Combe Fill South Landfill

Brief Research on the History and Remediation of the Superfund Site

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May 9, 2022

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Abstract

One of the most common EPA Superfund selected sites in the US seem to be groundwater contaminated sites. It is always easier to dump waste and pollute sites than to clean it up. During the mid to late 90s, this Combe Fill South Landfill was exposed to some hazardous chemical dumping without any care for the impact on the land and groundwater. These chemicals leaked their way into the aquifers underground and it is still impacting the groundwater, surface water, sediment/soil, and residents within the area. The common groundwater remediation method, pump and treat systems, has been implemented onto the site since early 90s and has been monitored and updated since. Recently, a record of decision was passed by the EPA to establish a long-term monitoring remediation system for the site to continue to treat and monitor the contaminated groundwater. With all the updates and improvements to the remediation system, the duration of the remediation period is unpredictable.

Background of the Landfill

The Combe Fill South Landfill operated as a landfill from 1948 to 1978 by a company named Chester Hills, Inc with being licensed for domestic non-hazardous municipal and corporate solid wastes. In 1978, Combe Fill Corporation (CFC) bought the site and continued operating the landfill until 1981. The landfill generally accepting the following wastes during these 40 years: “household wastes, personal care products, pharmaceutical products, calcium oxide, crushed containers of paints and dyes, aerosol product canisters, industrial wastes, dead animals, sewage sludge, septic tank wastes, chemicals, waste oils, and possibly asbestos” [1]. From 1973-1981, there were violations in the maintenance of the landfill. (especially disregarding the placement of residual soil layer on the waste dumping). During this time, there was suspicious material being dumped into the landfill during off-hours at night that contained hazardous chemicals where barrels of waste were buried across the site [2]. CFC was not able to meet New Jersey’s solid waste regulations. By 1981, CFC was seized for not being able to meet New Jersey’s solid waste regulations and filed for bankruptcy.

Soon after the site was shut down and NJDEP ordered to stop sending waste to the landfill. After water sampling and testing from private NJDEP wells, it was discovered that some of the wells were contaminated with volatile organic compounds (VOCs). Considering that this landfill area is semi-rural with fishing places, horse farms, grain and vegetable crops, and 350 homes, this contamination was an immediate concern.

By 1983, the site was selected as a superfund site by the EPA and the State for a remedial investigation and Feasibility Study (RI/FS) which was conducted from 1984-85 by the NJDEP that helped identify contaminants/chemicals of concern (COCs) in the groundwater. These studies helped in understanding the extent of the contamination in the aquifers and in making decisions on the best remedial actions to implement on the site. In 1986, CFS signed an ROD agreement for the remedial actions implemented onto the site.

During soil investigations in December 2003 and June 2004, (that involved field reconnaissance, drilling operations and test pit excavations) it was revealed that large amounts of pharmaceutical wastes, PCPs, and 55-gallon drums of hazardous wastes were buried within the northern edge of the site. Some barrels were buried right outside the landfill boundary; this area has later become known as the North Waste Cell.

Public Water Supply Extension

Ever since the results of water samples in early 1980s indicated contamination of VOCs, it was declared that an area of 62 homes (expanded to 325 homes by 1989) by “Schoolhouse Lane, Parker Road, and part of Old Farmers Road” would need alternative water supply [1]. Early 1990s sampling indicated that only a few homes were impacted than originally predicted. Therefore, the waterline extension plan was deferred, and POET systems were installed to 32 homes in the vicinity of the site and were checked 1-4 times a year. Later when 1,4-dioxane was first detected in 2008, the need for an alternate water supply was again reinforced because POET systems were ineffective in treating 1,4-dioxane as shown in NJDEP investigations. Experiments and analyses failed to develop effective treatment systems for reducing 1,4-dioxane levels in the water.

