ABSTRACT

Title of Thesis: MEADWORKS – HYDROLOGY, ECOLOGY, MEAD AND ARCHITECTURE

Kyle Huck, Dual Master of Architecture and Master of Real Estate Development, 2019

Thesis Directed By: Peter Noonan, AIA, LEED AP, Professor of the Practice, School of Architecture, Planning, and Preservation

This thesis seeks to redefine the relationship between communities and water infrastructure through a scalable and adaptable hybrid architectural solution. By focusing on the ambiguous intersection of nature and the built environment, this thesis will make an attempt at place-making in a setting typically disregarded by cities and communities. Challenging the boundaries of public infrastructure, architecture, and landscape architecture, this thesis will provide a dynamic solution to the water pollution epidemic of the Chesapeake Bay that involves subliminal community awareness and engagement. Through the program of a meadery, beekeeping, agriculture, and brewing will integrate with water treatment infrastructure to mutually benefit all processes.

MEADWORKS – HYDROLOGY, ECOLOGY, MEAD AND ARCHITECTURE

by

Kyle Patrick Huck

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Advisory Committee:
Professor Peter Noonan, AIA, LEED AP, Chair
Karl Du Puy, Professor Emeritus
Brian Kelly, Professor
Carl Bovill, Professor
Jessica Jones, Capstone Mentor
Maria Day-Marshall, Clinical Assistant Professor

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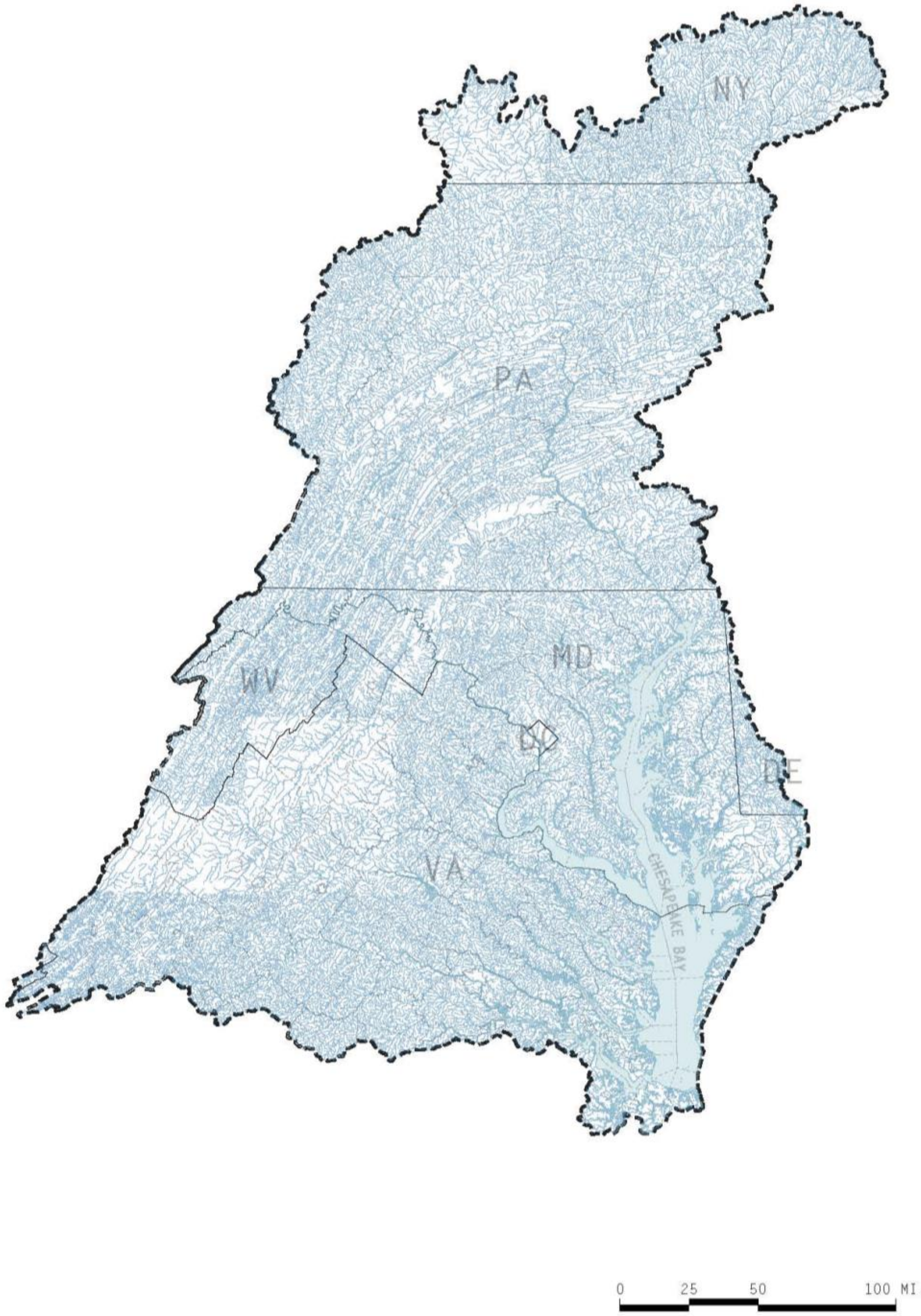


Figure 1 Chesapeake Bay Watershed, waterways. Diagram by author.

History

Formation

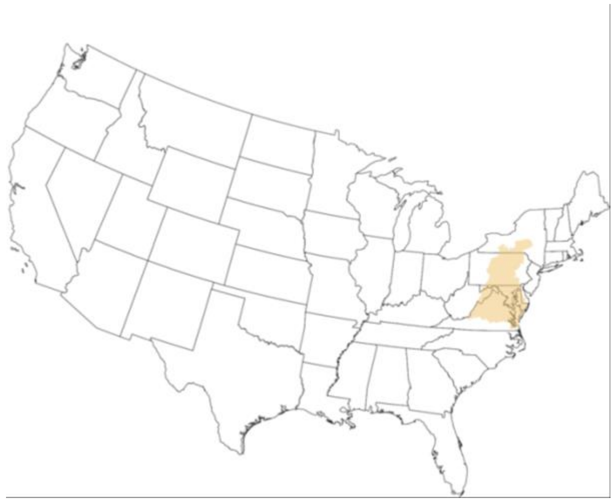


Figure 2 Chesapeake Bay Watershed Region in context of continental United States. Drawing by author.

The Chesapeake Bay as we know it today was formed over periods of millions of years. In the Eocene Epoch, roughly fifty-five to thirty-nine million years ago, a meteor collided with Earth near what is now the Delmarva peninsula, creating a crater fifty-five miles in diameter. In the Neogene Period, ten to two million years ago, ice ages locked away massive amounts of oceanic water in glaciers. Between Ice Ages in warmer periods, the melting glaciers began forming streams and rivers such as the Susquehanna, carving its way through modern day Pennsylvania. As the climate in the region continued to gradually warm over time, the effects of the melting glaciers continued to shape the riparian landscapes and shorelines. Water levels rose and frequently flooded the Susquehanna, Potomac and James Rivers, shaping the landscapes with growth of hardwood forests and coastal wetlands. Largely coniferous forests saw a growth in diversity of fauna and wildlife and became full of hardwoods and other varieties of trees. Thousands of years of continual biodiversity explosion evolve in the region – deciduous forests begin to dominate the land and, in the water, many species of fish, shellfish and other aquatic life flourished. Bass, shad, and oysters become prevalent in the bay's brackish waters. By the common era, the Chesapeake Bay's outline is relatively established due to the stagnation of glacial retreat, and nearly resembles how it is known today.[1]

Settlement

Paleo-Indian people arrived in the Chesapeake Bay region by 9500 BCE and continued to adapt with the evolving landscapes. Native Americans, including the Algonquin-speaking Powhatan tribes, prosper in the wild region adapting their hunting, gathering, and fishing techniques to the changing environmental conditions. By 1100, Native Americans began developing a reliance on crops such as corn, beans and tobacco, and therefore cleared land for agriculture, which ultimately lead to the establishment of more permanent settlements and villages. The first Europeans entered the Bay in 1524 in an expedition by Italian Captain Giovanni da Verrazano. By 1607, the English established the first permanent settlement in North America in Jamestown, Virginia, after a voyage funded by the Virginia Company of London. Shortly thereafter, Captain John Smith set out to explore and document the Chesapeake Bay in 1608 which resulted in a quite accurately drafted a map of the bay and its rivers.

[1] "History | Chesapeake Bay Program," *Chesapeake Bay Program*, accessed March 26, 2019, https://www.chesapeakebay.net/discover/history.

Figure 3 Captain John Smith's 1612 Map of Virginia and the Chesapeake Bay, oriented with West at the top.

The relevant human history in the Chesapeake Bay region is deeply rooted in agriculture, economics, and politics of what becomes the United States. In the southern Chesapeake colonies, land is cleared for agriculture, hook and line fishing operations increase, tobacco becomes big industry, and Native American populations dwindle. The first regulation of fishing was created for the Rappahannock river in the 1680s to prevent “wasteful fishing practices” and by the 1700s a quilt-like patchwork of agricultural settlements appears on east and west shores of the bay. English settlements grew rapidly, and the first signs of environmental degradation become evident. By the 1750s, colonists had cleared 20-30 percent of the region’s woodlands for agriculture which led to erosion of shipping ports and coastlines. Tillage and other agricultural practices prevent reforestation and exacerbate the erosion. Additionally, technological advances allow for commercial fishing practices take root and by the 1800s oyster harvesting rapidly increases in scope and yield. Natural resource cultivation and deforestation continues, and half of region’s forests have been cleared by the 1840s for lumber, fuel, or agriculture. Furthermore, the practices of use of fertilizers take root and the oyster market reaches beyond the region, causing harvest numbers to double over the next decade.

The Chesapeake Bay played a key role as political and economic center during and after the Civil War. Transportation options expand with the construction of railways and the 14-mile long Chesapeake Delaware Bay canal in 1829. The canal and use of steamboats allow further travel in the early 1800’s, opening previously undeveloped land on the Eastern Shore to agriculture and lumber operations.[2]

Geography

The Chesapeake Bay is the largest estuary in the United States, and the third largest in the world. The watershed covers over 64,000 square miles of various land uses and geographical characteristics. The bay’s water systems include over 150 major rivers, supplied by a complex network of over 100,000 streams. The tidal

[2] Ibid.

shoreline of the bay stretches over 11,684 miles which is longer than the entire west coast of the United States.[3]

Geographically, the watershed includes over 6 states and the District of Columbia, over 200 county jurisdictions, and spans three distinct geological regions: the Atlantic Coastal Plain, the Piedmont Plateau, and the Appalachian Province. The watershed has a fourteen-to-one land-to-water ratio, meaning that water actually only covers seven percent, or 4,480 square miles of the watershed and containing over 18 trillion gallons of water. This suggests that what we do on land has a significant consequence for the bay and its waterways.

3 "Facts & Figures | Chesapeake Bay Program," accessed April 22, 2019, https://www.chesapeakebay.net/discover/facts.

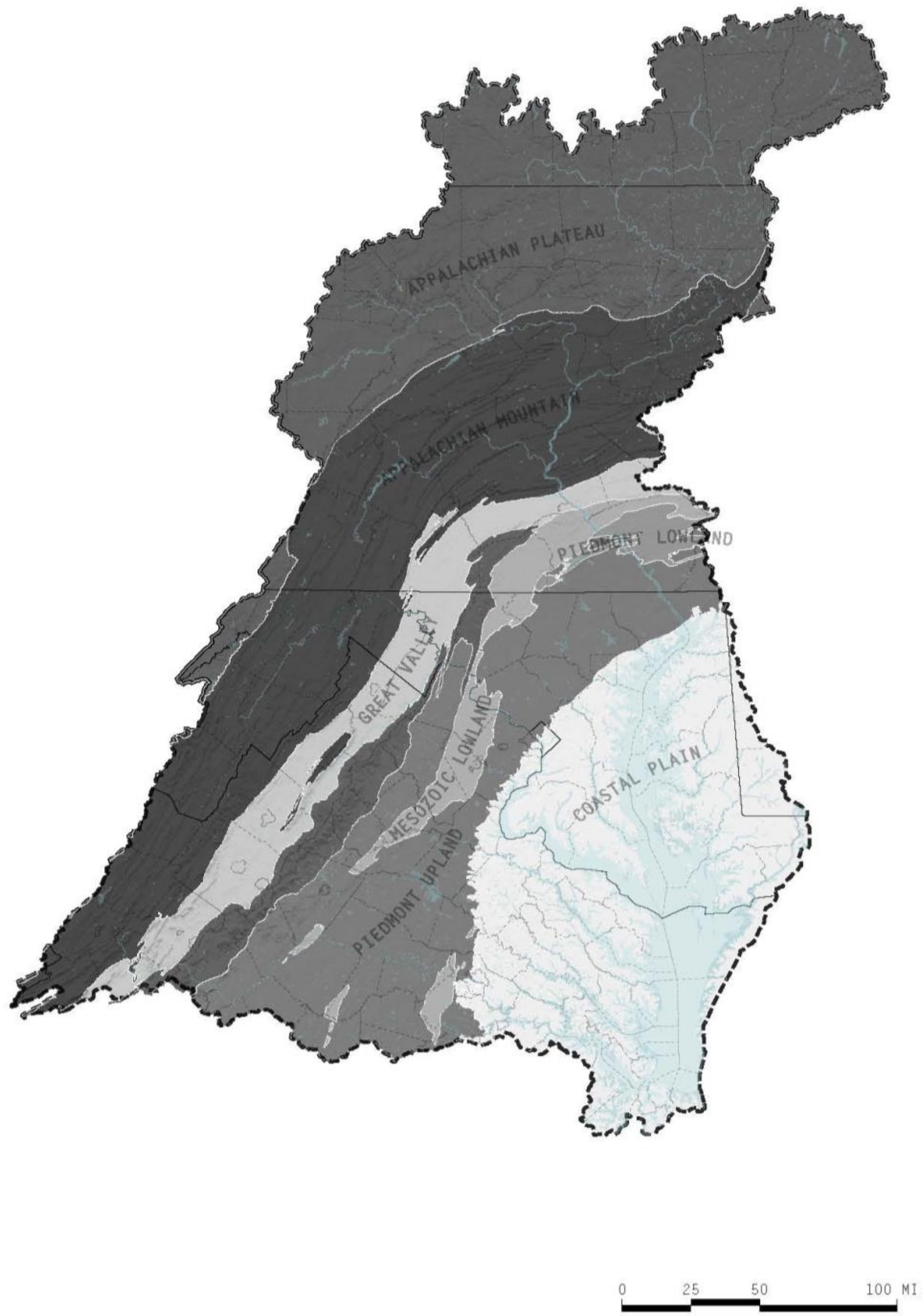


Figure 4 Geological Regions within the Chesapeake Bay Watershed. Diagram by author.

It is evident that the water systems within the watershed are delicate and widespread – which is precisely why the bay is under a constant assault from widespread pollution. Its wide range of ecosystems and regions are unique and all face similar and specific challenges. These systems are united by the policies that are aiming to regulate their impacts on the overall health of the bay – which is why a universal and adaptable solution to mitigate pollution and address the environment is needed.

Ecosystems and Land Use

The Chesapeake Bay Watershed has many unique and fragile environments which are home to over 3,600 species of plants and animals. As an estuary, its water is a mix of salt and fresh water, coming from both rivers and the Atlantic Ocean – this gradient creates many zones and different environments within the watershed.

The watershed also has a variety of land uses. Forests cover more than half of the land in the watershed and this proportion is rapidly declining as the population grows and developments spread. The region is home to over 18 million people – 10 million of which live along or near the bay's shores. The population is growing by 150,000 people per year and thus the land is being developed to accommodate. Sixty percent of the remaining forests in the watershed have been fragmented by roads and other gaps which are too large or dangerous for wildlife to cross – thus limiting habitats and biodiversity.[4]

[4] Ibid.

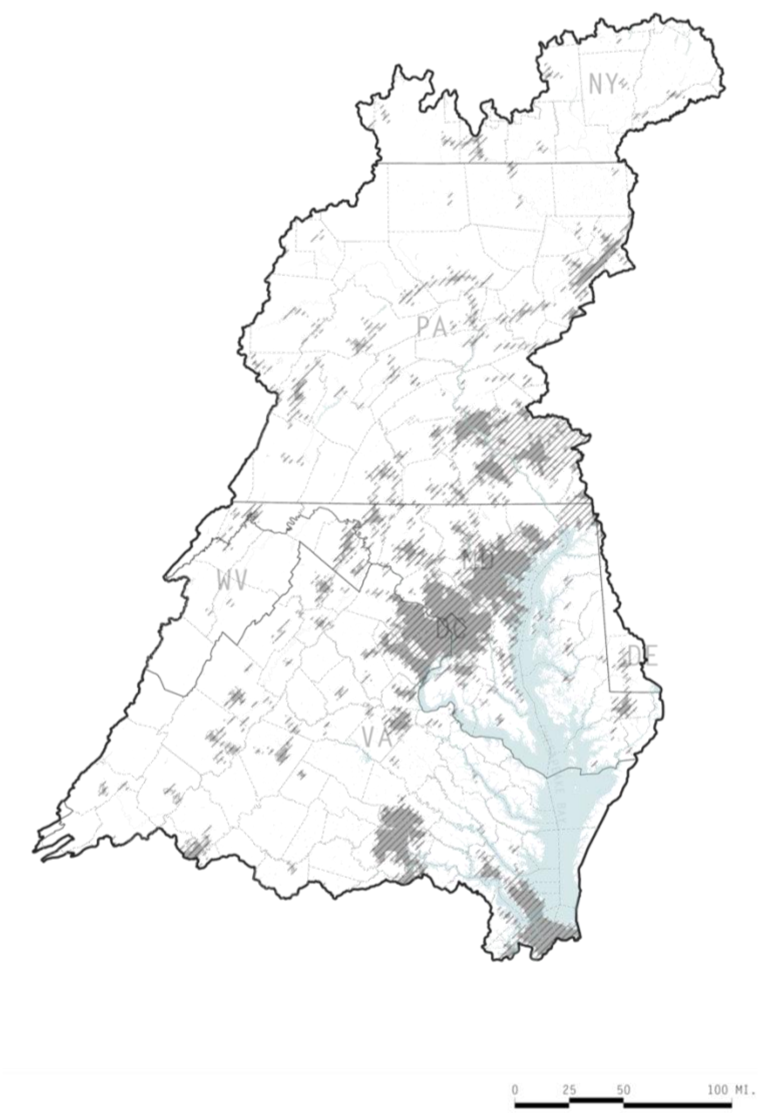


Figure 5 Urban Growth in the Chesapeake Bay Watershed. Diagram by author.

Economy

Undoubtedly, the Chesapeake Bay is an essential economic driver for the eastern United States and provide resources and opportunities for recreation, agriculture, business and tourism. These activities often are the 'reason for being' for many Bay towns, and the local economies heavily depend on the Bay and its long term outlook – highlighting just how crucial it is to act to preserve and restore the Bay to its best possible condition while still harmoniously providing all of its benefits to society.

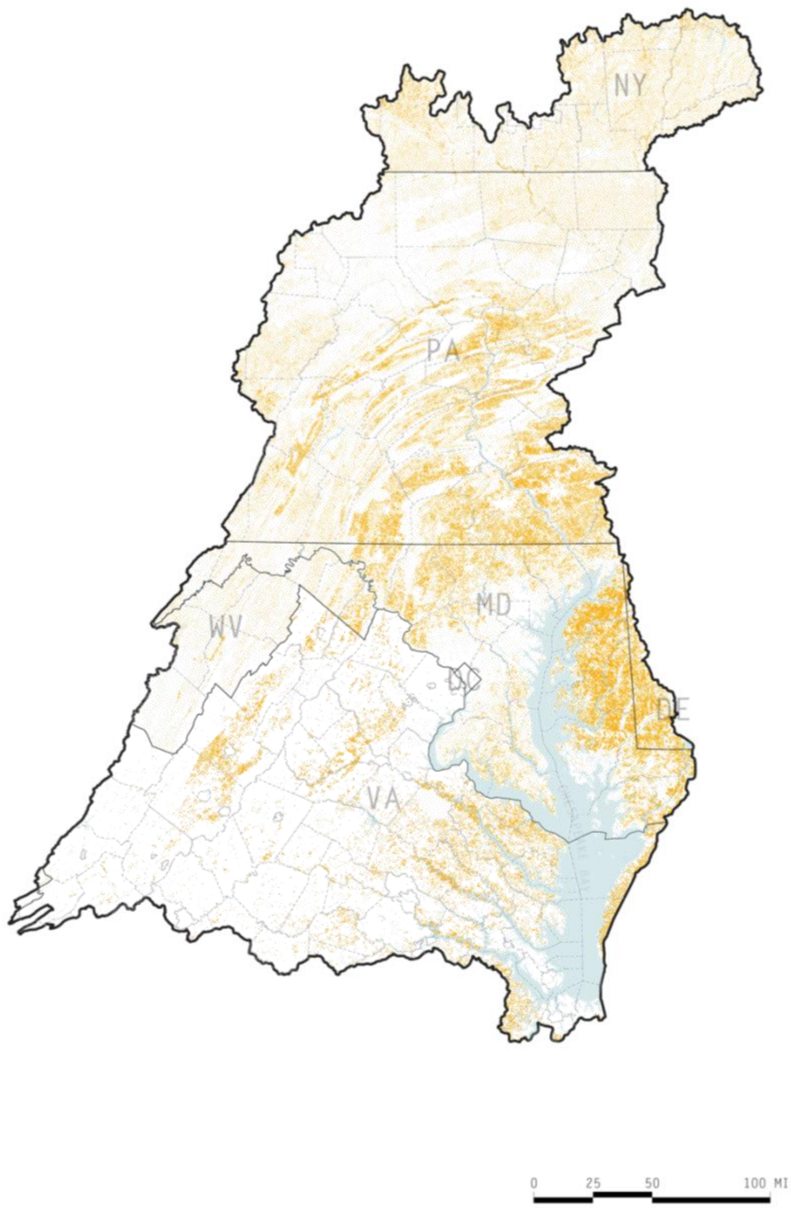


Figure 6 Croplands in the Chesapeake Bay Watershed, Noticeable concentration on Maryland's Eastern Shore. Drawing by author.

