One of the main difficulties of this research is gathering historic maps of Pittsburgh. As mentioned before, the maps were created by the Sanborn fire insurance company, which made the maps to assess fire risk. Incidentally, this means they only show more densely populated areas and leave out those areas which may be more rural, leading to a skewed view of how much of early Pittsburgh was urban and how much of it was more agricultural. There are county maps of the whole of Allegheny County from 1862 and 1872, but this scale is not seen again until 1967, in the form of satellite imagery, meaning that there are ninety to one hundred years in

which the maps focus more on the city center and less on the more agricultural, or perhaps suburban, areas outside of it.

Future Work

Future work might look into resolving these map gaps so that more thorough analyses can be undertaken. These would provide a more full understanding of the relationship between soil profiles and land use in the Pittsburgh area, and may also provide a template for future work looking at comparable cities elsewhere in the nation.

I do think that while the general processes of this work can provide a base on which other work can excel, a lot can be improved as well. While all the data is available in the literature for the soils of Pittsburgh, I do think that if a similar project to this one is ever within a larger interval of time, some first-hand samples could be a great help towards more fully understanding the area and the conditions within it. Additionally, in this work I presented generalized representative profiles of the different soil groups in the form of sedimentary columns based on the data from (USDA, 1981). It might help make a more full, coherent, and cohesive image of the survey area and the project as a whole if there were a couple of different sedimentary columns from a couple of different sample sites, and while with an area of this scale that may prove ambitious, I do think it would be a huge help, as well as a fantastic experience for the researcher to get some hands-on experience with sampling techniques.

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