In January 2011 EPA conducted a residential well investigation within the area. 213 potable water samples were collected from 160 homes (in Chester and Washington Townships). In June 2011 75 samples from 52 homes and the landfill treatment plant were collected. Tests and analytical results of the residential well investigation indicated that 13 homes in the North and East of the site had high levels of 1,4-dioxane concentrations (well above 3 μg/L).

In April 2011, EPA developed a treatment system to reduce 1,4-dioxane concentrations incorporating a combination of ozone addition and UV radiation. During the testing of the system, it indicated about 50% reduction in 1,4-dioxane concentrations and if the process was done multiple times, about 99% removal of the contaminant was shown to be possible. This was a feasible interim measure that was implemented until the alternative water extension supply could be constructed.

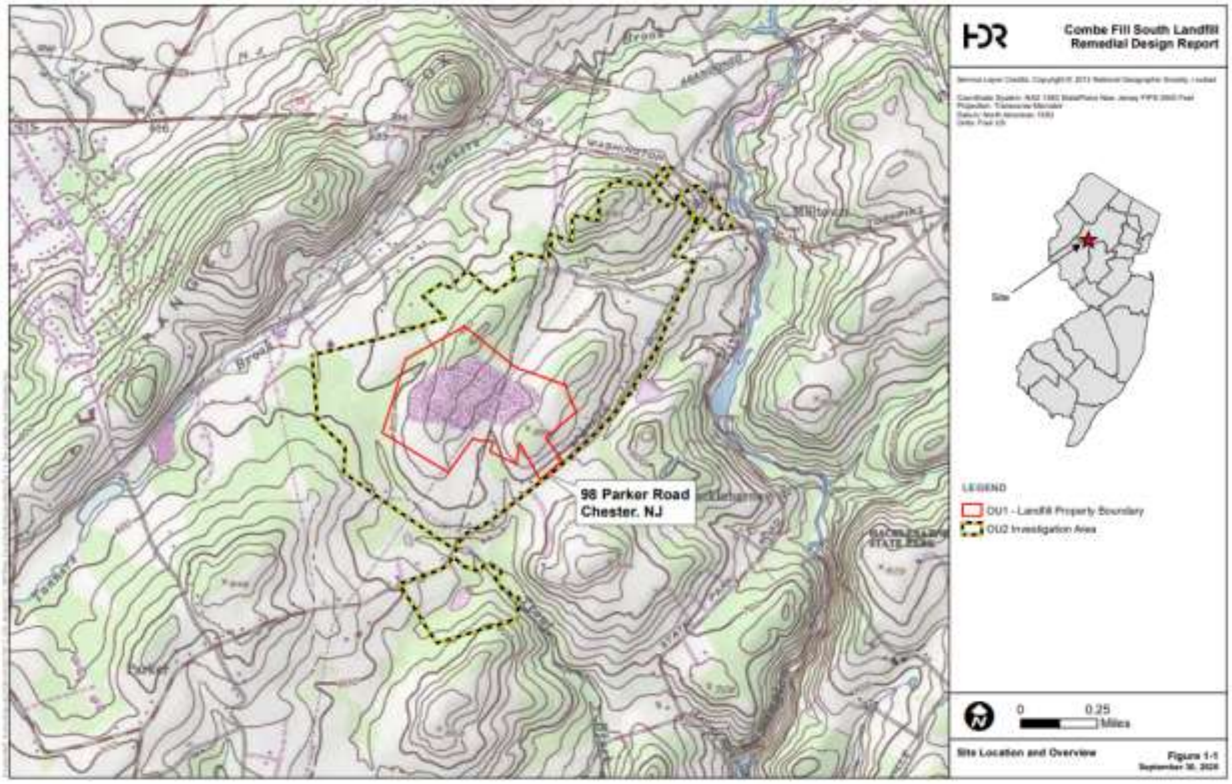
Designs for the waterline extension project were created around 2011-2012, permits were established by 2013, and it was fully constructed by July 2015. This waterline was provided for 79 total connections of residences and businesses that were affected by the groundwater contamination.