Agriculture

The agricultural quality of the soil around the Chesapeake Bay region was discovered and tilled by some of the first settlers in the region. Ever since, the agriculture industry has boomed around the bay. There are over 83,000 farm operations in CBWS region, accounting for upwards of 30% of the 64,000 square mile area, and producing over 50 commodities including corn, soybeans, wheat, fruits and vegetables.[5] The Bay's responsibility as a provider of fertile land for agriculture is tied to the health and growth of the communities. Farms are necessary for any society to provide food, as well as preserve undeveloped natural areas and aesthetic and environmental benefits. However as covered, agriculture is the single largest source of nutrient and sediment pollution entering the Bay due to the longstanding practices of excessive fertilizers and pesticides use, which penetrates and pollutes waterways.[6]

Agriculture in the watershed contributes 42% of the nitrogen, 55% of the phosphorus and 60% of the sediment load entering the Bay.[7] A 2010 EPA study showed that the use of chemical fertilizers account for 17% of nitrogen, and 19% phosphorus entering bay, and livestock manure accounts for 19% of nitrogen and 26% of phosphorus entering bay.[8] In 2012, a joint EPA, US Geological Survey

5 "Chesapeake Bay Watershed | NRCS," accessed April 23, 2019, https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/programs/initiatives/?cid=stelprdb1047323.

6 "Pollution | Chesapeake Bay Program," accessed April 23, 2019, https://www.chesapeakebay.net/state/pollution.

7 "ChesapeakeProgress - Toxic Contaminants Policy and Prevention," accessed April 23, 2019, https://www.chesapeakeprogress.com/clean-water/toxic-contaminants-policy-and-prevention.

8 "Guidance for Federal Land Management in the Chesapeake Bay Watershed, Chapter 2. Agriculture" (United States Enviromental Protection agency, May 12, 2010).

(USGS), and US Fish and Wildlife Service report showed that pesticides are indeed present in the streams and groundwater of the Chesapeake Bay watershed.

There is a need for more effective agricultural land cover and management. Well managed agriculture lands can act as environmental stewards and offer sustained crop yields, restored rivers and streams, and valuable habitats for insect, birds and other animals, store carbon, minimize soil erosion, and reduce flooding vulnerability due to climate change. However, a fundamental shift in some practices is needed to turn farm's negative effects into positive outcomes.

Poor irrigation practices and overwatering crops can promote erosion and push pollution into waterways. Excess water runoff carries fertilizers and pesticide chemicals and manure or soaks these nutrients and contaminates into groundwater supplies. Conventional tillage loosens soils and makes it more prone to erosion and runoff into waterways.[9] Continuous no-till and minimum-till farming are two forms of conservation tillage. Conservation tillage leaves 1/3 or more of farm field covered with crop residue or vegetation year-round. Cover crops are also used to provide soil cover and prevent erosion with annual, biennial or perennial plants grown in single or mixed stand. Some example cover crops could be legumes like cowpeas and clover, forage radish, or grains like wheat, rye or barley. They are used to fill in bare soil when main crop has been harvested to provide ground cover, prevent erosion, suppress weeds, reduce insect pests and diseases, absorb excess fertilizer, and reduce nutrient leaching, and enrich soul with organic matter. Furthermore, forest buffers of

[9] "Agriculture | Chesapeake Bay Program," accessed April 23, 2019, https://www.chesapeakebay.net/issues/agriculture.

grasses, trees and shrubs at edges of farm fields and rivers reduces the amount of pollutants that escape into waterways. Main goals for farmers should be to slow and absorb runoff, stabilize stream banks and reduce erosion and provide wildlife habitat.[10]

Chesapeake Bay Program partners are working with watershed farmers to curb agriculture runoff effecting the bay by implementing best management practices to meet goals set forth in the Total Maximum Daily Load, reducing farms operational costs, and improving production with conservation practices. Some programs are voluntary or incentive based, while Maryland's nutrient management planning for all agricultural operations are mandatory. These processes require a site-specific plan that reduces nutrient pollution while maintaining crop production. The documentation includes crop production potential, amount of nutrients needed to achieve this production level, and recommended amount, form, source, rate and placement and timing of manure or fertilizer application.

Business

The Bay not only provides fertile and plentiful land for agriculture, but also supports the region's fishing, tourism and real estate industries. A 1989 economic study by the State of Maryland estimated the Chesapeake Bay generates an economic

[10] Ibid.

benefit for the region of $33 billion annually.[11] The region is also home to two of the nation's 5 major north Atlantic ports – Baltimore and Hampton Roads.[12]

The Chesapeake Bay sustains one of the largest regional and seasonal seafood industries in the world. The Bay is home to the Blue Crab and Oysters which are annually harvested for a large market. According to a 2009 Fisheries Economics of the US report by the National Oceanic and Atmospheric Administration (NOAA), the commercial seafood industry in Maryland and Virginia had over $3.39 billion in sales, $890 million in income, and supplied over 34,000 jobs to the economy. The dockside value of the blue crab harvest bay-wide in the 2009 season was approximately $78 million.[13] Bay-wide, over 500 million pounds of seafood are produced per year.[14]

Recreation

The Bay is a huge resource for recreation – providing a venue for boating, watersports, swimming, fishing and more. The 11,684 miles of tidal coastline around the Bay has over 700 access points for various activities.[15] Fishing activities, mostly recreational for striped bass (rockfish) attract more than $500 million in economic activity annually for expenditures, travel, lodging and associated markets.

11 "EPA Needs to Better Report Chesapeake Bay Challenges – A Summary Report" (July 14, 2008): 40.
12 "Facts & Figures | Chesapeake Bay Program."
13 "The Economic Importance of the Bay," accessed May 15, 2019, https://www.cbf.org/issues/what-we-have-to-lose/economic-importance-of-the-bay/index.html.
14 "Facts & Figures | Chesapeake Bay Program."
15 Ibid.

Tourism

The Chesapeake Bay attracts tourists for various reasons, from visits to historic towns such as Annapolis and Chestertown or passing through on Route 50 to get to Ocean City, or for recreational boating, water sports, or fishing trips. According to the 2007 Economic Impact of Boating in Maryland Report, $2.03 billion dollars were spent and over 32,000 jobs are created annually in Maryland.[16]

Overall, the economic benefits of cleaning and preserving the bay lead to a healthier population, more productive waters and farms, more recreation related growth, and higher property values, allowing families and land owners to accrue equity.

Health and Outlook

Each year, the Chesapeake Bay Foundation funds research and publishes an annual report on the "State of The Bay," evaluating the progress or regression in various categories related to the environmental status and restoration of the bay. It has been discovered that over 80% of the Tidal Chesapeake Bay region is partially or fully impaired by toxic contaminants – pesticides, pharmaceuticals, metals – which enter the bay through air pollution, agricultural runoff, stormwater runoff, and wastewater, sometimes untreated.[17] The annual report ranks and grades the state of the bay with regards to pollution, habitat, and fisheries. The latest report at the time of

16 "The Economic Importance of the Bay."
17 "ChesapeakeProgress - Toxic Contaminants Policy and Prevention."

this thesis' writing is the 2018 report which highlights a particularly troubled period for the bay due to extreme weather and climate events – highlighting not only how fragile the ecosystems are, but also how fragile and delicate the bay's recovery process is.

The year of 2018 was especially a difficult year for the progress of the restoration of the Chesapeake Bay for a variety of reasons. An increase in rainstorms carried higher numbers of nitrogen and phosphorus to the bay. The additional nutrients and higher sediment runoff loads spurred an explosion of algal blooms across the bay. Further exasperating the efforts to restore the bay is the current political climate which has not been kind to the environment and the efforts to combat the human impact on climate change. These political waves can potentially unravel and rewind the significant efforts to a cleaner bay and more sustainable region.[18]

The report gives the following grades to each category:

- Nitrogen 12/100, a decline of 5 since 2016
- Phosphorus 19/100, a decline of 9 since 2016
- Dissolved Oxygen 42/100, an increase of 2 since 2016
- Water Clarity 16/100, a decline of 4 since 2016
- Toxics 28/100, with no change
- Forested Buffers 57/100, with no change
- Wetlands 42/100, with no change
- Underwater Grasses 25/100, increase of 1 since 2016

[18] Chesapeake Bay Foundation, "State of the Bay 2018," *Cbf.Org*, last modified 2018, accessed May 15, 2019, https://www.cbf.org/document-library/cbf-reports/2018-state-of-the-bay-report.pdf.

- Resource Lands 33/100, increase of 1 since 2016[19]

This thesis is particularly interested in the detrimental effects of agricultural runoff to the Bay, mostly in the form of nitrogen, phosphorus, and sediment loads. According to the 2010 Chesapeake Bay TMDL Executive Summary, "The Bay and its rivers are overweight with nitrogen, phosphorus and sediment from agricultural operations, urban and suburban runoff, wastewater, airborne contaminants and other sources."[20] Nitrogen and phosphorus pollution are an excess of nutrients which adversely fuel algal blooms, drastically reducing the oxygen levels in water creating dead zones that essentially choke underwater life. An average 331 million pounds of nitrogen and 20 million pounds of phosphorus is delivered Chesapeake Bay each year through the bay's system of tributaries. The amount of these nutrients entering the bay is influenced by land use, land management, precipitation and river flow.

Suspended sediment – loose particulate matter of sand, silt, and clay – are natural parts of ecosystem, but excess amounts cloud the water and harm grasses, fish, and shellfish. On average, over five million tons of sediment are delivered to the bay each year. Significant sediment load increases come from deforestation which leads to increased erosion. Pollution can be mitigated by absorbing rainfall with porous paving or gravel, channeling runoff into grass rather than asphalt, combatting erosion with plant buffers and trees and shrubs to capture runoff and hold soil in place.[21]

19 Ibid.
20 "Chesapeake Bay TMDL Executive Summary" (United States Enviromental Protection Agency, December 29, 2010).
21 "Pollution | Chesapeake Bay Program."

Chapter 2: Water

Water

Importance of Water

Water is essential to humans. Our bodies are made up of up to 60% water – being a large component of each of our vital organs including the brain, lungs and skin. However, human bodies do not produce our own water – instead we must consume water daily to stay hydrated and healthy, much like cold-blooded reptiles need to seek heat to warm their bodies. Generally, consuming 2 to 3 liters of water through drinks and food per day is optimal for a healthy adult. Water essentially acts as a building material for the human body down to the cellular level. It participates in bodily processes such as perspiration and respiration, and it transports nutrients and carbohydrates through our bloodstream. It is also a lubricant as saliva in our mouths and at our joints.[22]

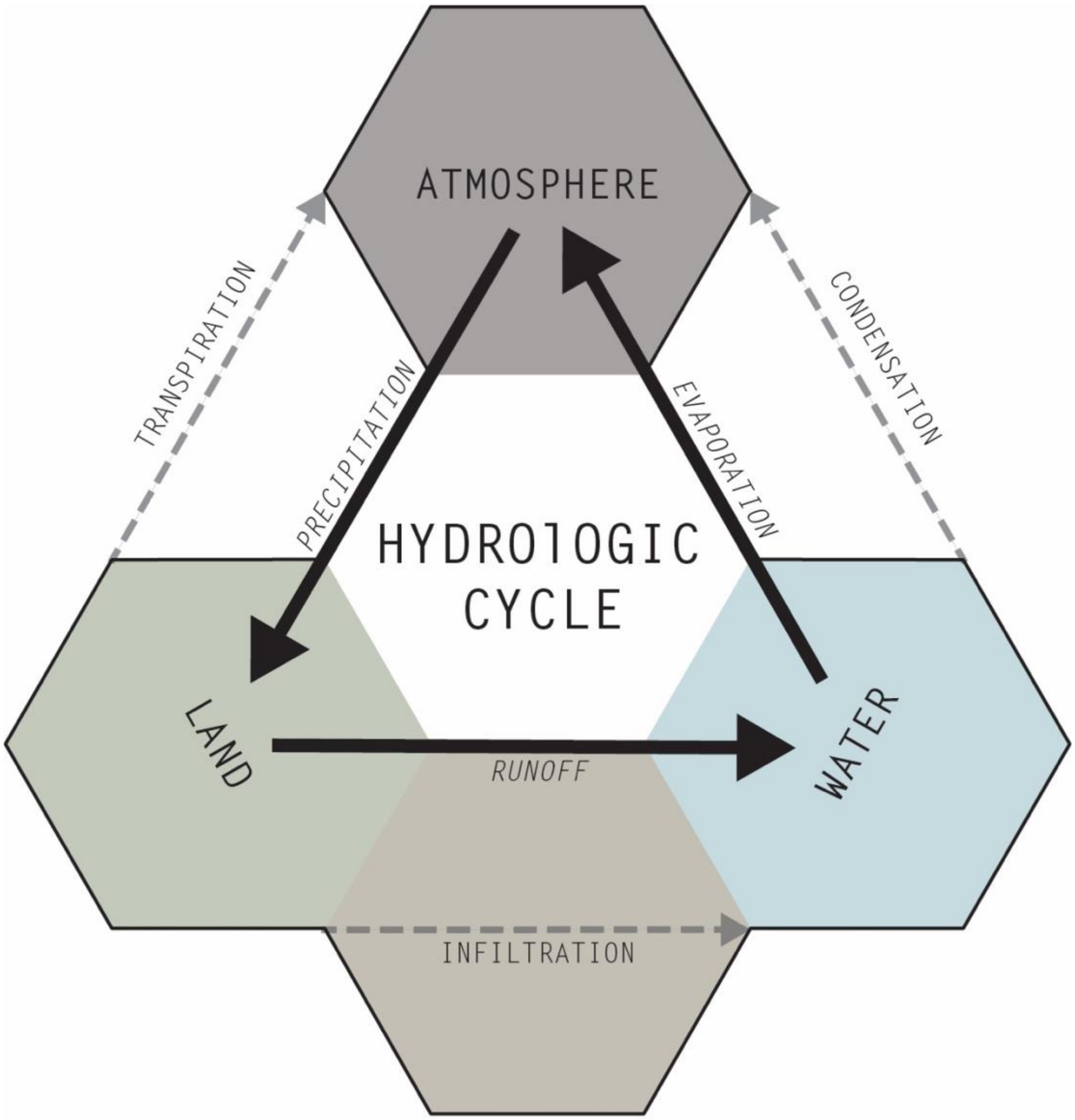


Figure 7 The abstract Hydrologic Cycle. Diagram by author.

Water is a critical component in the environment. The hydrologic cycle shapes landscapes, transports minerals, nutrients and pollution, and is essential to all

22 "The Water in You: Water and the Human Body," accessed May 16, 2019, https://www.usgs.gov/special-topic/water-science-school/science/water-you-water-and-human-body?qt-science_center_objects=0#qt-science_center_objects.

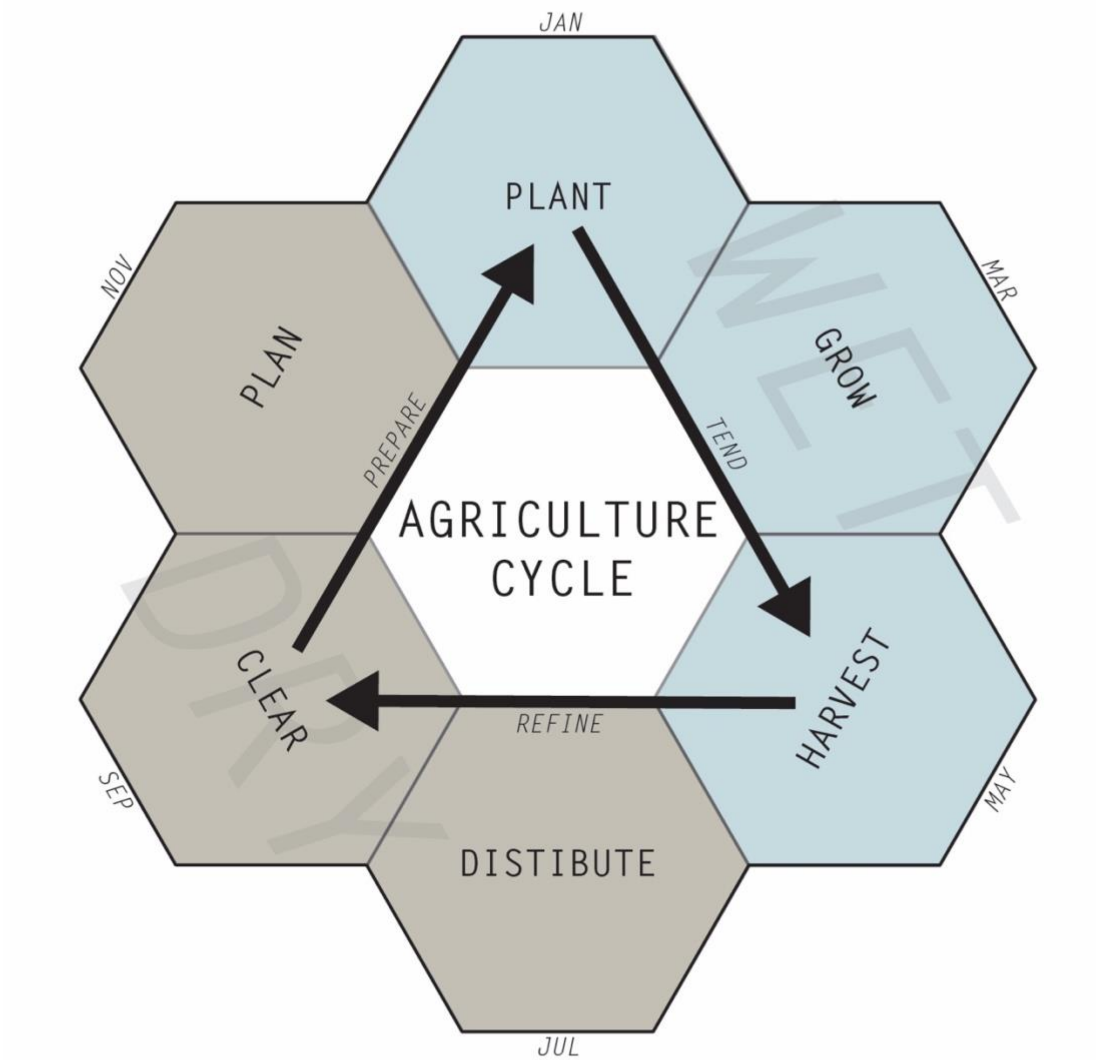


Figure 8 Agriculture Cycle. Diagram by author.

ecosystems. Water is also essential to agriculture. Plants and livestock cannot live and grow to produce the products humans eat without water. Water is used to irrigate fields of crops and carry nutrients to the seeds to grow. Overwatering and overfertilizing leads to a great problem of water pollution as a result of agriculture.

Types of Water and Sources

There are many types and sources of water, as well as many uses for it. Water comes from three main sources: the atmosphere in the form of precipitation, surface water in the form of rivers and reservoirs, and groundwater from wells and aquifers. On the other end, water use can be categorized in three main ways: domestic, industry, and agriculture.

Water in society is a cycle. It is harvested from a source and purified, typically at a public works facility, before it is distributed via infrastructure to the various users. Water then is used – either consumed or to serve another purpose where it

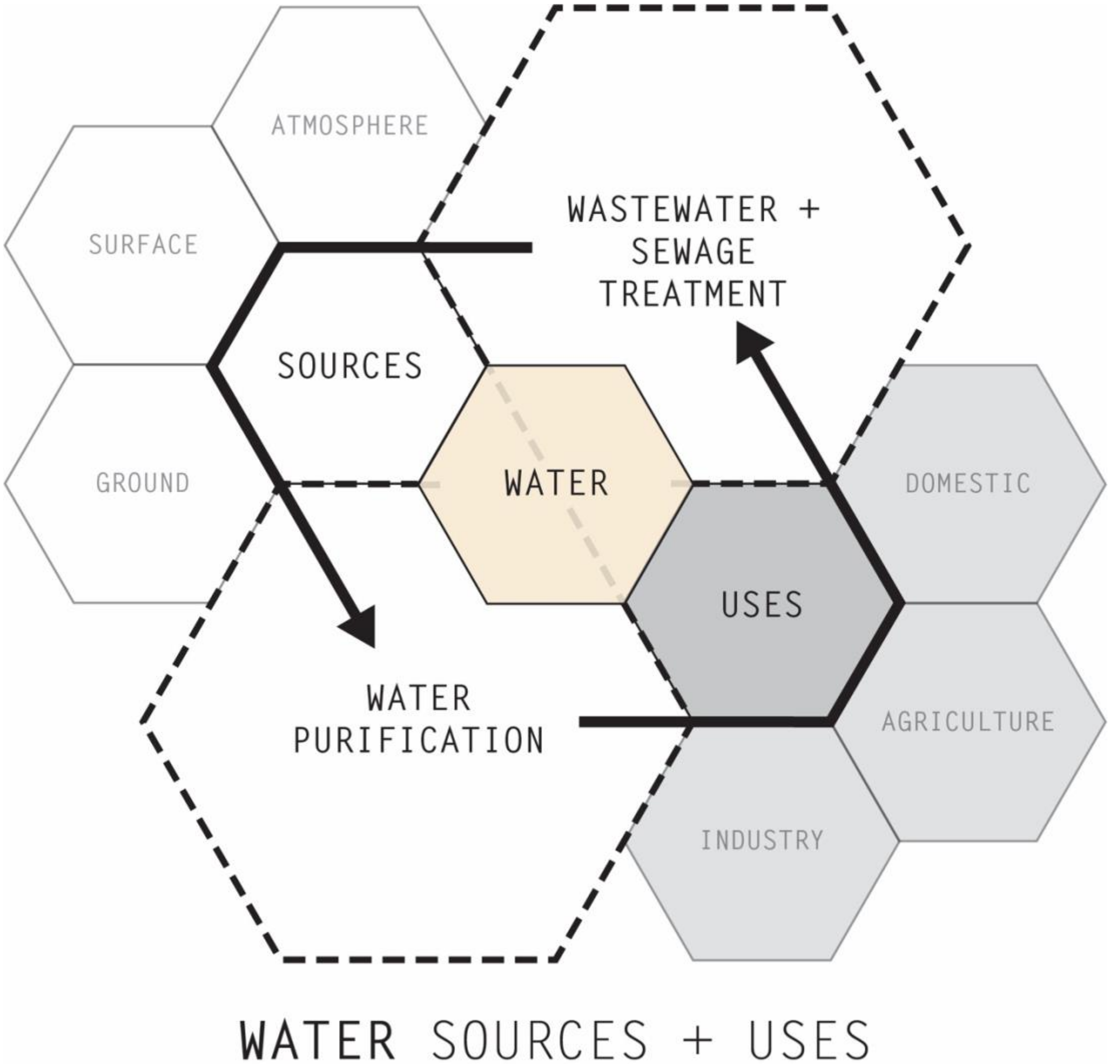


Figure 9 Water Cycle, Sources, and Uses. Diagram by author.

becomes wastewater – greywater or blackwater. Blackwater and greywater are both forms of wastewater, however blackwater is mostly from toilets and sewage where it is in contact with the bacteria in fecal matter. Greywater may carry all sorts of contaminants from soap, fats, oils, metals and minerals, to solid waste. This wastewater again is transported through infrastructure to another public works facility for wastewater or sewage treatment before it is discharged back out to the environment.