Investigative Studies and Site Characterization

Initial Remedial Investigation/Feasibility Studies (RI/FS)

After initial RI/FS studies in early 1980s and 1990s, two main operable units were established to focus on remedial actions. They are shown in the figure below as OU1 and OU2 [5].

Figure 1. The Operable Units 1 and 2 areas and the landfill property areas are shown [5].



The remedial investigations for OU1 were conducted from 1984-1985 by the NJDEP in which the main COCs were identified. By 1986, the ROD regarding the remediation process for the OU1 area was signed. This plan includes:

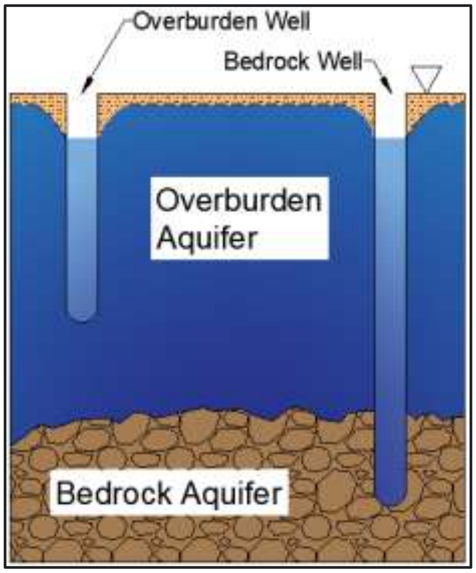
(1) alternate waterline supply for nearby homes,
(2) landfill capping with synthetical material or clay (preventing surface water or rainwater from absorbing through the contaminated site soil),
(3) installation of a landfill gas collection and treatment system,
(4) surface water and stormwater collection system,
(5) installation of a groundwater and leachate extraction and treatment system (water is then discharged into local waterways–Trout Brook), and
(6) environmental monitoring (further RI/FS studies to monitor the contaminant concentrations in the aquifer).

The landfill capping (2) and surface water collection system (3) were completed by the NJDEP from 1996-97. The target identified COCs at the time of the study were benzene, TCE, DEHP, alpha-BHC, lead, arsenic, and chromium. 1,4-dioxane was added to the COC list after it was discovered in 2011.

Groundwater Flow - Overburden and Bedrock Aquifers

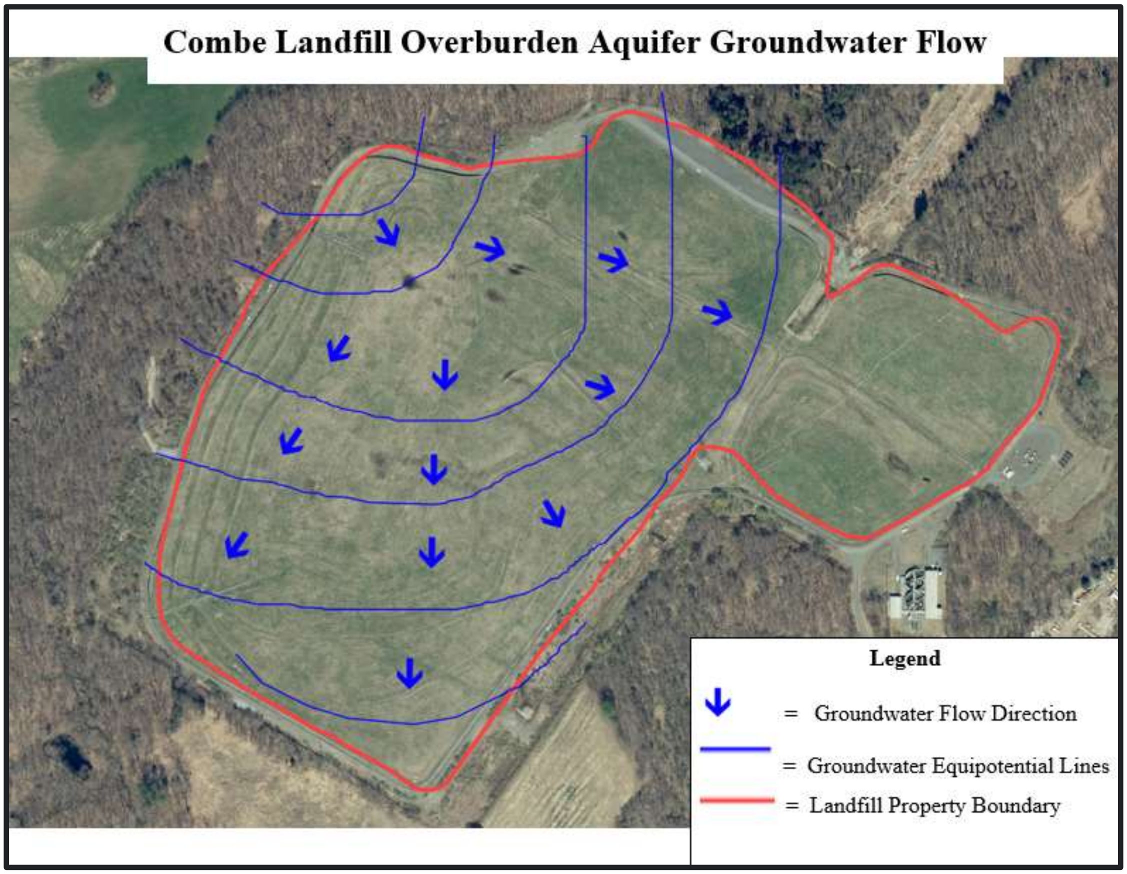
The landfill area lies over two main aquifers, the overburden or shallow aquifer and the bedrock aquifer. Much of the overburden aquifer has been contaminated with the landfill disposed wastes and is heavily monitored by groundwater sampling and testing to understand the plume of the contamination within the aquifer. While there are less bedrock wells, it is also being monitored frequently to prevent the contaminants from leaking through the overburden.

Figure 2. Shows the cross section of the groundwater table (▽), overburden aquifer, bedrock aquifer, and their drilled wells.



Overburden aquifer groundwater flow components:
(1) Horizontal flow of groundwater flows outward from the site and “follows topography towards surface water bodies” [1],
(2) Groundwater flow in the overburden and bedrock interface (from the higher to lower top of the bedrock surface)
(3) Vertical flow is mainly by the steep dipping bedrock fractures towards the bedrock-overburden interface. Downward flow in the overburden and bedrock aquifers occur at the landfill site and the immediate nearby area. Upward flow occurs in the surrounding streams by the site.
(4) The bedrock aquifer flow can be predicted to be similar to the overburden flow.

*Figure 3. Depicts the overburden groundwater flow direction. Helps to understand the transport of contaminants within the aquifer.



*Except for the landfill borders, all the data points and lines are approximated from EPA documents.

Geology and Hydrology

Field studies were also performed to understand the geology and hydrology of both the overburden and bedrock aquifers. Generally, landfills affect the soil above aquifers making them to be more permeable and allowing an increase in the absorption of water and if any contaminants get through. Geology tests show that the highly permeable soil and saprolite in the overburden aquifer are responsible for most of the infiltration of precipitation and leachate from the landfill into the groundwater (also into the bedrock aquifer). into the bedrock aquifer

During the drilling wells into the bedrock aquifer, it indicated that there are deep pathways and open spaces (voids) within the rock that could have played a role for fluid or precipitation to flow through the fill. Additional “finer and tightly compacted fill materials were also observed” to have allowed more fluid to flow through the fill.

Overall, the sediment right under the landfill has the following order: unconsolidated deposits of local soils, granite saprolite, and fractured granite bedrock.