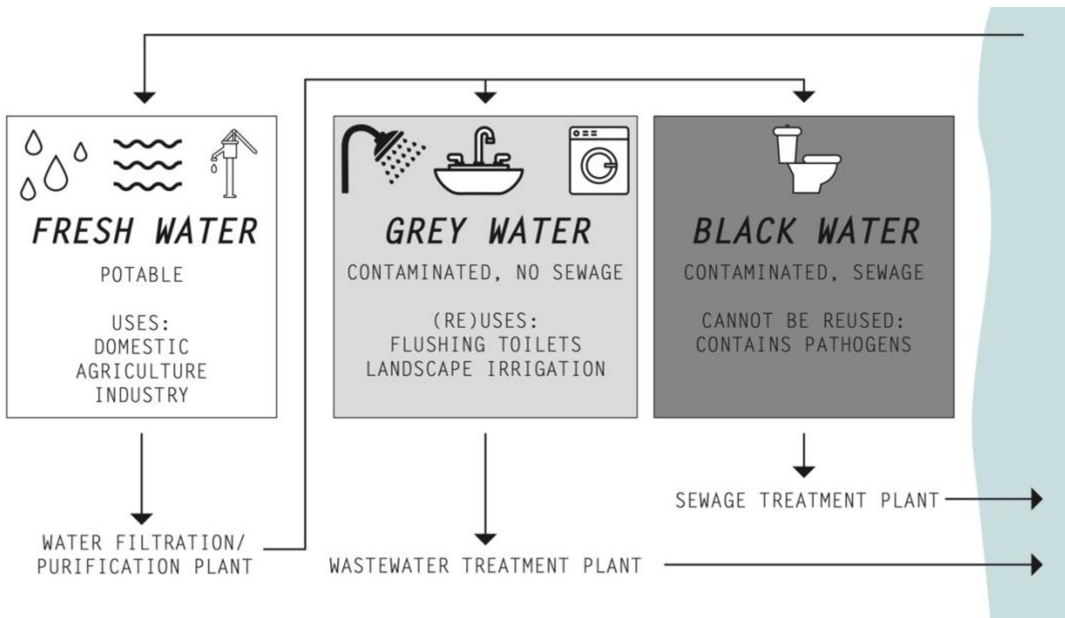


Figure 10 Water Types and Processes diagram, drawing by author.

When purified, drinking water is regulated by the United States Environmental Protection Agency (EPA). The Safe Drinking Water Act of 1974 and its amendments charged the EPA with this responsibility of developing regulations to protect public health in regard to water. The EPA sets national standards for drinking water through maximum contaminant level goals (MCLGs) and maximum contaminant levels (MCLs) for 83 specific contaminants including volatile organic chemicals (VOCs), microbiology and turbidity, inorganics, organics, and radionuclides which may have any adverse effect upon the health of people. There are many significant threats to the safety and supply of our drinking water, including improper chemical disposal, excess agricultural nutrient runoff and percolation, and animal and human wastes.[23]

Initially, the approach that treatment was the main strategy for protecting and ensuring the safety of drinking water. Since its introduction in 1974, the Safe Drinking Water Act has been amended in 1986 and 1996 and includes more broad strategies for targeting water quality threats at the source as opposed to just relying on treatment to meet the requirements. The legislature sets up four main barriers to ensure water quality protection – source water protection, treatment, robust distribution infrastructure, and public information.[24] By protecting water sources, spearheading public education, and investing in advanced water systems and infrastructure, the treatment facilities can be a more refining and less intensive intervention.

Water Infrastructure in The United States

Establishment of Regional Infrastructure

[23] United States Environmental Protection Agency, "Understanding the Safe Drinking Water Act" (June 2004): 4.
[24] Ibid.

The first significant water infrastructure investment in the Chesapeake Bay Region came in the 1860s when drinking water supply systems were built to connect Baltimore and the District of Columbia. Sewer systems were also built and carried wastewater and runoff directly into the rivers and bay. By the 1890s, the deforestation of the Chesapeake Bay region consumed over sixty percent of the land for agriculture and expanding developments. As populations in the D.C. and Baltimore areas expanded, so did their waste outputs to the Bay. Baltimore took the first steps in the 1910s to install separate storm water and wastewater treatment systems to filter waste and debris before discharging into the Bay. In D.C., a height restriction thirteen stories was established, forcing the population and development to sprawl out in the horizontal plane. Swamps and marches were drained to accommodate space for waste dumps and additional waterfront development around the region. At the mouth of the Susquehanna River, the Conowingo Hydroelectric Generating Station and Dam were built in the 1920's to provide electricity for the surrounding areas. At the time, this was the second largest hydroelectric power plant build in the US and still operates today.[25]

Recognition of Issues

By the end of the 19th century, scientists truly began to question the impact of humans on the Chesapeake Bay and its ecosystem. This recognition was brought on by dramatic drops in the oyster populations due to commercial harvesting. The

[25] "History | Chesapeake Bay Program."

oysters play a critical role in the ecosystems of the bay to keep the water clean.[26] The 1899 Rivers and Harbors Act was one of the first regulations to act on the county's water pollution issue, ruling that dumping trash and waste into navigable US waters is unlawful. By the end of World War I, water pollution was widely recognized as a major problem. Empowered by Congress in 1912, the Public Health Service undertook investigations and began to conduct research into pollution, sewage, and sanitation in U.S. waterways. The following year, the surgeon general addressed the issue and "called for establishment of a central authority and federal controls to handle mounting pollution problems in interstate and international waterways"[27]

Government action continued in 1924, when the Oil Pollution Act was enacted to forbid oil discharges into coastal waters. Unfortunately, the Federal Government's powers to regulate and enforce water quality standards were limited and complicated. Under the Federal Power Act, the government had the authority to approve safety of drinking water and to regulate pollution on the public domain, and other indirect controls through taxation and spending for welfare but these powers were not exercised, and the 1899 and 1924 acts were poorly and unevenly enforced.

Political Efforts to Address Pollution

The Great Depression loomed and finally hit the United States economy hard in 1929. In order to stimulate the economy and create jobs, the government made significant investments in the country's infrastructure in the 1930s. Public works

[26] Ibid.
[27] Robert A. Shanley, "Franklin D. Roosevelt and Water Pollution Control Policy," *Presidential Studies Quarterly* 18, no. 2 (1988): 320.

projects were funded to repair, build, and expand the nation's roads, bridges, parks and electric grid.[28] President Franklin Delano Roosevelt is regarded as the first President to allocate significant federal funding and effort towards addressing public works and water pollution. President Roosevelt's New Deal included a collection of programs and projects to stimulate the economy and restore prosperity among Americans during the Great Depression.

As part of President Roosevelt's New Deal, legislation was enacted in 1933 to establish the National Industrial Recovery Act (NIRA). Under this act, the President was able to regulate industry and wages to oversee fair wages and stimulus of the economy through public works projects. The NIRA included a $3.3 billion budget for a public works program, establishing the Public Works Administration (PWA), creating and economy of industry and conservation which inherently tied the welfare of the public to environmental protection. Over the next six years, more than $4 billion dollars were spent on over 34,000 projects for the "conservation and development of national resources, development of water power, flood control, construction of river and harbor improvements, prevention of soil and coastal erosion, and utilization, control, and purification of water."[29] This correlates directly to the issues our country faces today – crippled and underperforming, outdated infrastructure is desperately in need of modernization and replacement.

President Roosevelt strategically created the National Resources Planning Board (NRPB) in the executive office of the President in 1935 to lay the groundwork

[28] "History | Chesapeake Bay Program."
[29] Shanley, "Franklin D. Roosevelt and Water Pollution Control Policy," 320.

for a "comprehensive long-range national policy for conservation and for the development of the country's natural resources."[30] In tandem, the National Resources Committee (NRC) was created by executive order the same year – tasked with producing detailed studies of river basins and water, and was responsible for publishing the first comprehensive analysis of the water pollution problem as a national issue by the federal government. The NRC estimated that a $2 billion investment over a period of ten to twenty years would be necessary to achieve acceptable levels of pollution control in the country. It also advocated for a control strategy in which the federal government assist in the improvement of state enforcement, research and education, support and stimulate interstate and basin-wide plans and agreements, and provide financial aid in the form of loans and grants for worthy projects instead of imposing unrealistic rigid national level standards for pollution control. Similarly, the NRPB established long term land use and conservation goals and planned a national water policy. The resulting reports on regional planning, energy resources, river basins, water pollution and status of water pollution control advanced the government's understanding of the severity of the issues.

Despite major advancements in policy to bring the water pollution issue to the forefront of political conversation - there were several skeptics, critics and issues that contradicted the efforts of the FDR administration. Critics cite that cost of waste treatment for industry was a public problem of "greater concern than the pollution of public streams and rivers" and skeptics argue that the NRC studies were exaggerated

[30] Ibid., 322.

and that regulatory powers were not efficiently being enforced.[31] The Army Corps of Engineers and other congressional committee officials were reluctant to accept the proposals. The Army Corps of Engineers instead believed separate issues should be dealt with by separate experts, arguing that the coordination of unrelated activities is ineffective and disruptive to other processes.

In the height of the water pollution control debate in 1939, administrations fell into two main opposing perspectives on the subject. The first, referred to as a "Voluntaristic approach" advocated a federal regulatory role to "promote pollution abatement through injunction procedures" to exercise control over states on the matter.[32] This party's main argument was that the most serious issue in water pollution is its interstate nature, that pollution knows no political, state, or jurisdictional boundaries. This is critical for situations in which state enforcement efforts fail. Supporters were willing to risk a constitutional challenge, arguing that there was legitimate existing federal power to regulate pollution under Constitution's commerce, general welfare, admiralty and maritime clauses, along with the powers of treaty making.

The other position was the "Gradualist approach," which proposed federal participation through technical and financial assistance to the states, but the leaving the regulatory controls to state authorities. It was argued that it would be more advantageous to utilize and build upon existing arrangements when possible and leave pollution control enforcement as a State responsibility as it existed under 10th

[31] Ibid., 323.
[32] Ibid., 324.

amendment of the Constitution. The gradualist approach presented itself as a more workable and modest strategy to incorporate regulations on water pollution issues into the laws across the states.

Eventually, Congress cut funds for the National Resources Planning Board in 1943. Water pollution was widespread in nation at the time, but the most severe conditions were concentrated in the populous, industrial areas of the Northeast. The serious efforts to adopt water pollution law was suspended for the duration of World War II as the country engaged in the defense effort and directed its political energy towards the larger issues at hand.

Roosevelt's grasp on Congress eroded after his reorganization plan of the federal bureaucracy was resisted by Congress. His political power began to decline with the 1937-1938 economic recession and after the congressional elections of 1938, which resulted in an unexpectedly more conservative and Republican, anti-New Deal surge that decimated the liberal contingent - contradicting the President's initial intent.

The turbulent congressional climate created a power shift and conservatives worked to block the extension of federal government programs into new directions (i.e. water pollution control), and attacked some existing programs established under the efforts of President Roosevelt. This was further punctuated by the national defense and foreign relations issues that increasingly consumed the President's attention and effort.[33] Failures of the Roosevelt Administration demonstrated the

[33] Ibid., 328.

political and administrative challenges in establishing a national planning advisory in the American political system.

Although not successful ultimately in developing water pollution control legislation, Roosevelt was able to exploit the powers of his administration to promote awareness and measure water pollution issues. He issued executive orders which created a national planning agency to study and monitor the pollution problem. The Public health service expanded to provide technical and research resources to state and local authorities. Overall, FDR had success in short-term gains for water pollution control and paved the way for the federal government in following postwar administrations to continue to assume increasing responsibility of water pollution control.

Modern Efforts to Address Water Quality in the Chesapeake Bay

A major milestone for the Chesapeake Bay and the efforts towards a cleaner bay came on December 29, 2010, when the United States Environmental Protection Agency (EPA) established Chesapeake Bay Total Maximum Daily Load (TMDL) – a comprehensive "pollution diet." This legislature introduced accountability features to guide actions to restore clean water in the Chesapeake Bay and its waterways. This action was prompted by insufficient progress in restoration efforts of the previous 25 years and consistently poor water quality. This TMDL is required under the Clean Water Act and is a "keystone commitment of a federal strategy to meet President

Barack Obama's Executive Order [13508 on May 12, 2009] to restore and protect the Bay."[34]

The Chesapeake Bay Total Maximum Daily Load – the largest such pollution restriction ever developed by the EPA – is made up of a combination of 92 smaller TMDLs for individual tidal segments of the bay. This is critical as the bay's unique ecosystem is made up of several different types of habitats and fragile environments, including forests, wetlands, rivers and streams, estuaries and marshes. The TMDL plan identifies necessary pollution reductions from major sources of nitrogen, phosphorus, and sediment across bay jurisdictions and accordingly sets necessary limits on pollution to meet water quality standard goals of the bay. The goals of the TMDL are set specifically to have all practices necessary in place to achieve the following limits on the major nutrients:

- 185.9 million pounds of nitrogen (25% reduction)
- 12.5 million pounds of phosphorus (24% reduction)
- 6.45 billion pounds of sediment per year (20% reduction)

These limits are further divided by jurisdiction and major river basins to distribute the shared responsibility accordingly. The TMDL was designed to ensure that all pollution control measures needed to fully restore the bay and tidal rivers are in place by 2025 through extensive EPA measures and jurisdiction involvement and adoption to ensure accountability to reduce pollution and meet progress deadlines.[35]

[34] "Chesapeake Bay TMDL Executive Summary."
[35] Ibid.

Treatment Processes

People's desire to improve water quality date back to as early as 2000 BC. The primary goal of water treatment is the production of biologically and chemically safe water that is appealing to the consumer – clear and colorless, pleasant to taste, and odorless, nonstaining, noncorrosive nor scale forming, and reasonably soft. The design of a treatment facility can be approached in many ways and varies by the purpose and end use of the facility's effluent. There are multiple types of treatment facilities: water purification, waste water treatment, sewage treatment, water reclamation and more. Water purification facilities are typically involved in refining and treating ground or surface water into a drinkable water supply for the community. Water treatment and sewage treatment plants exist to essentially filter pollution, solids and other contaminants from society's used water before it is discharged back into the environment. Water reclamation facilities are a hybrid of treatment and purification in the sense that wastewater treatment plant effluent is taken and further refined, recycled and redistributed for non-drinking uses in industry and agriculture. The facility designed as part of this thesis will be a water reclamation and purification facility which will be used to mitigate the pollution of agriculture and recycle water for reuse.

Methods of Treatment

There are various methods for treatment of water depending on the influent and what the use of the end product will be. For reclamation and purification, the goal is mainly in refinement and chemically restoring water to a homogenous and usable substance. The technology of these processes is constantly evolving however the general structure and outline of the process is consistent.

For water purification, the source may be a well, river, reservoir and collected rainwater. This influent is held in tanks for gravity settling – suspended debris and solids settle to the bottom and are removed. Then the water is chemically disinfected before a coagulation and flocculation stage where more biological solids are removed and either composted, returned for further desaturation, or used for biomass fuel. Then another period of gravity settling further clarifies the water, then is further disinfected, filtered, and receives a final chemical treatment to remove molecular contaminants and other chemicals introduced throughout the process. The water is then stored or distributed through a network of infrastructure to the end user – homes, industry, and farms for use and consumption.

Once water has been used – for bathing, washing clothes or dishes, industrial processes, irrigation of crops – it is either goes down a drain, runs off the land, or seeps into the ground. When grey water or black water reaches a wastewater / sewage

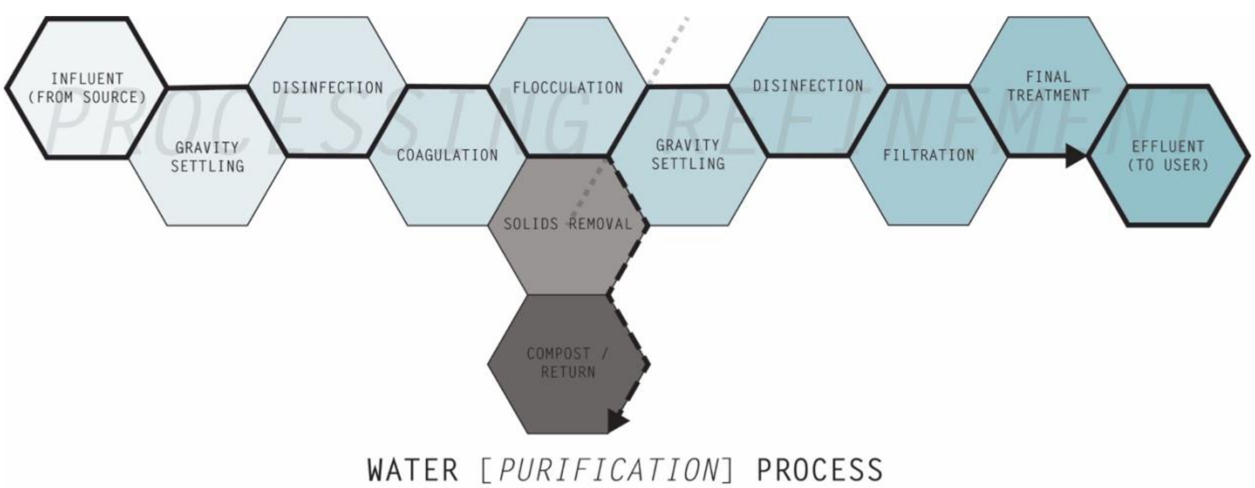


Figure 11 Water Purification Process. Diagram by author.

treatment plant, it initially is screened for debris and large pollution, which is removed and sent to a landfill. Then it goes through grit removal and gravity settling to further remove suspended pollution before being aerated and biologically reduced. Any sludge and solids that are separated through these stages are either further dehydrated or removed to be composted, used as fertilizer or biofuel. The substance is then gravity settled again, filtered, and chemically disinfected before being discharged back to the environment and waterways.

Facility Design Considerations

Water treatment involves not only the processes, but the combination of a properly designed facility and the skillful and alert operation of the plant. Thoroughly designed facilities include operable pre and post treatment storage and distribution systems which reach out into the served areas, and must be built to resist biological growths, corrosion and contamination. Sound engineering principles, consideration of flexibility and growth to accommodate future conditions and emergency situations are

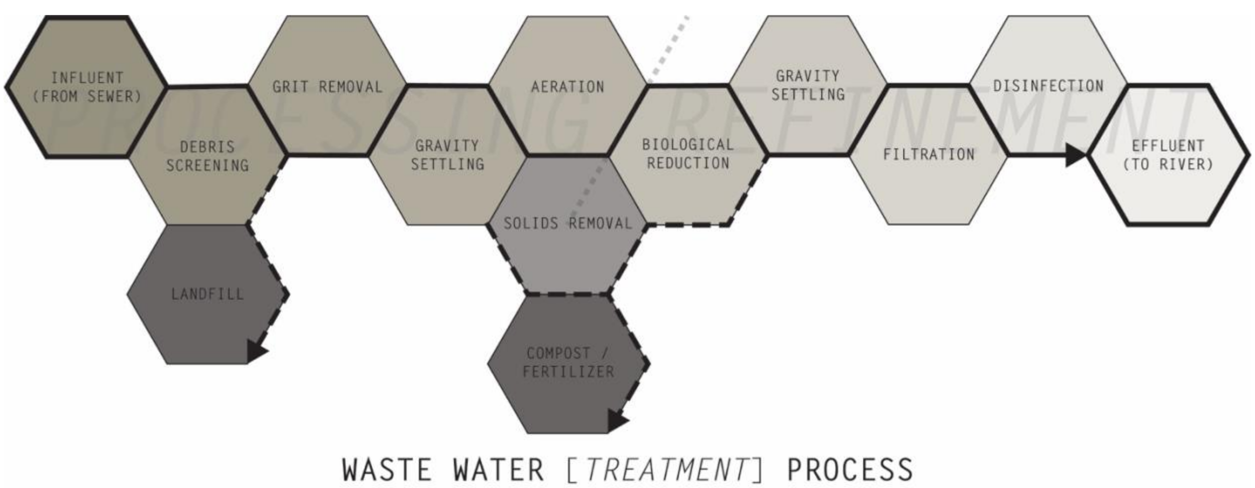


Figure 12 Waste Water Treatment process. Diagram by author.

key to an effective and lasting water treatment plant. Pilot plant tests are valuable to evaluate methods for new treatment plants.

The treatment infrastructure needs to be robust and adaptable to mitigate any issues and malfunctions. Single-purpose unit processes increase reliability and ability to address issues by being able to be isolated from the rest of the processes. An interconnected parallel dual production train minimizes impact of single unit failure and allows many processes and a larger volume of production to be handled at all times.