The overburden aquifer or also known as the shallow layer exists in the saprolite layer and is saturated with most of the waste. The thicknesses and the depths of the overburden vary depending on the ridges and low-lying areas in and around the site. The permeable soil and saprolite play a large role in the infiltration of precipitation to the bedrock aquifer.

The deep aquifer or the bedrock aquifer is part of the fractured granite bedrock. It was a major source of potable water for nearby residents and businesses. There are about 6 public wells within 2 miles of the site that contain this deep aquifer groundwater. There are some monitoring wells that show contamination within this aquifer, but the focus is on the overburden aquifer as it is directly impactful to the community and the environment.

Recent RI/FS Studies

After the discovery of 1,4-dioxane concentrations in the POET well samples, further investigation of the contaminant and its source was needed. Although this contaminant may have been present in the past, its concentrations were too low to be detected. Over time, accumulation of 1,4-dioxane in the aquifer increased its concentrations and became a human health and water quality concern. Therefore, a new investigation of the contamination in the landfill was imperative.

The recent RI/FS was conducted to OU1 and OU2 areas from 2010 to 2015 to investigate contamination or status of the deep bedrock aquifer and examine the extent of 1,4-dioxane contamination. This study established the following:
(1) Installation 9 pairs of piezometers and stream gauges
(2) Sample collections from 5 soil borings
(3) 200 groundwater samples, 22 soil samples, 24 surface water samples, 53 potable well water samples, and 24 sediment samples were collected
(4) Both short- and long-term water level monitoring data were collected
(5) Geographical surveys
(6) Downhole investigations
(7) Wetland delineation, wildlife surveys, well condition surveys, and land surveys

The study provided evidence indicating that the landfill and the North Waste Cell areas are the sources for 1,4-dioxane contamination within the overburden and the bedrock aquifers. The highest concentration of the contaminant was found in monitoring wells surrounding and downgradient of the North Waste Cell. It was also detected in the local surface water (Trout Brook) and the northeastern corner of the landfill. All samples exceeded 1,4-dioxane concentrations of 0.4 μg/L.

Contaminants of Concern and Health Hazards

Most of the eight identified COCs have acute, chronic, and reproductive/developmental effects. Benzene, TCE, DEHP, lead, and arsenic are also proven carcinogens to humans when exposed at large concentrations whether inhaled or consumed through water. Moreover, there is substantial evidence proving that DEHP and alpha-BHC are probable carcinogens for humans.

The nature and extent of all eight COCs within the aquifers were studied and the following are the most recent results for each contaminant.

1,4-Dioxane

Contaminant was present in both overburden and bedrock aquifers. There was a reduction in concentrations in the northeastern part of the landfill since remedial investigation phase work due to constant pumping and testing wells in 2017. The Southern area of the landfill also had a similar trend.

Benzene

Most of the contaminant plume is in the bedrock aquifer and along the utility corridor (north-east of the site). Since a 2017 long-term pump test in the extraction wells, concentrations have been decreasing, similar to 1,4-dioxane concentrations.

TCE

Although the groundwater samples within the aquifer under the capped fill material did not exceed Groundwater quality standards (GWQS), it was detected in the surrounding areas of the landfill with the highest concentrations at the north-east perimeter of the site.

DEHP

Most of the plume was identified within the bedrock aquifer along the northeast area of the landfill site during remedial investigations. However, during later detections, only one well sample indicated concentration above GWQS.

Alpha-BHC

Groundwater samples at the time of pre-design investigations indicated high concentrations exceeding standards. However, they have decreased during the remedial investigation phase of studies.

<u>Lead, Arsenic, and Chromium</u>

Lead and Arsenic concentrations were within the groundwater quality standards (GWQS) in the overburden aquifer but had fluctuating results during bedrock aquifer testing. While Chromium did not exceed GWQS in any of the pre-design investigations, it was later detected in later portions of the remedial processes.