If and when possible, gravity flow can be used to move water through the various stages of a water treatment facility. Gravity is always more reliable and energy efficient than traditional mechanical pumping systems which can easily fail and interrupt the reliability of a public service. Gravity can also be used in the application of treatment chemicals and other stages.[36]

In the design and layout of a water treatment facility, one of the first and most limiting factors will be the capacity, determined by the treatment type, population or land area served, as well as the intended water use. Capacity of a facility will inform the various support spaces that are required.

Ancillary facilities do not treat water but are necessary to enable the water treatment processes to run efficiently. Ancillary facilities might include electric power systems and other utilities (water, gas, waste disposal), administrative offices, meeting rooms, laboratories, maintenance facilities, public space, classrooms, control

[36] American Society of Civil Engineers and American Water Works Association, *Water Treatment Plant Design*, Second. (McGraw-Hill, Inc., n.d.), 541.

rooms, and garages which typically account for 15-35% of the total cost of the plant, proportional to facility capacity. These ancillary facilities are arguably as important to the design of the facility as the design of the processes themselves because these facilities are the most public, and are what the society may witness and judge a facility by, making it difficult for the public to actually understand and appreciate the processes of the facility.

Potential laboratories have many design considerations. The processes and evaluations that the labs are designed for need to be fully understood and may inform the connections and location of the labs within the entire facility. The ability for the labs to process, control, analyze and record data that can be relayed and used is critical to improving the functionality and effectiveness of the facility. Common elements needed in water treatment labs are sampling pipe lines direct from the facility to the analytical lab and a sampling basin or sink from which tests can be performed. Furthermore, ample space must be included to flexibly receive, analyze and store containers of samples.

It is critical to consider the future of the structures of the facility as they will often last longer than the 15 to 20-year period of the processes and equipment, which will eventually become outmoded, outdated, and worn out. Therefore, to understand how technology and equipment will change is critical to design a potentially modular and adaptable facility and layout which can change with the technology.

Furthermore, design of a public water treatment facility must anticipate and accommodate visitors, employees, and deliveries. It is also an opportunity to be designed as a source of municipal or company pride within a community. Siting of a public works facility is key to its operation, public reception, and efficiency. Selection of clear upland site for supply water purification is preferable to a downstream location which receives discharges from industry and agriculture. However, for a reclamation or wastewater treatment facility, a downstream site is more functional. Additionally, facilities should be located close to power and utility supplies and connections to minimize utility runs. With gravity as a potential natural advantage, a site with topographical changes of upwards to 20 feet can be adequate to flow and gravitate the water through most of the processes. Lastly, it is critical for the site to be protected from flooding – either through siting out of a floodplain or with active design features to mitigate a flood event. Flooding can overflow a facility and release untreated water into the environment.[37]

Future of Water Treatment

Historically, it is easy to see in most cities and towns how the public works facilities and water treatment have been sited at the edges or outside of the towns that they serve, with the public turning its back to these vital organs of the functions of their society. The public works facilities are often figuratively disconnected from the population which they serve. The people lack an understanding of where their water comes from and where it goes after its use, and need an inviting public facility which can bridge this gap and inform not only the public on the processes, but the larger

[37] Ibid.

scale impacts that the facility and the population's actions have on the environment and the system of water.

Water treatment plants across the Chesapeake Bay Watershed are receiving grants and investment to upgrade and bring them up to date with the best treatment processes and technologies to meet the TMDL requirements of the EPA. Continual advancements in technology are making water treatment plants more compact with a focus on an agenda of efficiency, sustainability, net zero energy, and automation. As our standards for water quality continually get more stringent with advancements in technology, water treatment facilities will need to adapt and advance in tandem.

Chapter 3: Bees

"You will probably more than once have seen her fluttering about the bushes, in a deserted corner of your garden, without realising that you were carelessly watching the venerable ancestor to whom we probably owe most of our flowers and fruits … and possibly even our civilisation, for in these mysteries all things intertwine."

- Maurice Maeterlinck

History of Bees and Human Interactions

Mammals and the flowering plants that produce pollen and nectar on which the first insects foraged and pollinated co-evolved roughly around 100-150 million years ago during the Jurassic and Cretaceous periods. Ten to twenty million years ago, social honeybees of Asia, Africa, and Europe appeared, evolving likely from the solitary bees in the Afghanistan region. Documentation in forms of rock paintings found in Spain, South Africa and Zimbabwe depict humans honey-hunting, dating back to between 10,000-6,000 BCE. Even chimpanzees (the closest living relatives of humans) have been observed by Jane Goodall bravely raiding beehives for honey.

During classical era of Greece and Rome (500 BCE-476 CE) bees were kept and admired for their honey. The domestication of bees became fairly common, especially in Europe where the populations and honey production were falling off.

Bees were often represented in artwork, heraldry and coins. European literature describing bees and the human understanding of bee life appears in the Classical Period. Although generally inaccurate and idealistic, many writings document the human admiration for bees.[38] Authors like Pliny the Elder "praise bees for their government, discipline and military-like organization...as well as their usefulness to people," commenting on the cooperative nature of the production and consumption of honey in bee hives.[39] Similarly, Joseph Warder wrote of bees' loyalty, and John Levett of their regal power and civil discipline. These themes manifested in the cultural meanings and metaphors developed over time around bees, nodding to the social discipline in the bee's societal structure and production operations.

The Role of the Bee in the Ecosystem

Honeybee Society

Honeybees have a cooperative social structure. A hive may consist of upwards of 50,000 individuals. There is always a single queen bee, whose sole responsibility is to breed and lay up to 1,200 eggs per day. The majority of the hive are female worker bees. Older worker bees forage for pollen and nectar to bring back to the hive for food. Younger worker bees typically remain in the hive to clean cells, make the food,

38 J.H. Galloway, "The Industry of Bees," *Gastronomica* 7, no. 1 (2007): 100–103.
39 Alves, "Mead," 152.

and tend to the brood. There are also a few hundred male drones whose sole purpose is to mate with the queen.

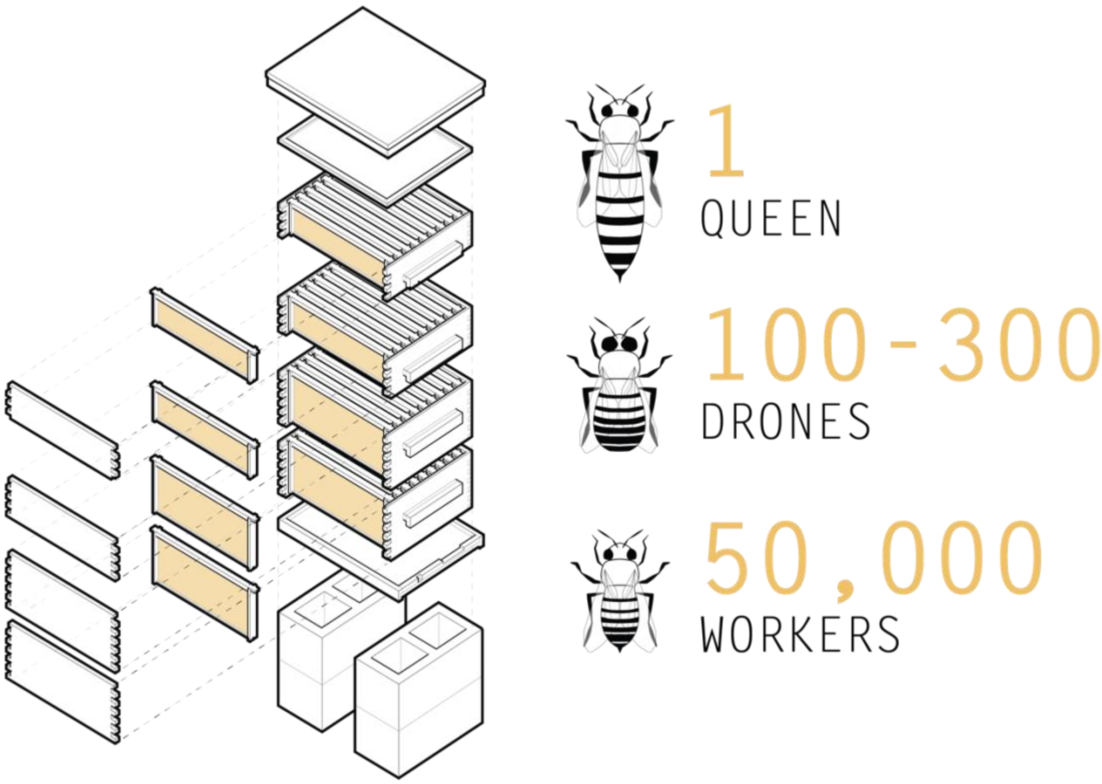


Figure 13 Typical Makeup of a Langstroth Beehive, drawing by author.

Pollination and Honey

Honeybees forage and fill their honey sacs with nectar and pollen from flowering plants and trees. Enzymes and saliva transform nectar and reduce pollen content of the honey in the bee's sacs as it returns to the hive. Upon arrival back to the hive, the returning bee will communicate to its hive mates the location of the food source from which it is returning by performing an elaborate "waggle dance" to demonstrate distance and position in relation to the sun.[40] The returning forager then

40 Ibid., 152.

regurgitates the contents of its honey sac into a hive's wax comb which is then ingested by workers to continue the refinement of the mix to transform it into honey – ultimately a mixture of water, sugars like laevulose and dextrose, trace proteins, nitrogen and ash.

Impact on Humans

Honey bees are critical to the production and growth of over 90 crops in North America and contribute to over 35% of global food production. In the United States, Honey bees have a net worth of over 15 billion dollars for their essential role in the production of fruits, nuts, vegetables and other food products. Some crops rely on bees for up to 90% of their pollination, and almonds, for example, are completely dependent on bee pollination. Commercial pollination is a large industry of which costs have risen with the decline of populations.[41]

Threats to Bee Populations

The United States bee population has been in steep decline over the past six decades, falling from 6 million colonies to 2.5 million colonies – which poses a great threat for the agriculture industry. Colony loss rates in commercial beekeeping have been averaging 30% each winter, where historically this rate was consistently 10-15%. This massive loss is rooted in a number of critical issues facing bees. The loss of habitat through deforestation and development is a leading force.[42] Abel Alves, in

41 "Fact Sheet: The Economic Challenge Posed by Declining Pollinator Populations," *Whitehouse.Gov*, last modified June 20, 2014, accessed May 22, 2019, https://obamawhitehouse.archives.gov/the-press-office/2014/06/20/fact-sheet-economic-challenge-posed-declining-pollinator-populations.
42 Ibid.

his article, *Mead: A Study in Human Culture's Interaction with the Natural Environment and Other Animals*, states:

> Endless agricultural fields and accumulated housing may or may not provide for growing human populations, but they assuredly interfere with the bee's ability to forage as these human impositions on the environment consume more and more acreage of flowering trees and plants.[43]

Widespread use of agricultural pesticides and herbicides also are infiltrating hive food supplies and poisoning populations. Other contributing factors to the bee decline are the lack of biodiversity and genetic diversity, mite infestations, and colony collapse disorder in which there is a sudden, unexpected catastrophic loss of bees in an entire hive. Due to the rapid decline of the bee population, beekeepers in the United States have lost 10 million beehives at a cost of $200 per hive, reducing the size of the industry without effecting demand for their products – namely honey.[44]

Apiculture

Practices

The methods employed by man for retrieving honey have evolved over time and date back to the fifth dynasty of Egypt, ca. 2494-2345 BCE. Early, humans would destroy the hives and bees to gain unhindered access to the honey, but this was soon realized to be counterproductive. Over time various other attempts at retrieving the liquid gold without disrupting the bees evolved. A method that subdues colonies with

[43] Alves, "Mead," 162-163.
[44] "Fact Sheet."

smoke while the honey is extracted proved to be more successful and sustainable.[45] Over time, this method and other beekeeping techniques have evolved and advanced this process.

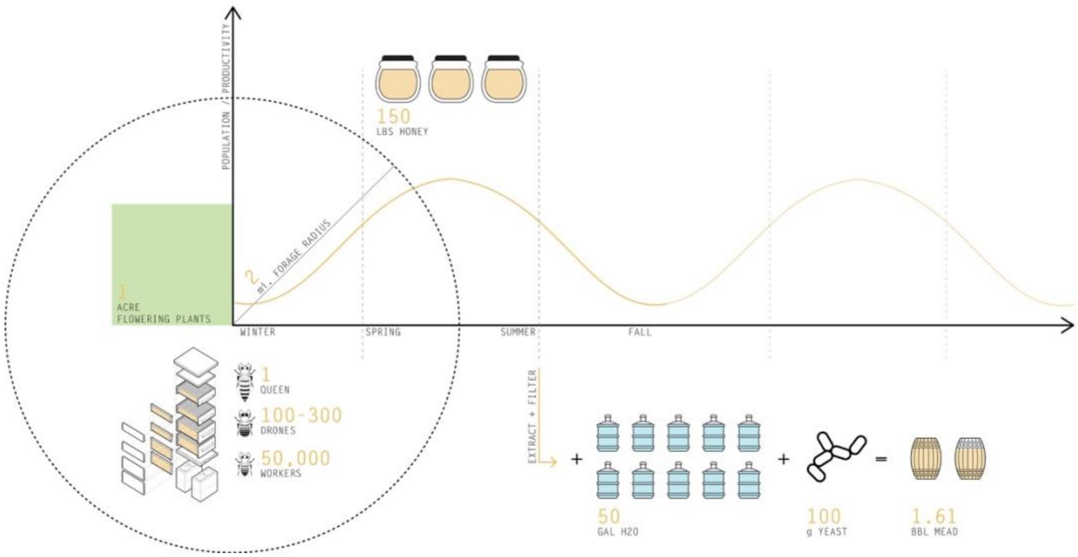


Figure 14 Synthesis Diagram, from hive to bottle. Drawing by author.

45 Alves, "Mead.", 153.

Chapter 4: Mead

History of Mead

Although generally associated with Celtic and Old Norse cultures, mead has global and multicultural origins. Mead preceded wine and viticulture in the Mediterranean and ancient Italy. It was a more dominant fermented beverage among the Greeks prior to 1600 BCE and the rise of viticulture, but then came to be degraded as the drink of northern barbarians. To the northern 'barbarians' mead "possessed all the richness of mythic imagery that wine had for the Greeks and Romans."[46]

As winemaking and agriculture swept the Mediterranean basin, admiration for mead among the Greeks and Romans was lost. Foraging of both humans and bees were better accommodated in northern Europe with sparser populations and more contained agricultural fields. Able Alves notes that "…mead is more associated with ancient Celts and Vikings than with the Greeks and Romans… because the urbanized and populous Greeks and Romans relied on the tamed gardens and farms…"[47] This directly lead to the continued understanding of mead as a cultural staple among the Germanic Tribes and Old Norse.

The rarity and decline of mead production and drinking can be seemingly related to the decline of foraging land, flower fields and forests for bees. Therefore,

[46] Ibid., 153.
[47] Ibid., 163.

the humbling and liberating drink, mead, is closely tied to the survival of bees. As humans realized the decline of available honey due to declining bee populations, domestication of bees was thought to be a solution - however domesticating and preserving populations of bees did not necessarily equate to the same amount of nectar being collected by the bees from flowers. Robert Gayre, author of *Wassail! In Mazers of Mead*, documents this realization:

> For, at the same time, he was putting the axe to the great trees which provided nectar, and was putting the plough into the fields, and planting in the place of wild flowers, grain plants which yield no nectar for the honey bee.[48]

As the European forests were in rapid decline to support the timber industry and population growth, the operations continued to expand, conquering and plundering nature elsewhere in the world, reducing honeybee's habitat and furthering the notion of mead as a rare and exotic beverage.

Roles of the Intoxicating Drink in Society, Culture and Mythology

What I won from her [Gunnlod] I have well used:

I have waxed in wisdom since

I came back, bringing to Asgard

Odrerir, the sacred draught.

[48] Robert Gayre, *Brewing Mead: Wassail! In Mazers of Mead* (Brewers Publications, 1986), 100.

The "High One," Odin, describes his exploit and praises mead, or Odrerir, in the Elder Edda.[49] In mythology and folklore, mead was a 'gift of the gods' and could inspire poetic ecstasy and "impart inspirational wisdom and knowledge."[50]

It is believed that mead may have been the first intoxicating drink consumed by humans, but although there is no direct evidence, this assumption is built firmly on the antiquity and documentation of honey gathering in many different cultures and regions. The drinking of mead in a vast hall was one of the vital rituals of the Old Norse and Germanic tribes. These events were community-building, but also sometimes lead to conflict and disaster demonstrating the potential of the intoxicating drink to transform drinkers for good or ill. As portrayed in the excerpt above, even the Norse God Odin was portrayed as dishonoring himself to acquire mead. In the texts of the Ancient Greek Orphic mysteries, it is said that Titan Kronos slept intoxicated with honey when his son Zeus overthrew him.

Mead Brewing as a Craft

Intoxicating beverages have been part of human culture for nearly all of time and were seen in some cultures as magically containing the potential for both great good and evil. When applied to mead, one can infer that the bees' communal efforts of transforming plant matter into honey is for social *good*, however the humans' transformation of honey into mead (as an intoxicating beverage) was more ambiguous

[49] Lee M. Hollander, *The Poetic Edda*, 2d ed., rev. (Austin : University of Texas Press, 1977).
[50] Alves, "Mead." 154.

(as for if its purpose was for good or evil). This begins to hint at the unique aspect of mead – it is not made by man nor by bees, however its production is a cooperative effort of a society of bees and the humans who extract honey and transform the natural product into another form. This passing of hands is a twofold transmutation where humans add another deliberate step in the processing and refinement of honey as it ferments and becomes mead. This process is intrinsically dependent on humans being able to adapt and accommodate to the natural behaviors and needs of bees, and to some degree, vice versa. This is inherently what separates mead from its alcoholic counterparts. Abel Alves notes:

> Humans can directly cultivate the barley and grapes that give us beer and wine, but mead requires the bee as intermediary between humanity and human attempts at domination of the natural world.[51]

Therefore how mead is made – from the flowers of which the nectar is harvested to the beehives that make the honey – is inherently a mixture of natural processes that are then manipulated and crafted diligently by man to make unique and attractive recipes, some of which have stood the test of time, and others that are experimental and break boundaries.

Raw Materials

Brewing mead requires simple ingredients, and in varying amounts as recipes may dictate. At the core, mead is made with water and honey, fermented through the addition of yeast which converts the sugars in the honey to alcohol and carbon

[51] Ibid.

dioxide gas. Fruits, herbs, and spices can be also added to the mixture to create a desired recipe or flavor. High quality ingredients and honey yield high quality mead.[52]

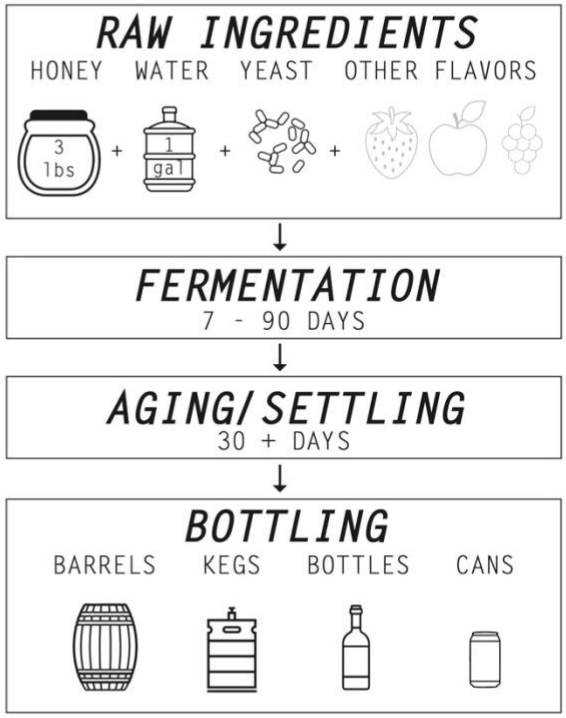


Figure 15 Mead Brewing Process Overview, drawing by author.

Equipment, Processes, and Fermentation

Sterile equipment is key to quality mead brewing. Standard equipment in a commercial meadery would include:

Fermentation tanks and other vessels, sized for production volume
Cellar or storage tanks
Boilers and Chillers

[52] "Commercial Mead Production," *Wines Vines Analytics*, accessed May 23, 2019, https://winesvinesanalytics.com/features/110520.

Airlocks
Hoses
Mixers
Hot box / honey warming room
Bottles + bottling machine
Corks or caps + machine
Thermometer
Hydrometer
Automation and control systems

The process of mead production in a traditional way involves diluting honey into water, adding yeast and letting time and fate do the work over several months. However, this method is neither time efficient nor effective in making high quality, clear mead. Commercial mead brewing is a bit more complex but can be done in shorter periods. After equipment is sanitized, water and honey are combined and mixed into a solution. In order to have a clean, sediment and haze free product at the end, it is critical to filter out the protein molecules, waxes, pollen and any other particles in the honey water mixture. Ultrafiltration (UF) removes most particles from 0.1 microns down to 0.01 microns. Without removing any flavor or color, this step ensures an economic, marketable, and attractive end product. Then, to turn the filtered honey water solution into alcoholic mead, yeast and nutrients are added. Specific yeast cultures have specific conditions in which they will perform best. Various yeasts can be used to make mead, most often being similar to wine yeasts. Fermentation, clarification, and stabilization processes can be controlled through the manipulation of process, technique and applied chemistry to shorten the maturation time with an equal quality. Traditional processes that may take upwards of 12 months can be done in periods of 2 to 3 months or shorter with modern techniques. Once fermentation is complete, the mead is racked into another vessel for clarification, and to remove it from the spent yeast sediment. The mead will clarify and stabilize over time, often guided with additives, and then will be ready to be bottled, sold and served.[53]

Market and Culture

The case for mead is one in which history repeats itself. Mead was once a popular choice of beverage, lost its shine, and is once again roaring ahead as a leading market in the craft beverage industry. According to data from the American Mead Makers Association (AMMA), from 2014 to 2015, the sales and production of craft beer grew by 17 percent and 18 percent, respectively. In the same time period, mead sales and production increased by 42 percent and 128 percent, respectively.[54] Sergio Moutela, owner and brewer at Melovino Meadery, credits this growth to the curiosity of the millennial generation and their interest in craftsmanship, sustainability and local goods:

> They [millennials] don't want to be told what to like. Instead, they would rather try and discover new things on their own. That is what mead about. It is not just what the Vikings drank or what is poured at Renaissance festivals. Its history is respected and honored, but the future of mead is here now.[55]

53 Ibid.
54 Zach Fowle, "Full Mead Ahead," *DRAFT*, last modified December 7, 2016, accessed May 23, 2019, https://draftmag.com/mead-growth-2016/.
55 Meghan Kavanaugh, "We Are At the Beginning of a Mead Maker Renaissance," *Restaurant Insider*, last modified August 5, 2017, accessed May 23, 2019, https://upserve.com/restaurant-insider/mead-food-trend/.

The direct relation to the environment – particularly through the plight of the honeybee – is another aspect that makes mead unique and attracts a market of people interested in environmental issues such as climate change. Moutela goes on to infer that the mead industry is currently where the craft beer industry was 12 to 15 years

Figure 16 Number of Meaderies in the US, https://upserve.com/restaurant-insider/mead-food-trend/

ago. From 2011 to 2017, over 450 meaderies have opened their doors and poured glasses.[56]

The culture of the mead industry is deeply rooted in the education of consumers, environmental justice, and saving bees. It is an industry of friendly competition, experimentation, and tradition.

[56] Ibid.

Chapter 5: The Site

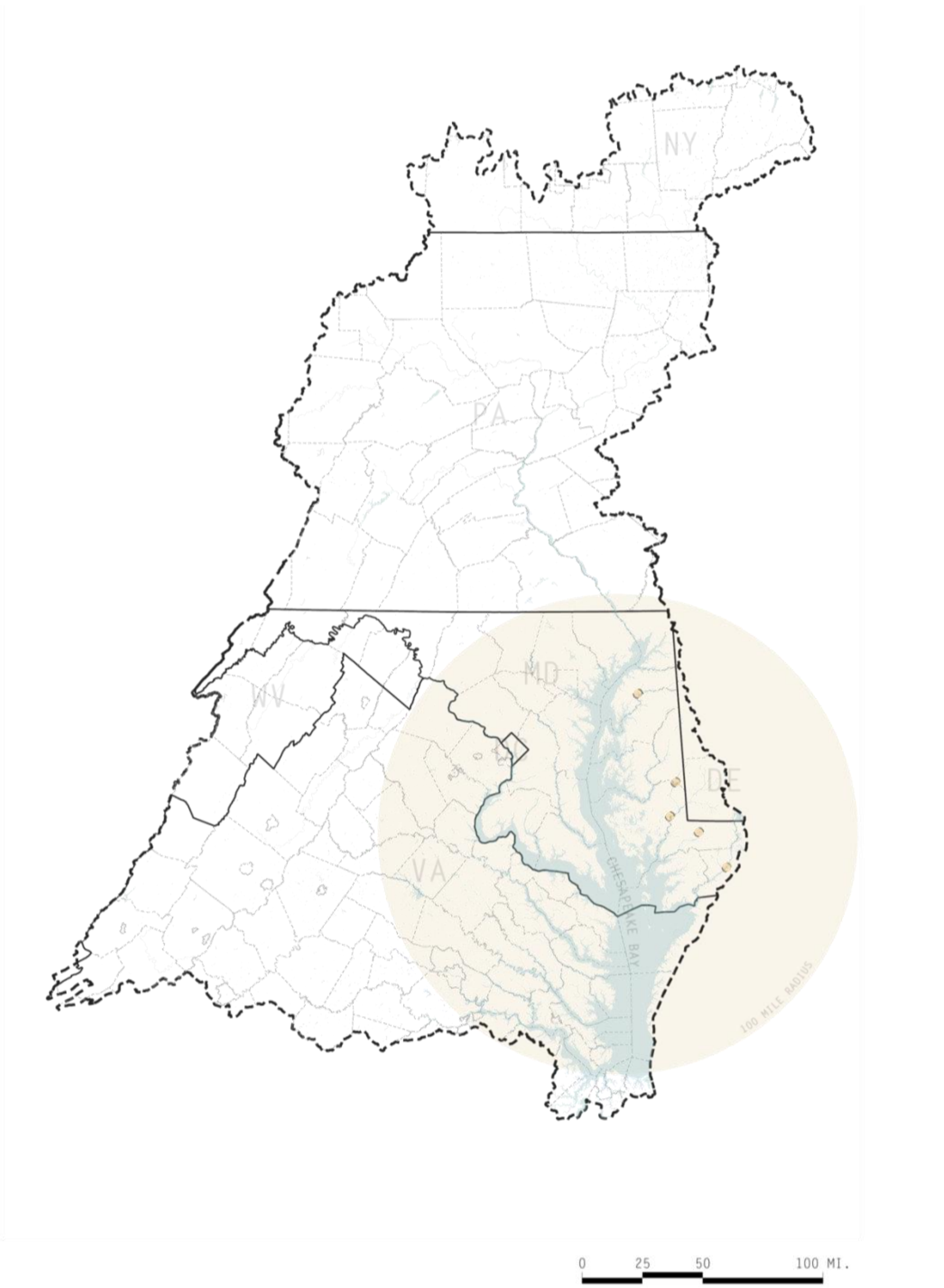


Figure 17 Five potential sites located on the Eastern Shore of Maryland, within the Chesapeake Bay Watershed. Diagram by author.

Selection

The site selection process for this thesis was rigorous. The necessity of an applicable site with significant proximity to the Chesapeake Bay, cropland, forest, as well as opportunities for the creation of threshold and restoration of a local environment was restrictive. Ultimately, from investigating over three dozen potential sites, one was chosen. It should be noted that this project is not site-specific – the very

Figure 18 Five sites on the Eastern Shore of Maryland. Diagram by author.

process of site selection proves that there are numerous valid sites around the Chesapeake Bay and in the watershed were this concept is applicable. The search narrowed in on the Eastern Shore of Maryland and identified Chestertown, Federalsburg, Vienna, Salisbury, and Snow Hill as prime candidates for this thesis. However, Vienna, Maryland was selected and will be used as a virgin site for which the bounds of the project scope are not limited nor restricted – allowing for maximum experimentation and freedom in the design and strategies to be explored.

Location

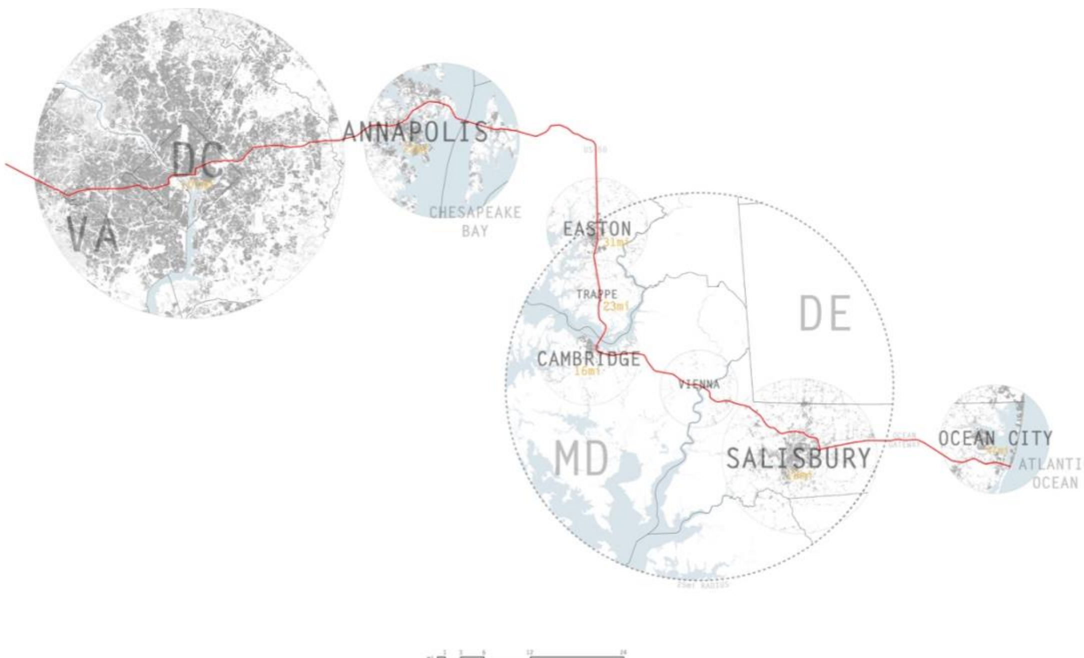


Figure 19 Vienna, Maryland on the US Route 50 Corridor. Drawing by author.

Vienna is located on the Eastern Shore of Maryland in Dorchester County, on the tidewater shores of the Nanticoke river. The Nanticoke river is a 64-mile long waterway and drains approximately 800 square miles of land in Delaware and

Maryland directly to the Chesapeake Bay. The Nanticoke watershed has been a focus area for preservation and restoration and has been listed as one of the "Last Great Places" by The Nature Conservancy.[57]

Located directly on the river, Vienna is also connected on land by Route 50, the Ocean Gateway. Fifteen miles west on Route 50 is Cambridge, Maryland, and 18 miles east is Salisbury, Maryland. Vienna is 100 miles from Washington, DC, and 45 miles from Ocean City. Vienna has a large network of farmland surrounding the town, as well as a great amount of natural marshland and preserved forest. The Linkwood Wildlife Management Area and the Blackwater National Wildlife Refuge are within a few miles.

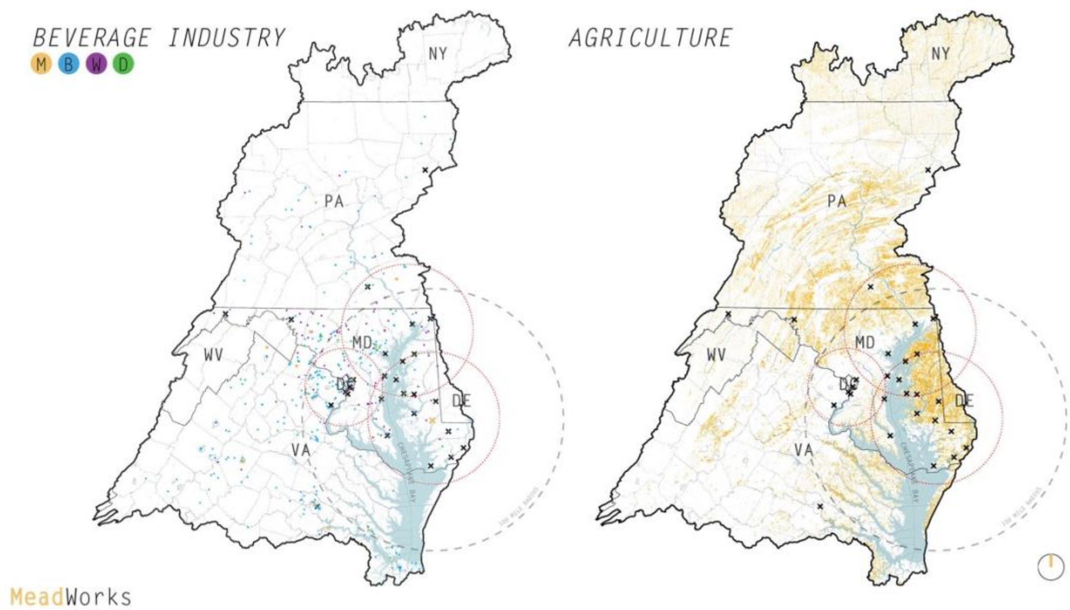


Figure 20 Site Parameters - Beverage Industry and Agriculture in the Chesapeake Bay Watershed Region. Drawings by author.

57 The Nanticoke Restoration Work Group, "Nanticoke River Watershed Restoration Plan" (May 19, 2009): 4-5.

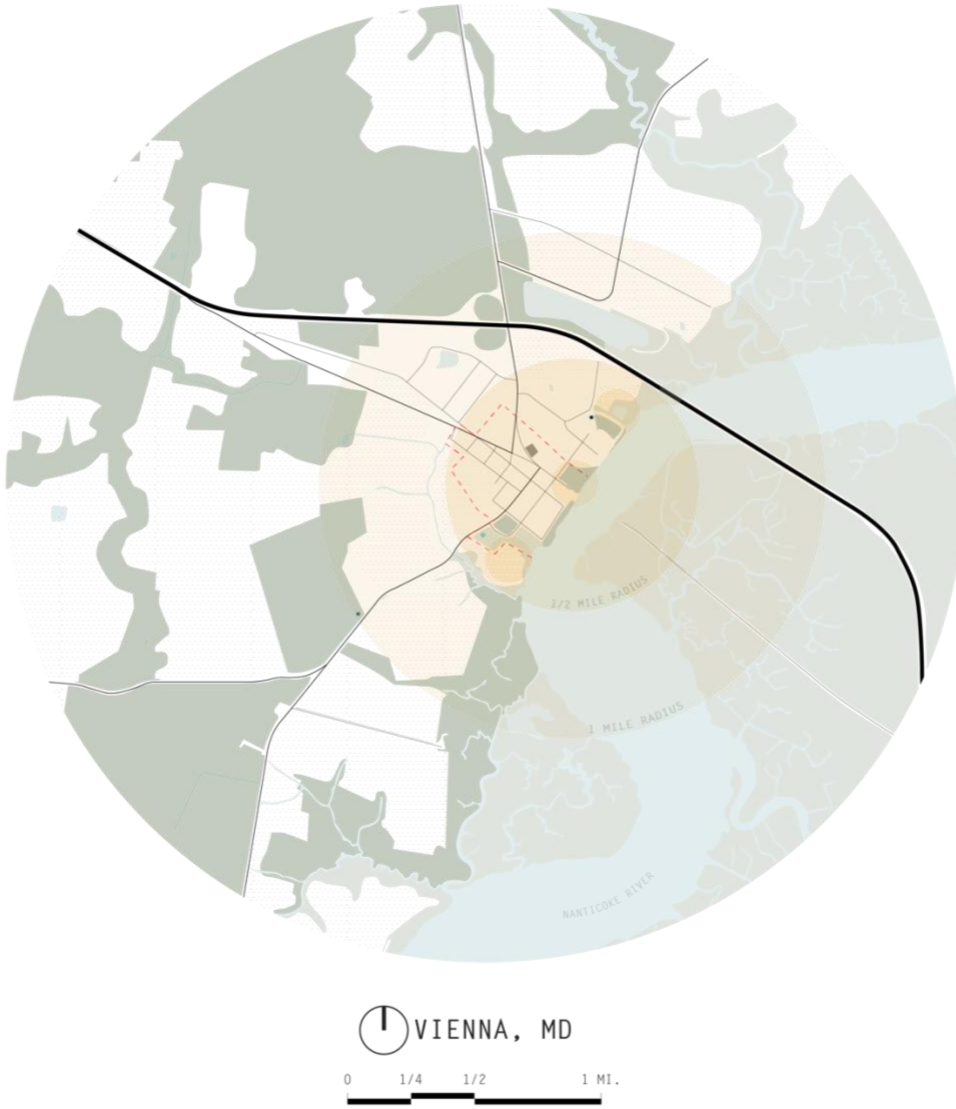


Figure 21 Vienna, Maryland on the Nanticoke River. Diagram by author.

History and Identity

Foundations

Long before European settlers arrived in the region, the Nanticoke Watershed was inhabited by the Nanticoke Indians – decreeing the area of Vienna as Emperor's

Landing, believed to be ceremonial feasting ground and home to seasonal waterside activities. It is believed that Captain John Smith, in his 1608 expedition to explore and map the Bay and its waterways, landed near Vienna during his voyage.[58]

In 1664, a ten-thousand-acre tract of land, known as Nanticoke Manor along the northern shore of the Nanticoke River was granted to Lord Baltimore by Charles Calvert. By 1671, a ferry service crossing the river was established and continued until the first bridge crossing was built in 1828. The town and region prospered in ship building, fishing, fur and white oak trade, commerce, and tobacco farming. It soon became the Custom's District of the region by 1768 and was beginning to suffer the competition of the establishment of Baltimore, Maryland.[59]

Figure 22 1903 Map of Vienna, Maryland, showing the railroad crossing.

[58] "2003 Greater Vienna Comprehensive Plan," December 22, 2003, accessed May 24, 2019, https://planning.maryland.gov/Documents/OurWork/compplans/03_CMP_vienna.pdf.
[59] "A Brief History of Vienna, Maryland.," last modified 2011, accessed May 24, 2019, https://viennamd.org/legacy.html.

The Baltimore, Chesapeake and Atlantic Railroad was chartered in 1886 and began construction in 1889. Running 87 miles from Baltimore to Ocean City, the railroad crossed the Nanticoke river at Vienna and provided both passenger and freight service to the Delmarva peninsula. The Baltimore, Chesapeake & Atlantic Railway company (BC&A) was plagued with financial issues and was eventually acquired by the Pennsylvania Railroad by 1928. By 1931, passenger service was discontinued, but the line remained to be used occasionally by freight trains until the 1960s when service was discontinued. The corridor created through the peninsula has been repurposed and used by the Delmarva Power and Light Company power lines.[60]

Vienna was chosen in 1926 by the Eastern Shore Gas and Electric Company for the location of a new coal-fired 12,000 Kw electric generating plant. This incoming industry, along with the established agriculture and trade, boosted the local economy, provided jobs and sustained Vienna as a prospering Eastern Shore port town.[61]

Outlook and Comprehensive Plan

The most recent comprehensive plan for the town of Vienna focusses equally on environmental, historic, and economic improvements. The document calls Vienna "the Pearl of the Nanticoke" and describes the town as "a small and attractive river port town with roots in the earliest history of Maryland and the Eastern Shore."[62] The document defines the vision for Vienna:

[60] Rachel Mancini, "Maryland Historical Trust NR-Eligibility Review Form," August 14, 2000, accessed May 24, 2019, https://mht.maryland.gov/secure/medusa/PDF/Talbot/T-1126.pdf.
[61] "A Brief History of Vienna, Maryland."
[62] "2003 Greater Vienna Comprehensive Plan."

> Vienna is envisioned as a gateway to the Nanticoke River and Watershed and a model Chesapeake Bay community which is conservation-oriented and respects its heritage and natural environment while planning progressively for the future.

While focusing on conservation-oriented and heritage-sensitive healthy growth and development, Vienna can be a prime site for a program which involves community engagement, improving infrastructure, and highlighting its greatest asset – the Chesapeake Bay. The plan reports that the town since the turn of the century has already been experiencing new energy and revitalization after a period of population decline: farmland and natural resources are being preserved, the Waterfront Park is being enhanced, the town's history has been chronicled in a new Vienna Heritage Museum in the heart of town, new jobs and economic development as well as construction and rehabilitation of housing is ensuring a stable and healthy future.[63]

[63] Ibid.

Figure 23 Figure-Ground of Vienna, Maryland. Drawing by author.

S.W.O.T Analysis

Strengths

Vienna is a unique river crossing village and a gateway to the Nanticoke, with connections via water (Nanticoke River) and land (Route 50, the Ocean Gateway). It is located centrally along the river at a 20-mile midpoint, acting as a stopping point for many passing ships. It is also located nearly equidistant between Cambridge and Salisbury, and Easton and Ocean City – placing it strategically in the perspective of Delmarva travel, tourism, and trade. Its historic and unique location is largely preserved and features great natural resources, and a working landscape of prime farmland, pristine marshes and waterways, and woodlands. Environmentally, Vienna is located north of the halide (salt) zone in a unique oligohaline zone where salt and freshwater are mixed and foster biodiversity. Within a 125-mile, two-and one-half hour driving radius, including Washington, DC, Annapolis, Baltimore, and Philadelphia is a population of over 15 million people. The town sees traffic of over 21,000 vehicles per day in Average Annual Daily Traffic. The town, strategically located on the outside of a meander in the river, is surprisingly not very prone to severe flooding due to the 15-foot high sand bar formed by the river.[64]

Weaknesses

The river crossing is Vienna's main reason for existence. Other than the power plant, the town hosts no major industry for mass employment. According to the United States Census, Vienna has a small population of about 265 individuals with a median household income of $59,643.[65]

The area also has a high-water table – creating surface water drainage issues. Topography is minimal, with a maximum height of 15 to 20 feet above the river[66]

Opportunities

The town annexed a large portion of farmland over the past few decades and presents the opportunity to extend the town's grid and residential fabric. Vienna's

64 Ibid.
65 US Census Bureau, "Vienna, Maryland," last modified 2018, accessed May 24, 2019, https://www.census.gov/search-results.html.
66 "2003 Greater Vienna Comprehensive Plan."

unique history and identity, as well as its small footprint in a major location provide opportunities for this thesis to define a sense of place and integrate with the town by aligning with its environmental and development ideals.

Threats

As both an opportunity for growth and a threat to its small-town charm, Vienna is located directly in the path of serious development pressure roaring down the Eastern Shore from the bay bridge.[67]

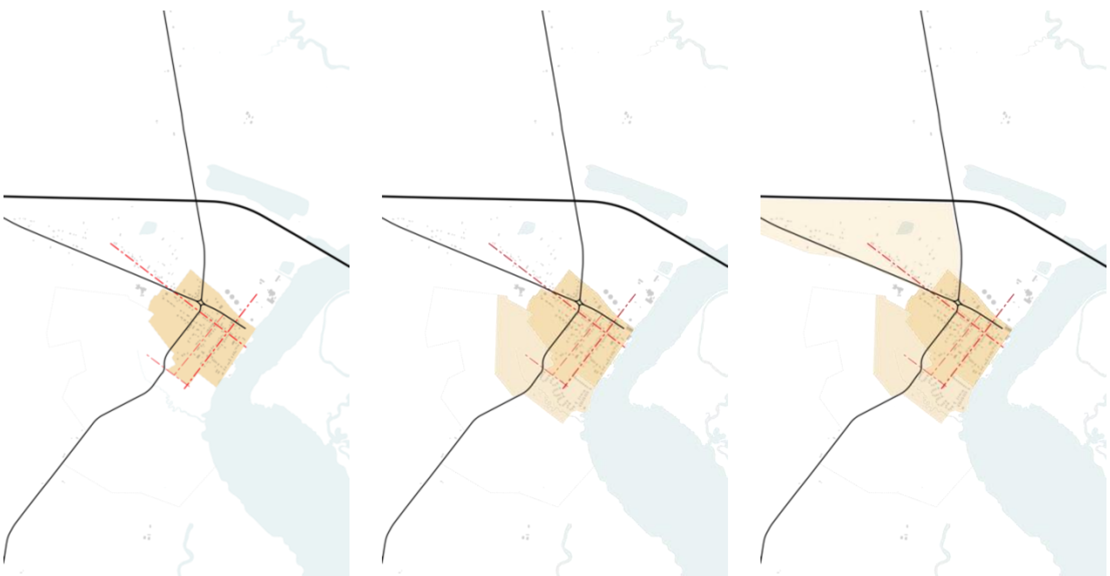


Figure 24 Tiers for Radial Town Growth. Tier 1, 2, 3 from left to right. Drawing by author.