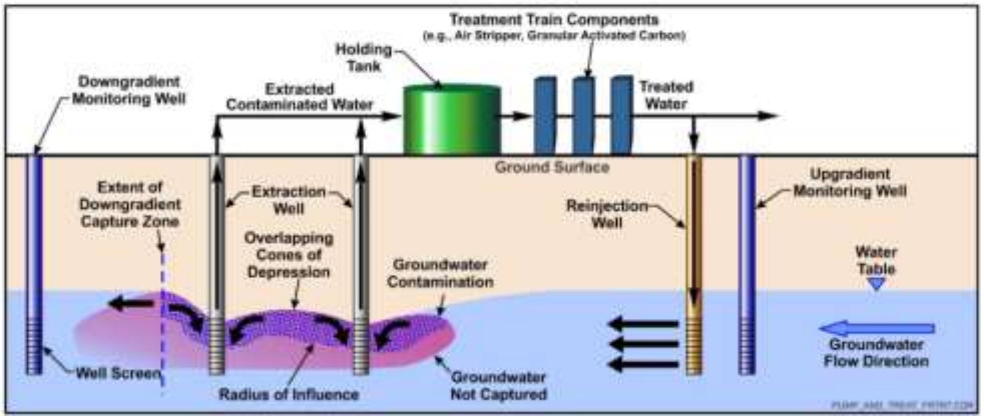
Remediation of the Site and Current Status

By 1997, the landfill cap and leachate extraction and treatment systems were installed into the site. Synthetic clay material was used to cap the landfill and a pump and treat system was installed to extract leachate from the landfill and groundwater from the aquifer, treat the contaminants, and discharge the water into Trout Brook. This pump and treat system is established by installing/drilling extraction or pumping wells throughout the site based on the hydrogeological assessments and identification of preferential flow paths within the aquifer [5]. Pump and treat system is also known as groundwater extraction and treatment system (GWET).

<u>Pump and Treat Systems or Groundwater Extraction Treatment (GWET) Systems</u>

It is a groundwater treatment system that pumps groundwater from aquifers (by drilling extraction wells), treats above ground, and discharges into local waterways. It is effective in maintaining a control of the groundwater plume and contaminant removal through diluting methods. The system is also efficient in decreasing and controlling groundwater mounding and migration.

Figure 4. General diagram of the different functions in a GWET system.



The following factors need to be considered and addressed beforehand:

(1) Contaminant type, area and volume,

(2) Capture zone analysis,
(3) Vertical & horizontal wells, recovery trenches or galleries,
(4) Number and types of extraction pumps,
(5) Treatment train components (air strippers, and/or granular activated carbon filters, etc.),
(6) Treatment system compound,
(7) Location and permitting,
(8) A monitoring well network, and
(9) Treatment system influent, intermediate, and effluent sampling points.

Generally, the extraction network wells are designed to become a barrier to contaminated groundwater flow so that the contaminated groundwater does not migrate outside of the downgradient plume so that receptors are protected. The process and motion of pumping from a groundwater well creates a "cone of depression" around the well which forms a "parabolic capture zone" (most of the groundwater from up and down-gradient directions is captured–some of the side gradient) [6]. Capture zones and cone(s) of depression must be designed well so that a proper water level is maintained to prevent mounding by a contaminant barrier or "exposure of the capillary smear zone for volatilization by soil vapor extraction" [6]. Capture zones can be designed where the extraction well(s) could become the boundaries for contaminated groundwater migration.