[67] Ibid.

Chapter 6: Precedents

Advanced Water Purification Facility

Oxnard, California // Mainstreet Architects + Planners, Inc. and CH2M Hill

Figure 25 Advanced Water Purification Facility approach through engineered wetlands

The City of Oxnard, California is applying innovative technologies and strategies to address the city's challenges of water uses, resources, and supplies. The city has set itself apart from other municipalities by reducing its reliance on imported water through a strategic water resource program, Groundwater Recovery

Enhancement and Treatment Program (GREAT)[68]. The program included the creation of the Advanced Water Purification Facility in 2013 to process a portion of secondary effluent from the city's existing wastewater treatment plant in order to recover and produce high-quality treated water for various purposes including agricultural irrigation, landscape irrigation and groundwater recharge[69].

Designed by a team of architects from Mainstreet Architects + Planners, Inc. and engineers from CH2M Hill[70], the progressive and attractive design of the facility and its site challenges the typical model of water infrastructure facilities. The Advanced Water Purification Facility is innovative in its design, siting, and processes.

The AWPF employs a multiple-barrier treatment train with microfiltration, reverse osmosis, and ultraviolet light-based oxidation processes[71] to efficiently and sustainably purify the effluent from the Water Pollution Control Facility and supply 25 million gallons a day of reclaimed water to the City[72].

The AWPF is strategically located on a 4.65-acre site located adjacent to the city's Water Pollution Control Facility and a short distance from the Pacific Ocean. The site provided the design team with many constraints – including a small buildable footprint and height restrictions, brackish and salt water environments, and a high water table on site. These constraints lead to process optimization and many

68 US Census Bureau, "Vienna, Maryland," last modified 2018, accessed May 24, 2019, https://www.census.gov/search-results.html.

69 Jim Lozier and Ken Ortega, "The Oxnard Advanced Water Purification Facility: Combining Indirect Potable Reuse with Reverse Osmosis Concentrate Beneficial Use to Ensure a California Community's Water Sustainability and Provide Coastal Wetlands Restoration," *Water Science & Technology: a journal of the International Association on Water Pollution Research* 61 (March 2010): 1157–63.

70 Ibid.

71 Ibid.

72 Mainstreet Architects + Planners, Inc., "Advanced Water Purification Facility / Mainstreet Architects + Planners, Inc."

innovations in the design: large-diameter reverse osmosis units to minimize number of units required (one of the first facilities with such elements), common electrical rooms and chemical containment areas, and on-site demonstration mesocosm wetlands. Many of these strategies not only made the site more efficient, but also led to reduces equipment and construction costs[73].

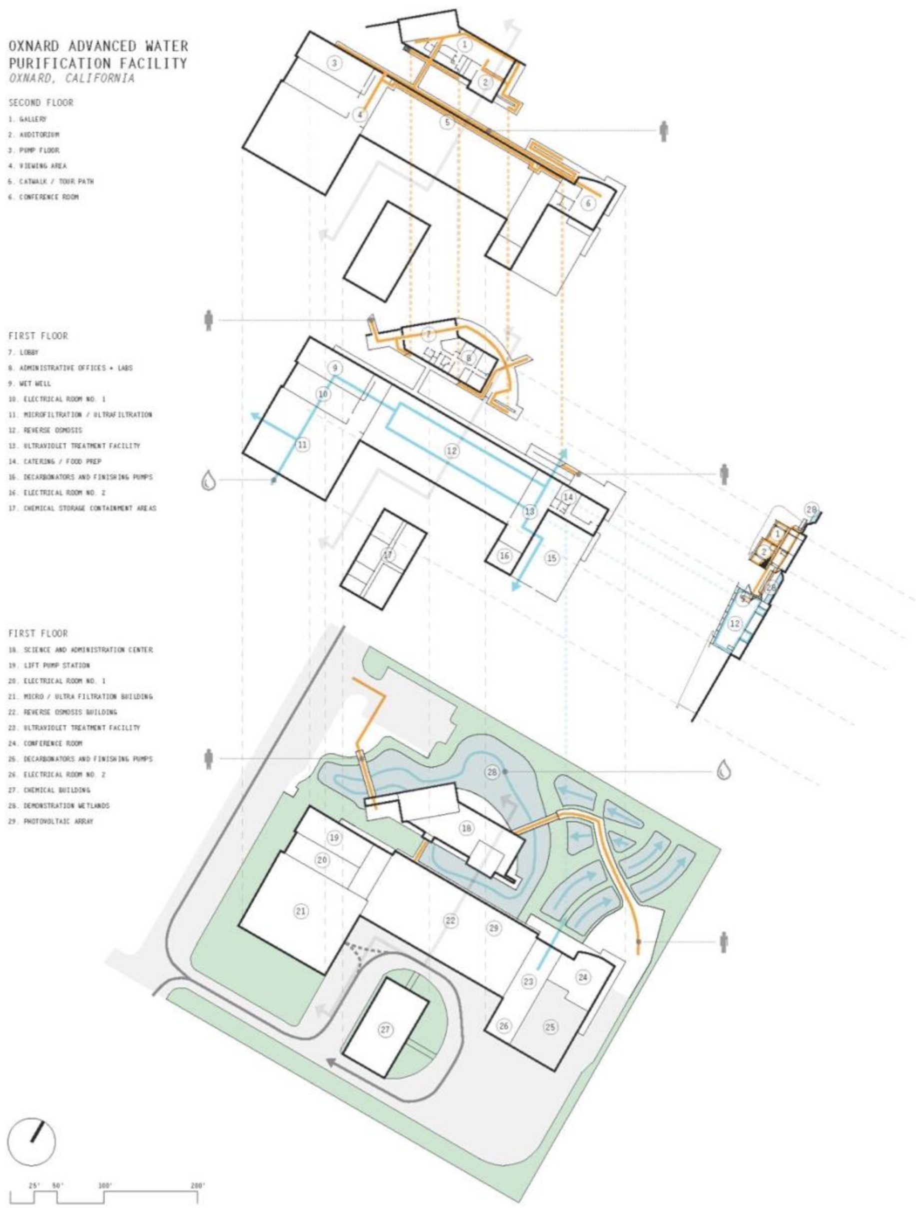


Figure 26 Oxnard Advanced Water Purification Facility Flows diagram, drawing by author.

[73] Lozier and Ortega, "The Oxnard Advanced Water Purification Facility."

The influent for the AWPF process will be the effluent from the city's Water Pollution Control Plant. Upon inlet to the microfiltration system, this secondary effluent will be continuously dosed with free chlorine to manage biofouling on membranes. A pumping station pressurizes the chlorinated effluent and sends it to be flowed through pressure strainers into a pressure-type microfiltration unit. The microfiltration process removes particulate matter and pathogens to produce a high-quality feedwater for reverse osmosis. Any backwash water from the MF system is recovered, pH-adjusted and/or dechlorinated, and discharged through a sewer to be returned to the Water Pollution Control Facility for retreatment[74].

The microfiltered feedwater is then chemically conditioned with sulfuric acid and scale inhibitors prior to reverse osmosis treatment. The reverse osmosis system has two trains, each with three steps to allow for a recovery rate of 80-85 percent. The concentrate of soluble salts byproduct from the RO process is then either discharged to the ocean or processed through a "demonstration-scale engineered natural treatment system (ENTS)" on-site[75].

The combined water from both trains of the RO process are then subjected to an Ultraviolet light-based advanced oxidation (UV/AOX) process by which hydrogen peroxide and UV light oxidize micropollutants and disinfect microbial matter. This step results in highly reduced levels of protozoan, bacterial, and viral pathogens that may have been present in the water. Effluent from the UV treatment will then be chemically stabilized with liquid lime to minimize corrosion in delivery systems and

[74] Ibid.
[75] Ibid.

prevent chemical changes during recharging. The AWPF is the first facility to employ liquid lime stabilization, as opposed to the traditional and higher maintenance dry lime techniques[76].

The facility employs many sustainable elements including photovoltaic panels for renewable energy production, automated passive cooling systems, passive and active daylighting controls for lighting and passive solar heating, and reduced onsite water consumption and native landscaping[77]. The most innovative and unique feature of Oxnard's AWPF is the engineered wetlands. A pilot-study evaluated and provided proof-of-concept for the use of RO concentrate as a feedstock for a variety of salt marsh plant species. The study concluded that the concentrate can sustain native plant environments, remove nonconservative elements through natural biological and chemical transformative processes, and respond positively to the ecologically safe discharge. The wetlands demonstrate the ability of natural environments to remediate and benefit from RO waste concentrate. The inclusion of the demonstration wetlands on-site helps keep the processes contained and creates a public amenity to complement the facility's visitor center where the public can interact with the various treatment processes and learn about the facility and the GREAT program[78].

New Belgium Brewery

Asheville, North Carolina // Perkins+Will

[76] Ibid.
[77] Mainstreet Architects + Planners, Inc., "Advanced Water Purification Facility / Mainstreet Architects + Planners, Inc."
[78] Lozier and Ortega, "The Oxnard Advanced Water Purification Facility."

Figure 27 New Belgium Brewery, main building and restored wetlands

New Belgium Brewing Company is a 100% employee-owned American craft brewery with two locations, the Asheville complex being the second and increasing the production capacity by 500,000 barrels/year. New Belgium is the fourth-largest craft beer brewery in the nation and the eleventh-largest brewery in the United States, according to the company's website.

In 2012, Perkins+Will was selected by the company to design New Belgium's first East Coast location. "United by a shared commitment to sustainability and community development,"[79] the partnership between Perkins+Will and New Belgium was forward-thinking and resulted in the design, construction, and operation of one of the most innovative and eco-friendly breweries in the US.

79 "New Belgium Selects Architect For East Coast Facility," *Brewbound.Com*, last modified June 20, 2012, accessed April 25, 2019, https://www.brewbound.com/news/new-belgium-selects-architect-for-east-coast-facility.

The New Belgium East Coast Brewery transformed a 17.5-acre brownfield site along the French Broad River into a densely programmed and intentionally restorative natural site integrated into the River Arts District.[80] The qualities of the site provided opportunities to harmoniously juxtapose the industrial nature of the brewery into the natural environment.

According to Perkins+Will, the brewery's design was intended to create a brewing "machine" that also celebrates the notion of craft through thoughtful exposure of the process' functional elements. Armed with a modern industrial aesthetic, the design nods to the site's past barns and warehouses while creating a unique identity for the brewery.

A critical aspect of the New Belgium brewery as it relates to this thesis is its site – located on a river with many opportunities to revitalize the site, restore natural wetland habitats, and activate the river front with pedestrian access. The building celebrates the site by framing views of the natural environment, including many programmed and natural outdoor public spaces, and using a neutral and natural material palette.

Programmatically, the brewery is the main production location for New Belgium and includes extensive production, packaging, and distribution spaces, as well as public domains for tours and enjoyment of beer, several outdoor spaces, and vibrant offices for administration.

[80] Perkins+Will, "New Belgium Brewing East Coast Brewery / Perkins+Will," *ArchDaily*, last modified August 15, 2018, accessed April 25, 2019, https://www.archdaily.com/899697/new-belgium-brewing-east-coast-brewery-perkins-plus-will.

Martin’s Lane Winery

Kelowna, British Columbia, Canada // Olson Kundig

“The building is split into two parts, with one part literally following the land, and the other part following the horizon line. My favorite element of the project is the magic that happens when these two parts of the building come together.”

Tom Kundig, FAIA, RIBA

Figure 28 Martin's Lane Winery, made up of two intersecting rectangular forms situated in a hillside vineyard

Martin’s Lane Winery is a site and program-driven design that resulted in a unique and functional form. Located on a 96-acre vineyard overlooking nearby Okanagan Lake, the building is tucked into the hillside and draws on the parallels between the site’s topography and the gravity-flow process of winemaking. Programmatically, the building is separated into two intersecting rectangular forms. One follows the site’s natural slope and contains all of the production related spaces, while the other cantilevers out to the horizon, overlooking the vineyards and lake, and houses the visitor areas.[81]

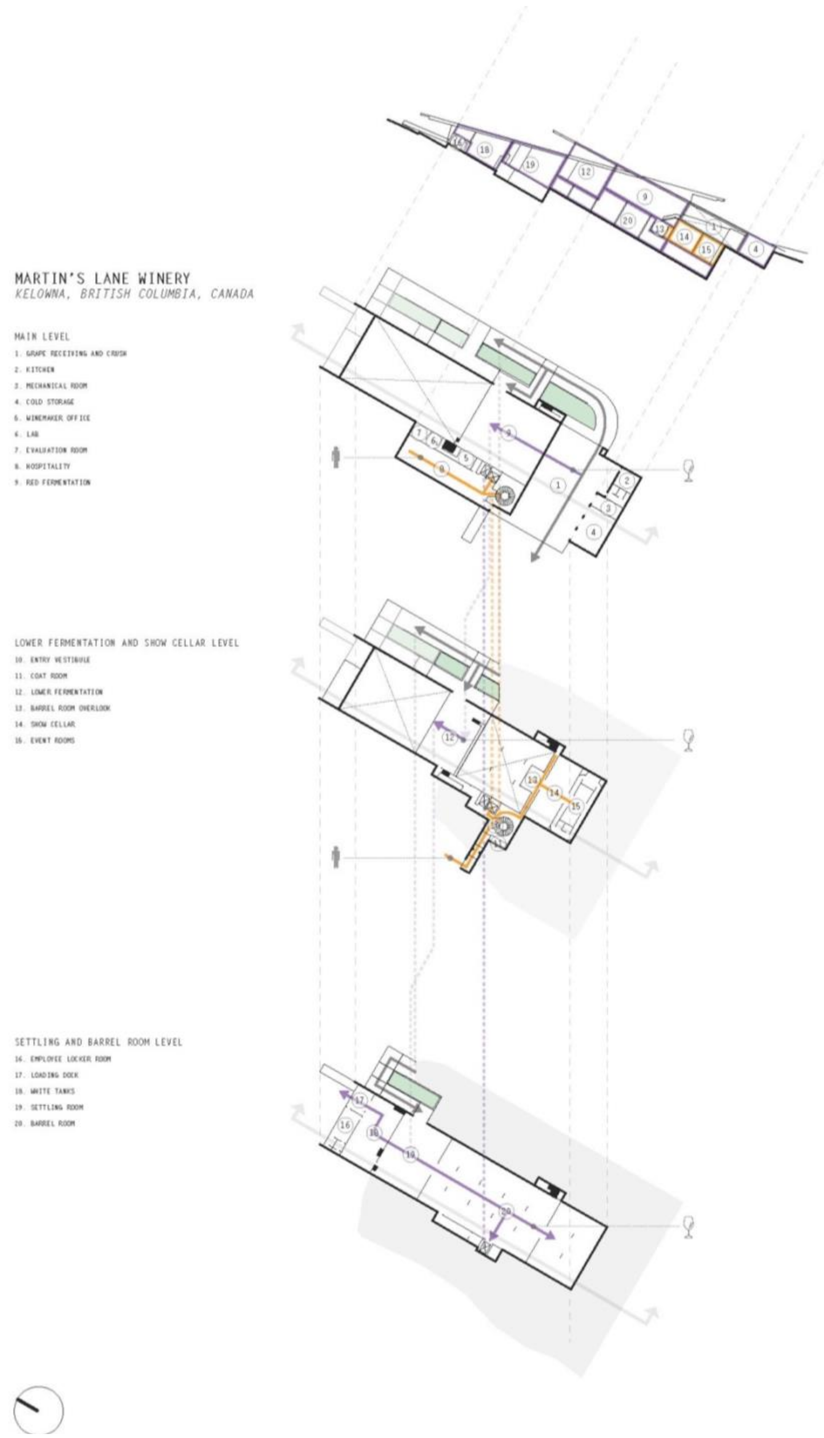


Figure 29 Martin's Lane Winery Flows diagram, drawing by author.

81 Tom Kundig, "Olson Kundig — Martin's Lane Winery," *Olsonkundig.Com*, accessed April 25, 2019, https://olsonkundig.com/projects/martins-lane-winery/.

At under 35,000 square feet[82], this project is programmatically relative to the scale and function of the mead brewing operations anticipated for this thesis. Understanding the adjacencies of certain production functions and the relation to site treatment and strategy is key, which this project exemplifies. The seamless integration of visitor and production spaces within a purposeful and functional form on a unique site is admirable and inspiring.

<u>Tashjian Bee and Pollinator Discovery Center</u>

University of Minnesota, Chaska, Minnesota // MSR Design

Figure 30 Tashjian Bee and Pollinator Discovery Center, design is referential to historic barns with intricately detailed structure

82 Fernanda Castro and Tom Kundig, “Martin’s Lane Winery / Olson Kundig,” *ArchDaily*, last modified July 2, 2018, accessed April 25, 2019, https://www.archdaily.com/897284/martins-lane-winery-olson-kundig.

Tashjian Bee and Pollinator Discovery Center is a small-scale, education focused design, set in a unique site within the 1,100-acre Minnesota Landscape Arboretum. By using previously developed land within the preserve, the building has minimal impact on the surrounding natural environment, and through its design, provides more habitat for birds and pollinators to increase biodiversity and create opportunities for education. Its purpose is to provide "learning opportunities for children and adults about the lives of bees and other pollinators, their agricultural and ecological importance, and the essential, fascinating, and delicious ways our human lives intersect with theirs,"[83] essentially summarizing one of the three main objectives of this thesis.

The Bee Center's design is a simple form, referential to historic barns. Divided into two wings, the building is very open, multi-functional and adaptable. Traditional agriculture buildings are purpose-built, economical and efficient – values that are all adapted in the design of the Bee Center. The design is distilled down to the simplest, most necessary yet beautiful form. Its orthogonal gable-roofed forms are simple, easy to construct and employ contemporary improvements of traditional and economical wood construction techniques. Material selections and construction are meticulous – taking advantage of passive design strategies and using exposed glulam truss framing for a contemporary nod to the conventional wood framing of barns.

The program is connected to nature and its site with pollinator gardens, beehives and food production gardens. The building's three main spaces are

[83] American Institute of Architects, "Tashjian Bee and Pollinator Discovery Center," *Aia.Org*, last modified April 2019, accessed April 25, 2019, https://www.aia.org/showcases/6130338-tashjian-bee-and-pollinator-discovery-cent/?utm_source=real-magnet&utm_medium=email&utm_campaign=hna19-3-cote-top-ten.

inherently linked by the articulation of structure, daylighting and site connections – creating clarity, efficiency, and a dramatic relationship. The design embodies and advertises the center's mission to exemplify conservation and best practices for the natural environment with programming to facilitate community-based functions to educate the public on sustainable farm-to-table practices. This mission is shared with hundreds of thousands of visitors who are invited to "deepen their understanding of, and connection to, the natural world around them."[84]

From a sustainability and construction standpoint, the Bee Center is efficient, interesting, and environmentally focused – designed to be Net Zero. Demonstration gardens feature annual, seasonal, and pollinator-specific habitats to attract and accommodate wildlife and serve as teachable moments surrounding the building. Utilizing permeable pavers and a metal roof, the site absorbs and manages storm water. Low-flow fixtures are used, as well as an on-site sewage system to eliminate the reliance on long sewer connections and recharge the local aquifer. Extensive energy analysis led to a high-performance building envelope. In addition to passive strategies like orientation, natural ventilation and shading, the Bee Center features other sustainable technologies including a geothermal field, photovoltaic panels, and radiant floor heating is supplied by a 15-ton ground-source heat pump.[85]

84 Ibid.
85 Ibid.

Chapter 7: Design

Concept

The Architectural Issue

MeadWorks is a thesis which explores the relationship of people, the environment, and infrastructure and attempts create place in areas typically disregarded by society. In the context of the Chesapeake Bay, which is undoubtably facing a water quality crisis, this thesis attempts to create a new model for public water infrastructure that can be a catalyst for other towns to deploy.

At the core of the issue is the disconnect between people and the environment and the “invisible” infrastructure that mitigates between. An average person may use 80-100 gallons of water per day, but they rarely think about where it comes from and where it goes after being used. If people are unaware of the consequences of their daily water use, the bay cannot expect to improve. MeadWorks proposes an architectural solution that transforms the notion of infrastructure being a service architecture into one that is more public and civic.

Guidelines

Two core guidelines were created to achieve this. First and foremost, public infrastructure should be sited in a prominent location with high visibility. Secondly, to further enhance the public nature, the infrastructure should be paired with or integrated in a public landscape, amenity or other use.

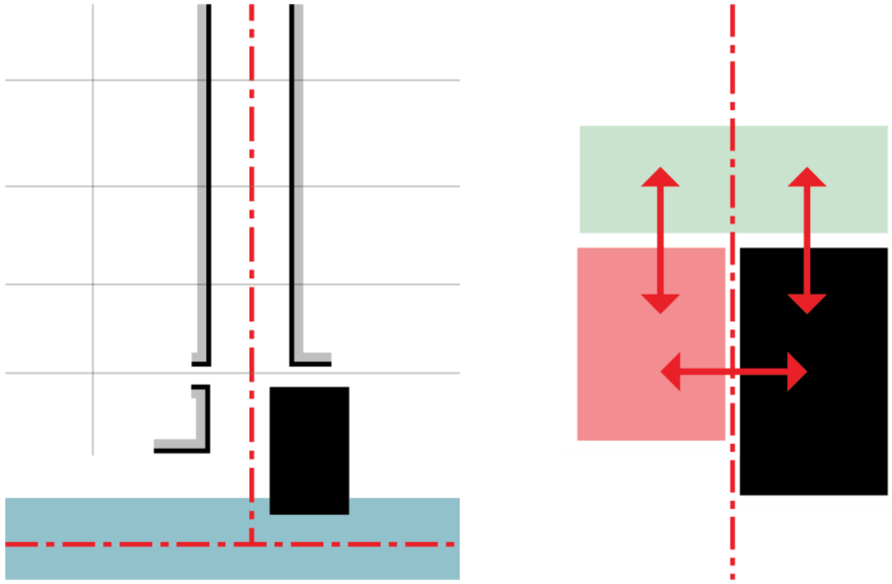


Figure 31 High Visibility Site and Pairing with Landscape or Other Public Use. Diagrams by author.

The Ideal Pairing

The ideal pairing for a water purification facility would be light industry that attracts and unites people - such as Breweries, Wineries, Distilleries, and Meaderies. These facilities share many things in common with water treatment and purification - mainly, a connection to water and the environment. By combining a social (industrial) use with a service use which work together, users gain a more impactful experience of witnessing the natural and engineered cycles of each system and the direct relationships of each to the environment.

Siting

Anticipating Growth

Anticipating future growth, MeadWorks was prominently sited in at the nucleus of the radial growth. The site chosen for the MeadWorks campus is a brownfield at the edge between the power plant and the fabric of the town, and at the terminus of Old Route 50 where it once crossed the Nanticoke.

Figure 32 MeadWorks Site, in yellow, at intersection of town + industry, land + water. Drawing by author

Places and Connections

The site allows MeadWorks to integrate with and become a node at the north end of the waterfront park system. Its siting is also related to other particular places around the town. It has a direct tangential relationship to existing infrastructure and industry at the edge of the town – beginning to blend this barrier. The Vienna WWTP is located just west of the site - allowing for easy connections to be made. Vienna Elementary school is just up the road and can also benefit from the MeadWorks Campus as a learning tool about water treatment practices, the environment and habitats, as well as bees and honey. A proposed 65-unit farm-to-table residential development, Nanticoke Landing, is planned for the waterfront property on the southern end of town. With Meadworks to the north and Nanticoke Landing to the south, this effectively extends the network of greenspace and bookends the town's presence on the waterfront.

MeadWorks is centrally located in relation to all of these other important connections in the town, and creates a landmark where Old route 50 once crossed the river

Figure 33 Places Diagram - Vienna, Maryland. Drawing by author.

Site Massing Strategy

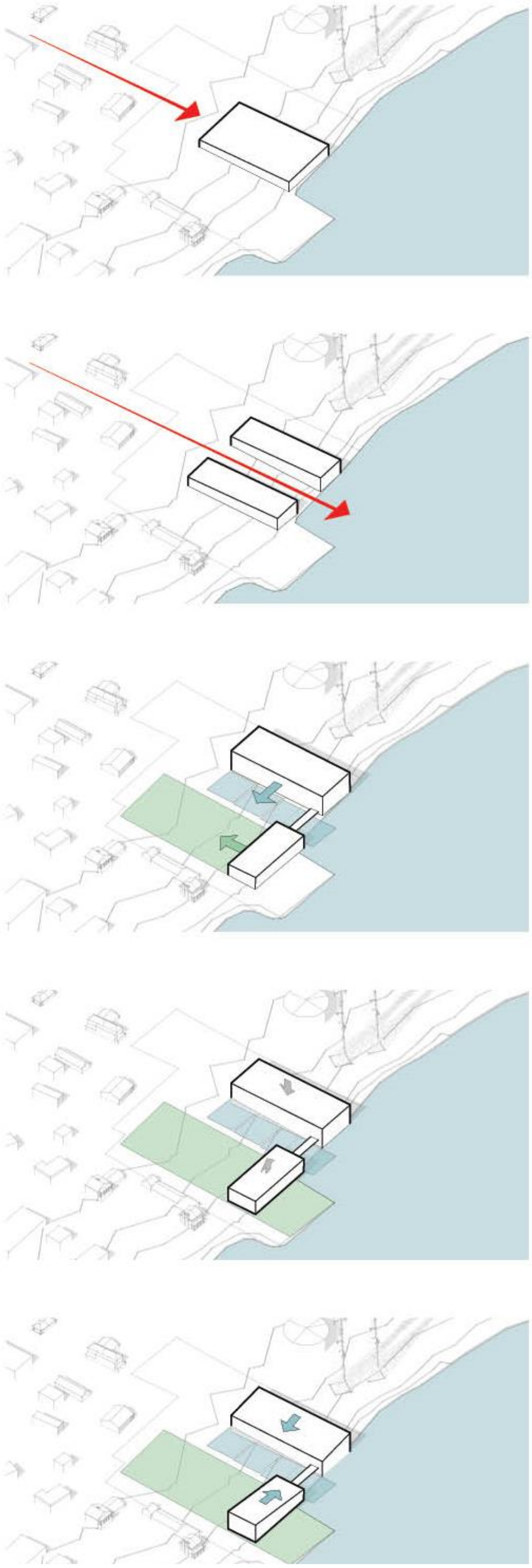


Figure 34 Site Massing Strategy. Drawings by author.

First, the program was massed on the site, at the end of the Old Route 50 axis – in a highly visible and public location on the waterfront.

The program was split into two buildings to allow for visual connection to the waterfront and the thrust of the old bridge to act as a void.

The proportions were adjusted and the MeadWorks building was rotated to be parallel to the river, capturing the site as an outdoor room. A terracing wetland was created in the void of Old Route 50 and paired with a landscape of pollinator gardens.

Then the WaterWorks building was sunken into the landscape and the MeadWorks buildings was risen above. Finally, each building was formed with a shed roof, sloping inwards towards the axis of the terracing wetlands and referencing the vernacular of Eastern Shore sheds and barns.

Design

Site Plan

The site is organized as a campus – allowing for many different experiences. The buildings are figures in the landscape, which is defined by four main spaces, the Lawn, the Engineered Wetlands, the Pollinator Gardens and the orchard.

Figure 35 Site Plan, mixed media. Drawing by author.

Site Organization

Figure 36 Site Program. Diagram by author.

The campus has two main buildings as well as two auxilliary buildings. The Vienna Advanced Water Purification facility is located to the north, parallel to the axis of old route 50 and the powerplant. Vienna MeadWorks is located parallel to the river and defines the landscape on the interior of the site.

The group of buildings breaks up the program and creates an outdoor room in the site. The public spaces of each building command the landscape and have direct visual connections to the landscape.

The main organizational axis of the site is along the Old Route 50. Paths outline where this once significant corridor crossed the Nanticoke River from this site. The void of this space connects the town visually to the waterfront and reaches across the river.

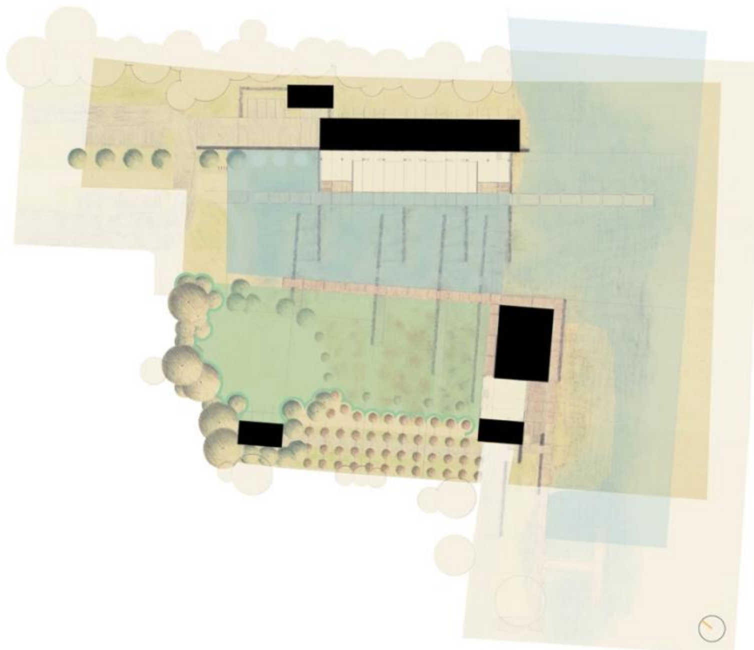


Figure 38 Outdoor Room. Diagram by author.

The buildings are also juxtaposed in the way they are situated in the landscape. The waterworks building is a more solid, wall-based structure, sunken into

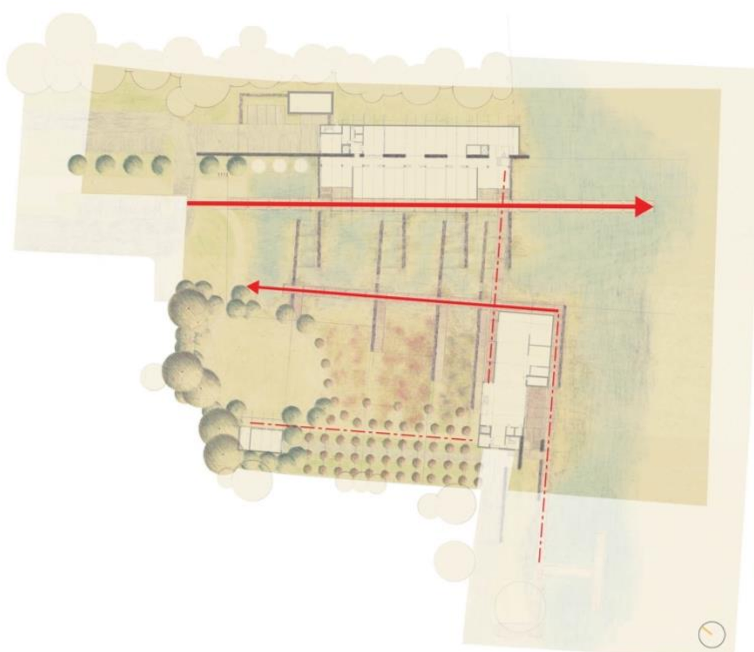


Figure 37 Axis and Path. Diagram by author.

the landscape. The MeadWorks building is a more delicate pavilion raised above the landscape on piles.

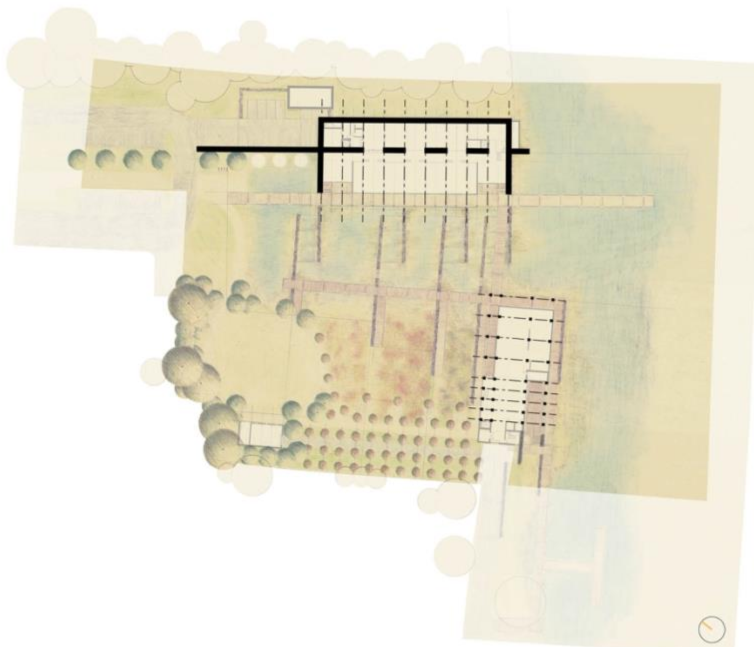


Figure 39 Buildings in / of the Landscape. Diagram by author.

Landscape and structural elements were used in addition to paths to organize and unify the site and define places of movement and stasis.

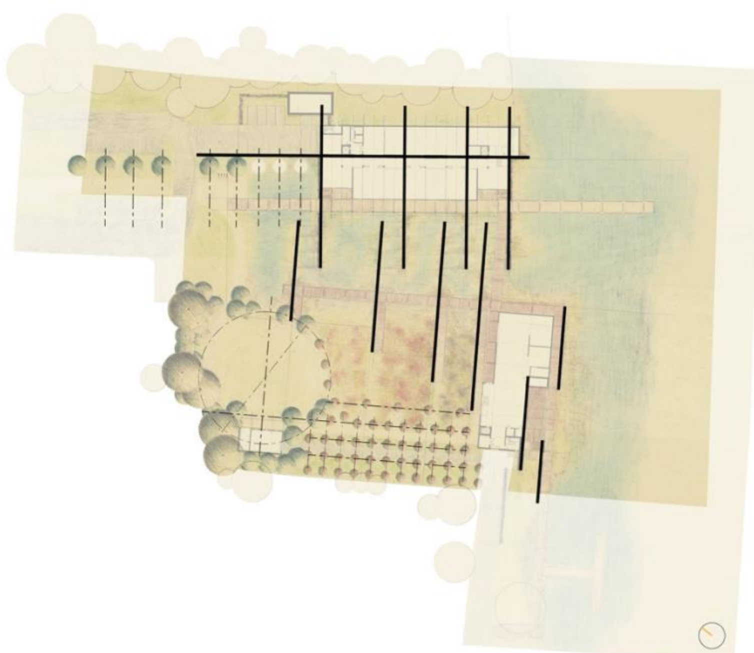


Figure 40 Elements in the Landscape. Diagram by author.

Although the site is open for exploration, the architecture suggests a general rhythm and procession that unifies the two programs as a cohesive campus and leads visitors to key places.

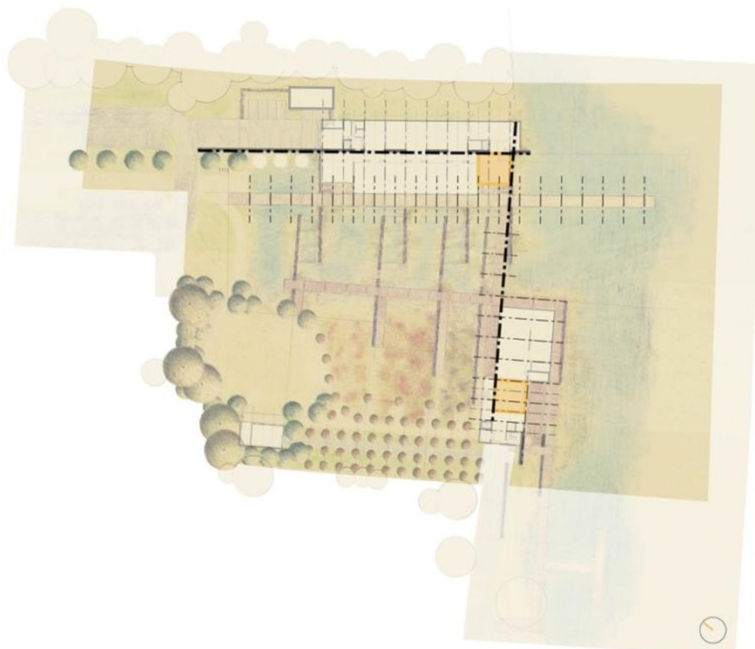
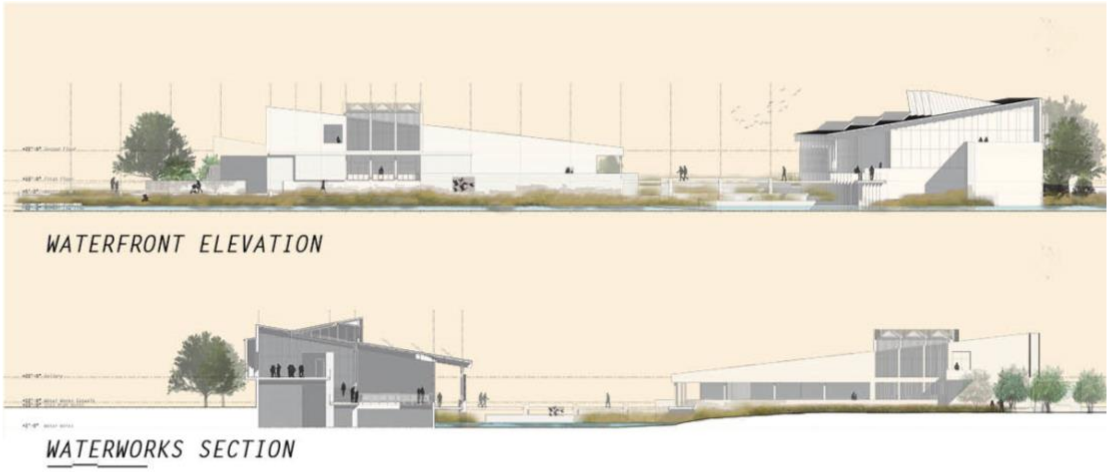


Figure 41 Rhythm + Procession. Diagram by author.

Site Sections + Elevations



Experience

Upon approaching the site, trees and cisterns guide visitors to the boardwalk to the waterworks building.

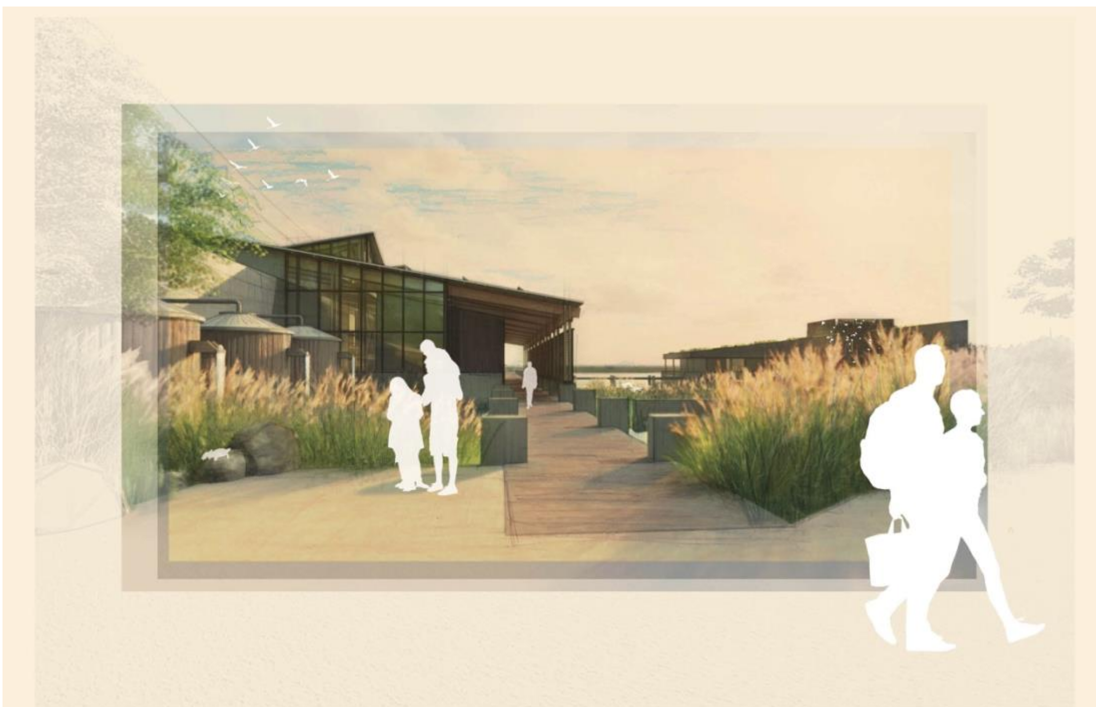


Figure 42 Site Approach from Old Route 50. Mixed media drawing by author.

Inside the Nanticoke Water Purification Facility, the public can take tours on a catwalk level and observe the processes happening below.

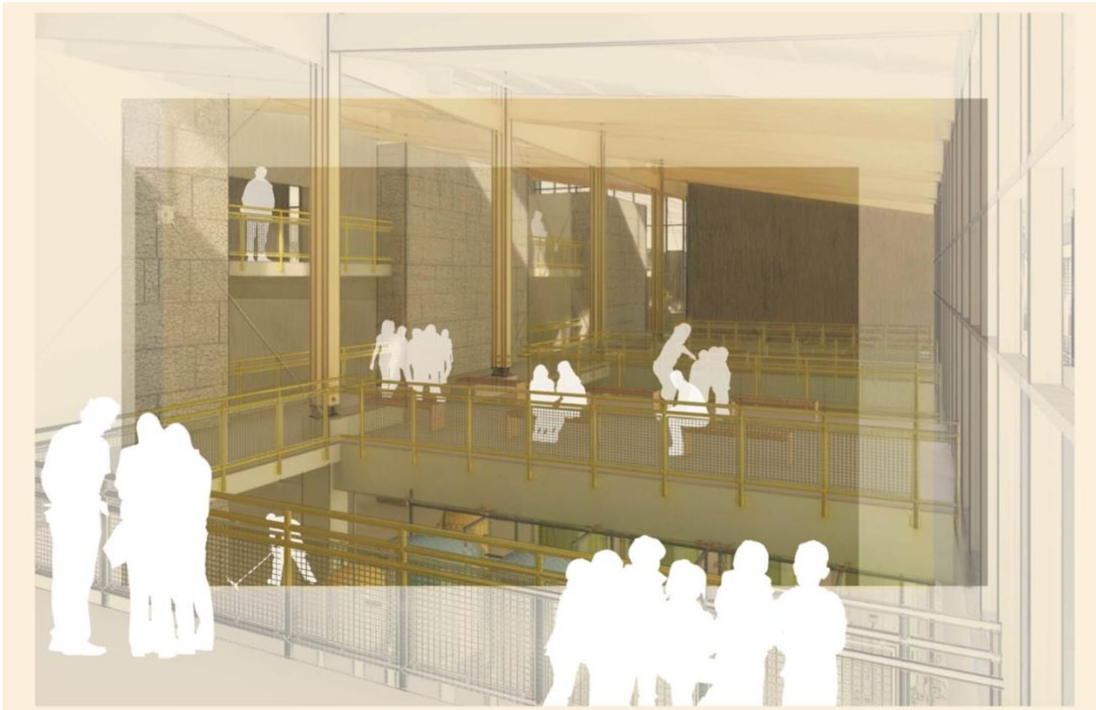


Figure 44 Catwalk tour of Vienna Advanced Water Purification Facility. Mixed media drawing by author.