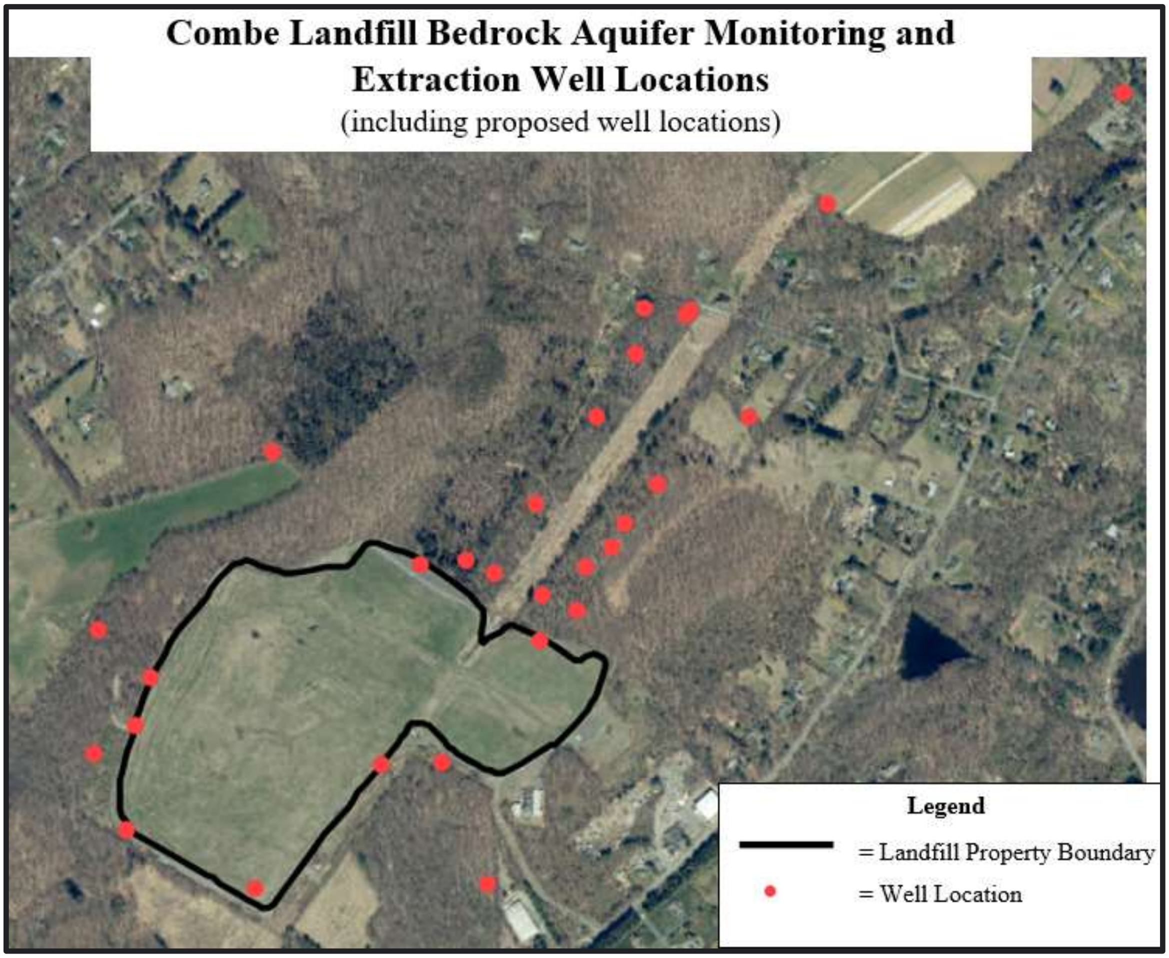
However, it is known to be ineffective due to the tendency of most contaminants to sorb into the heterogeneous sediment layers of most aquifers. Even if the pumps are extracting and treating the water, the contaminants absorbed into the sediments are slowly back-diffusing into the groundwater from the soil again.

Current Status of Remedial Actions

In 2018, an updated remedial plan was established to maintain a long-term monitoring system on the site. This updated remediation plan included the following:
(1) Upgrading the existing pump and treat system to handle increased volume of groundwater
(2) Installation of more bedrock aquifer extraction wells near the OU1 and OU2 borders for more hydraulic control of the contaminated plume. (See the figure in the next page)
(3) Upgrading the GWET or also known as pump and treat system to include treatment for 1,4-dioxane
(4) Disposing and treating all the North Waste Cell area wastage to decrease 1,4-dioxane contamination
(5) General long-term monitoring and sampling of the groundwater contamination concentrations of the entire OU2 site.