The tour concludes in a waterfront room which frames views across the river to the natural landscape in which the building is functioning to preserve. It is a place of contemplation and appreciation for the environment and the water infrastructure.

Figure 43 Waterfront room. Mixed media drawing by author.

From there, visitors can proceed out to the pier for subliminal connection to the water or they can explore the landscape and walk the line where the waterscape and landscape merge between the wetlands and the pollinator gardens.

Figure 45 Landscape Boardwalk, looking towards MeadWorks. Mixed media drawing by author.

Visitors can also learn and interact with the bees, walking through the orchard and alley of hives that contains the south edge of the site. The hives produce honey that is then used in the making of mead in the building just beyond.

Figure 47 Hive Alley / Orchard. Mixed media drawing by author.

Inside the Meadworks building, visitors arrive in the Hive - a figural tap room atrium where community can enjoy local mead while connected to the gardens and waterfront.

Figure 46 "The Hive" Taproom. Mixed media drawing by author.

Figure 49 Aerial from town. Mixed media drawing by author.

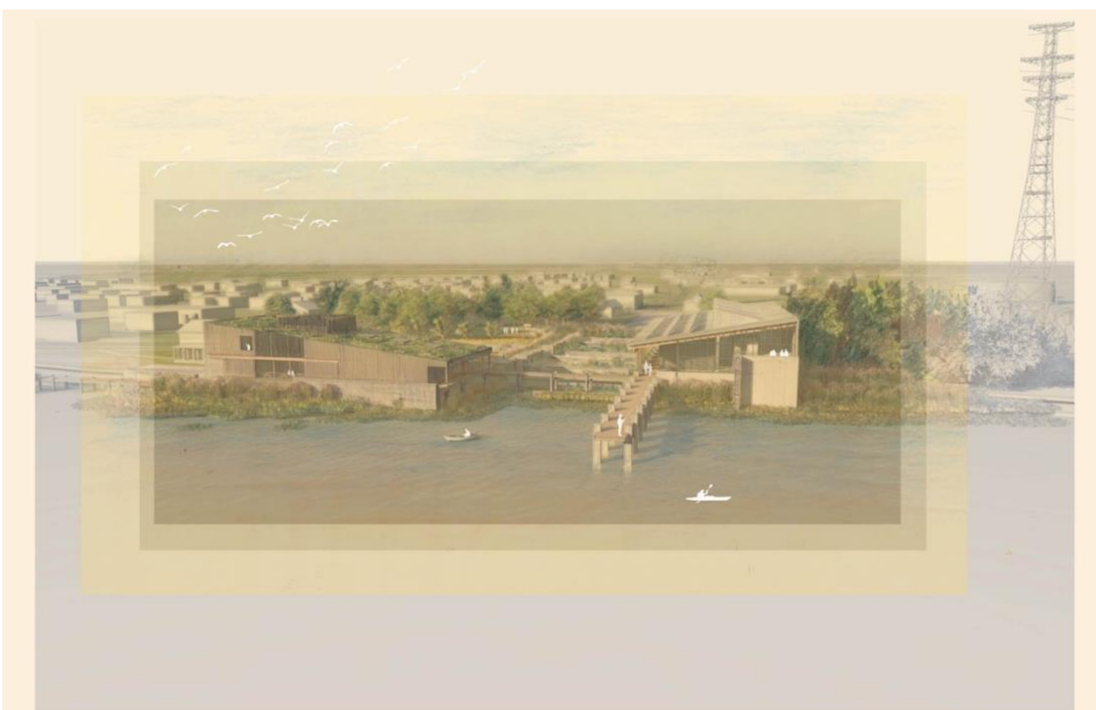


Figure 48 Aerial from river. Mixed media drawing by author.

Application

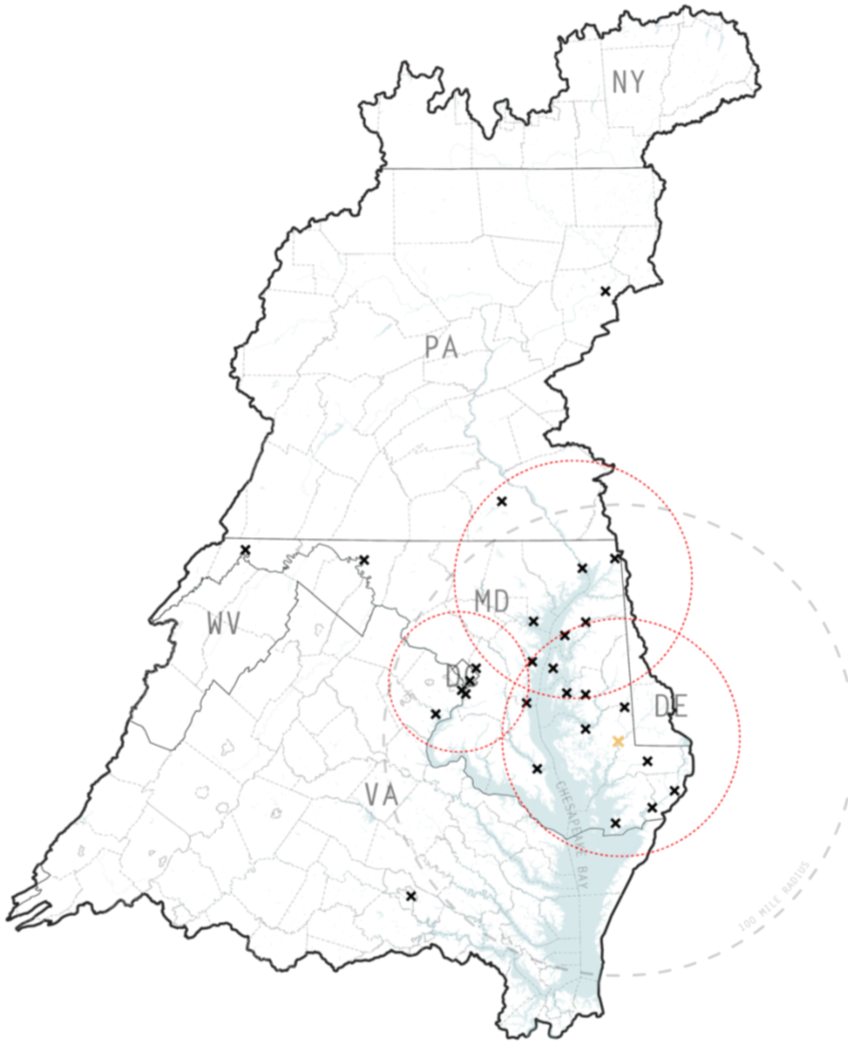


Figure 50 Various locations evaluated for a MeadWorks-type program. Drawing by author.

The goal of this experiment was to propose a new approach to public water infrastructure in the Chesapeake Bay region. This model, which is sited in a highly visible site, and paired with a public amenity can be adapted and implemented in counties throughout the bay region to engage the public and have a more profound effect on improving the water quality of the Chesapeake Bay.

Presentation

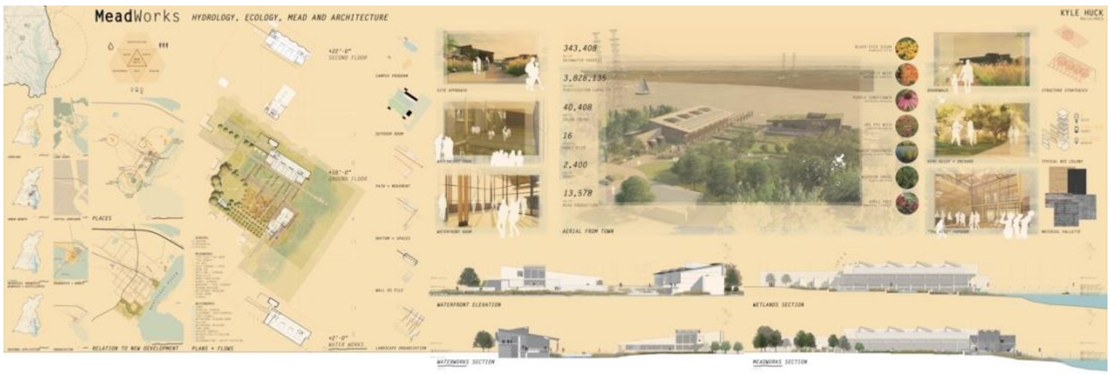


Figure 51 Final Thesis Defense Boards, 8'x24'. Drawings by author.

Appendices

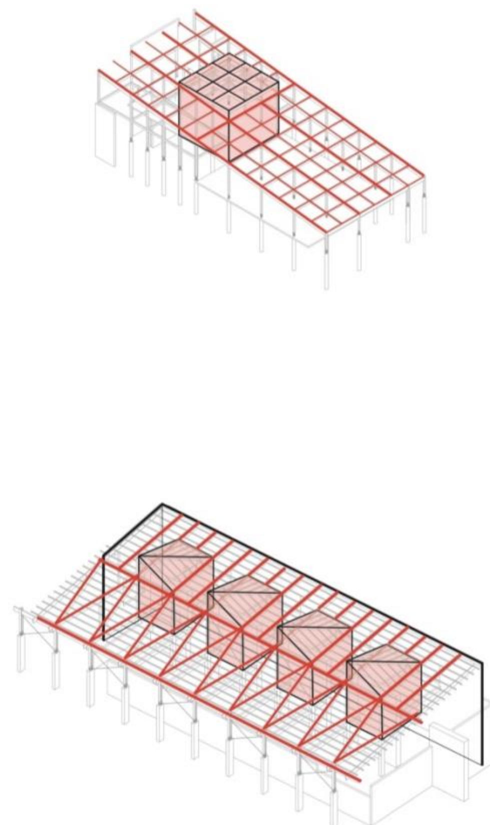


Figure 52 *Cellular, Movement / Stasis informed structure design. Drawing by author.*

Figure 53

MeadWorks and Nanticoke Landing Sites. Drawing by author.

Figure 54 Nanticoke Landing Site Plan. Drawing by author.

Figure 55 Vienna, existing figure-ground. Drawing by author.

Figure 56 Vienna, existing street network. Drawing by author.

Figure 57 Vienna, proposed figure-ground, distinctive. Drawing by author.

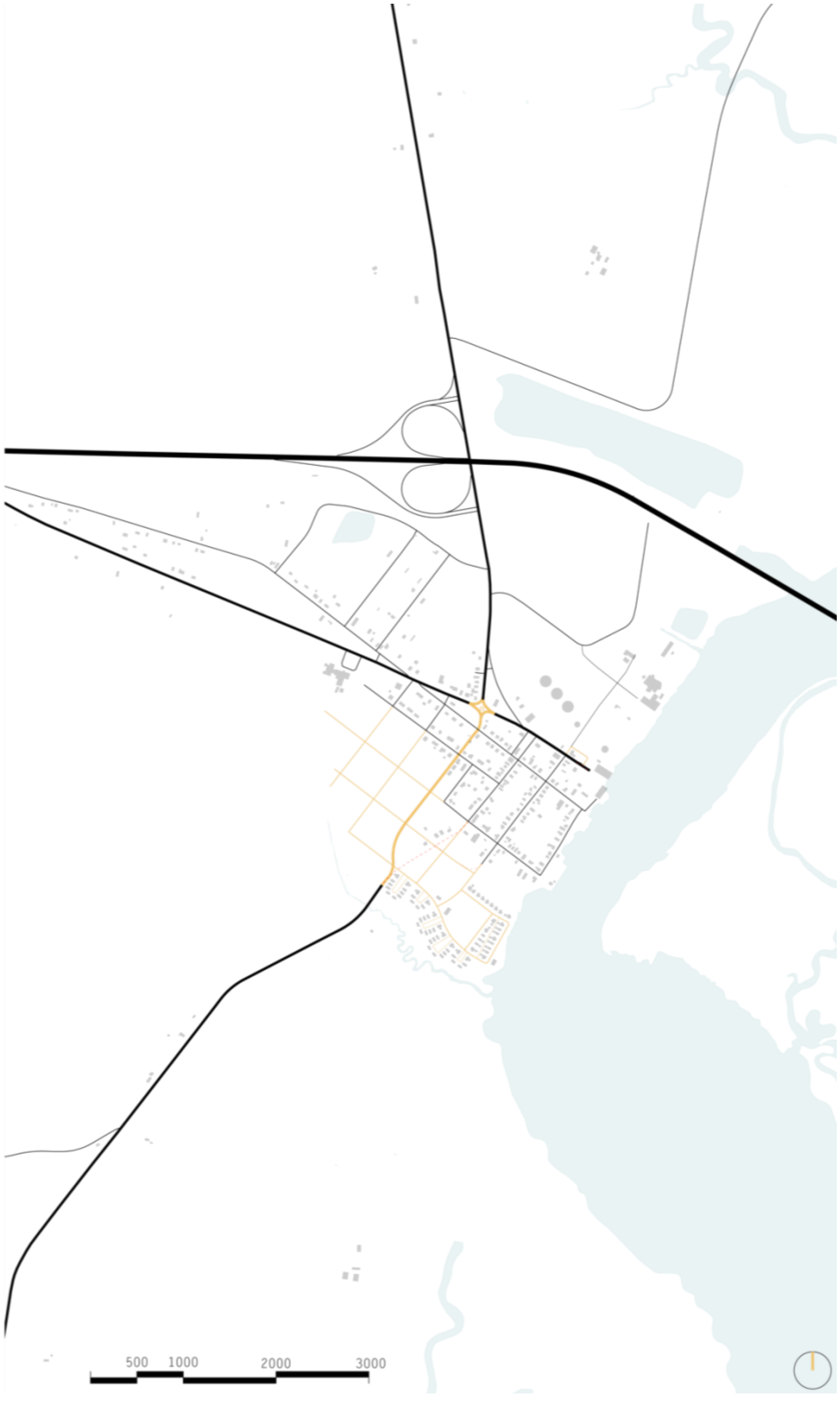


Figure 58 Vienna, proposed street network, distinctive. Drawing by author.

Figure 59 Vienna, landcover. Drawing by author.

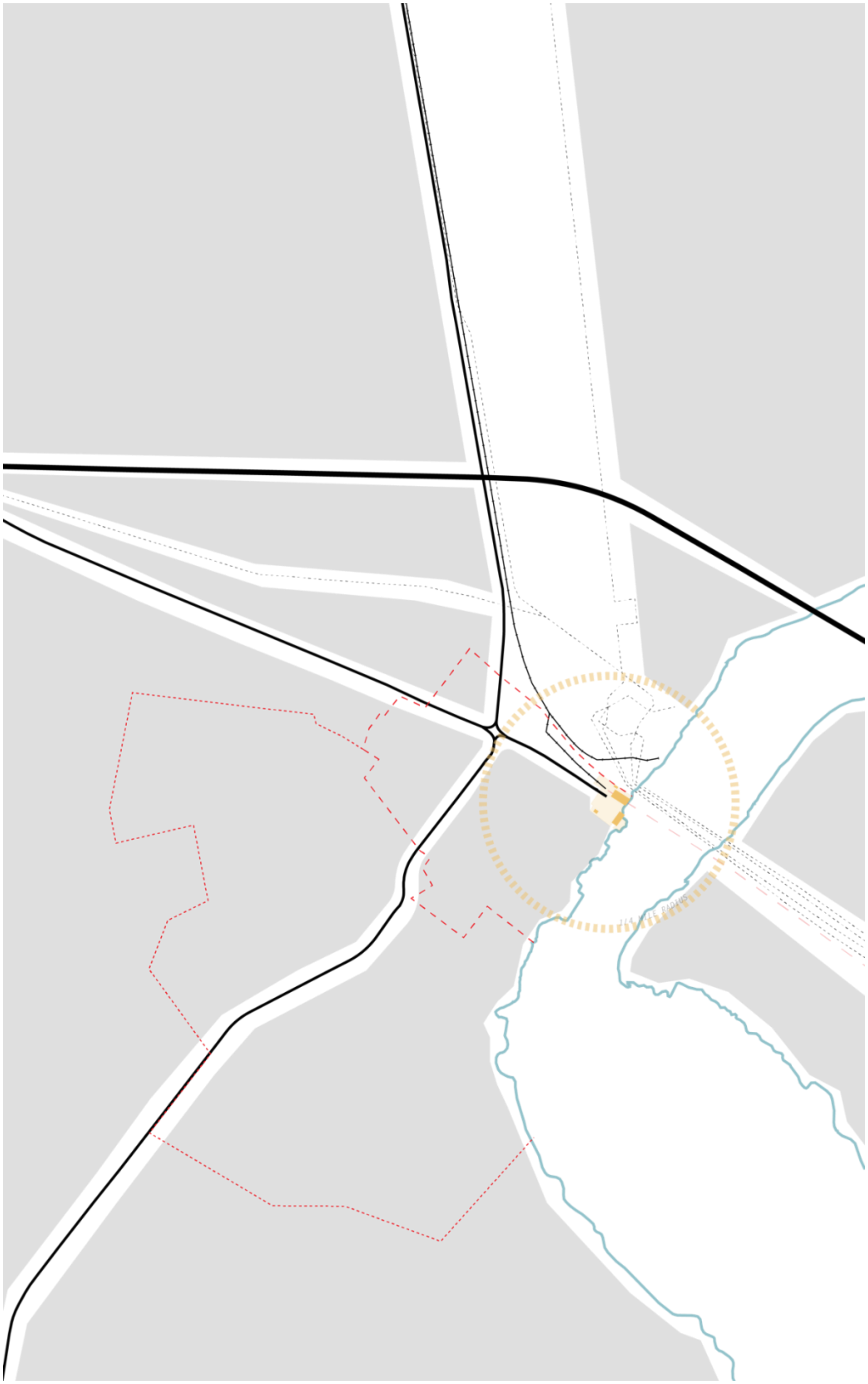


Figure 60 Physical, Infrastructural and Natural Corridors. Drawing by author.

Figure 61 Vienna, Current Sea Level, 2019. Drawing by author.

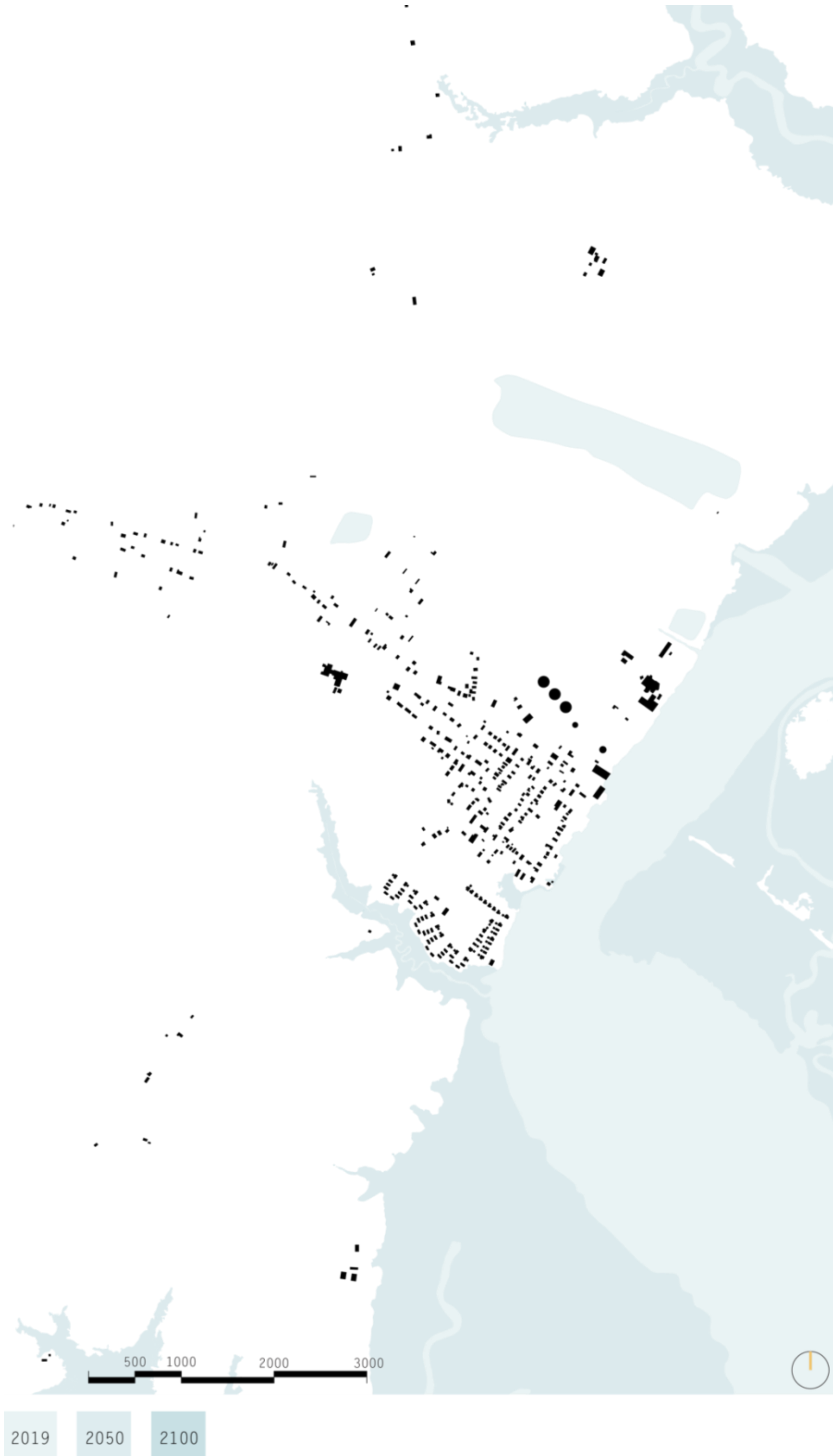


Figure 62 Vienna, 2050 Sea Level Rise +2.1'. Drawing by author.

Figure 63 Vienna, 2100 Sea Level Rise +5.7'. Drawing by author.

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