By establishing these objectives, a proper control of the contamination plume can be achieved and maintained for future years.

*Figure 5. The map below shows the extraction and monitoring well locations of the bedrock aquifer. It includes the proposed well locations as according to the new long term remediation plan.



*Except for the landfill borders, all the location points are approximated from EPA documents.

Conclusion

Only about three percent of the Earth's water is freshwater and about 0.76% is groundwater. The earth's hydrological cycle and environment naturally filters water and provides freshwater access to life on the planet through lakes, rivers and groundwater. However, due to careless human activities that are harmful to the environment and water, there are many groundwater contaminations sites throughout the world. Within the National Priorities List sites of EPA Superfund Sites, about 85% of them are related to groundwater contamination.

Most contaminants are stable in the environment and do not biodegrade or oxidize easily within soil, air or water. This is one of the main reasons why groundwater contamination sites have long term remediation plans. Groundwater infiltrates through sediment, rock and soil underground where chemicals are stored for long periods of time. When remediating groundwater contaminated sites, it is important to also clean the contaminated soil and rock along with groundwater treatments. However, this is an extremely expensive process where soil and bedrock treatment systems are not easy to establish on the site.

Additionally, there is a lot of uncertainty when dealing with groundwater systems because of limited direct visibility of aquifer(s) structure with the soil/sediment and bedrock. Even with all geological and hydrological testing to understand the plume of the contamination and the groundwater flow, there is relative uncertainty with knowing various factors that can impact the system.

Considering the extensive research and effort involved with remediating contaminated sites, changes should be made to prevent it from the start. As a role in the general public, this can and should start with proper management of wastes. By reducing single use materials, reusing as much as possible, properly recycling and decreasing personally produced wastage, it can greatly aid towards forming a circular economy. However, it is not completely realistic to have a functioning society without wastage. Therefore, this wastage must be properly managed at modern designed landfills where a daily soil cover, composite liner system, and landfill leachate/gas collection systems are incorporated. These carefully engineered landfill designs can prevent groundwater contamination in landfill areas effectively.

Despite closure in the early 1980s, this Combe landfill contaminated site still requires remediation that costs millions of dollars and a multi-step process to remove toxic substances that continue to threaten human health and the natural environment. Poor decisions or carelessness can negatively impact the environment and the surrounding life for decades to come.

Appendix

[1] Carpenter, A. “Record of Decision Amendment for OU1 and Record of Decision for an interim action for OU2 for the Combe Fill South Landfill Site”. *US EPA*. 28 September 2018. https://semspub.epa.gov/src/document/02/550182.

[2] Chester Township former Mayors Ben Spinelli and Bill Cogger

[3] “Combe Fill South Landfill Chester Township, NJ”. *US EPA - Superfund Site*. https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.Cleanup&id=0200489#bkground.

[4] Herzberg, M. “Combe Fill South Landfill”. *NJDEP Site Remediation Program*. 28 June 2004. https://www.nj.gov/dep/srp/community/sites/pi/g000004005.htm.

[5] HDR Engineering Incorporated. “Final 100% Remedial Design Report for the Combe Fill South Landfill Site”. *EPA*. 1 January 2021. https://semspub.epa.gov/src/document/02/174608.

[6] “Groundwater Pump and Treat”. *Federal Remediation Technologies*. 31 July 2020. https://frtr.gov/matrix/Groundwater-Pump-and-Treat/

[7] Water Science School. “How Much Water is There on Earth?”. *USGS*. 13 November 2019. https://www.usgs.gov/special-topics/water-science-school/science/how-much-water-there-earth#overview

[8] “How Superfund Addresses Groundwater Contamination”. *US EPA*. https://www.epa.gov/superfund/how-superfund-addresses-groundwater-contamination