Chesterfield Public Services Land Development

Fire Station and Parks and Recreation Service

A Technical Report submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science

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In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Scout Kernutt Bale

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Advisor

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Table of Contents

1. Introduction

1.1 Problem Statement

Chesterfield County, located south of Richmond, Virginia, is home to approximately 380,000 people. It has seen a steady increase in population, especially given its proximity to the state's capital. The growing population has increased the demand for essential services, particularly emergency assistance and recreational opportunities. A lack of proper emergency services can pose a significant threat to residents in the area, putting both properties and lives at risk, creating a critical need for adequate emergency services and a sufficient number of fire stations. In addition to fire stations, there is a need for parks and recreation facilities. These facilities will create opportunities for community members to engage in various physical and social activities. To meet the needs described, a collection of parcels in Chester, Virginia have been combined to be developed and address these issues. The ultimate goal of this project is to design a fire station and parks and recreation facility on this plot of land that will ensure public safety and provide the community with a space for outdoor interaction while meeting the necessary jurisdictional requirements and regulations.

1.2 Objectives

By April 2025, we will submit an approximately 8-page plan set, which will include at least one of each of the following: existing conditions, demolition plan, grading plan, utility plan, site plan, stormwater management plan, and erosion and sediment control plan. In addition, we will submit a brief report summarizing the process and results of this capstone project. There will also be a slide set and poster that summarize the final design and the design process to present our design to our industry partners and UVA faculty.

For our design to be accepted, our project must be submitted on time and meet industry standards for acceptable site design. Deliverables need to be compliant with local, county, state, and federal regulations for buildings, parks, and fire stations. This includes federal regulations, such as Americans with Disabilities Act (ADA) compliance for the trail and parking lots or local zoning ordinance compliance for the whole parcel. Additional regulations exist, such as Virginia Department of Transportation (VDOT) entrance and road requirements, including the need for a safe roadway for fire trucks to drive through, a truck fuel area, and[fill in specifics!]. Additionally, our work needs to be clear, complete, and on time to be accepted as a proper design plan. Ultimately, the success of our project will be determined by how we manage our time and resources.

2. Design

2.1 Constraints

2.1.1 Key Considerations

As with many designs, a multitude of constraints must be taken into consideration throughout the design process. These include spatial limitations like the 15,500 ft^2 footprint of the fire station building and the approximately 10 acres of land in the parcel, as well as regulations imposed by the state of Virginia that standardize roads and stormwater management, to name a few. Some of these are standards that can be seen in more detail in Appendix C. At the county level there are zoning requirements that must be taken into account when combining the previous parcels into one parcel for this project. Each aspect of the design must meet ADA requirements. Less technical, though no less important, are constraints on time – there is limited time for the team to complete this project, creating a need for excellent time management and efficient division of tasks within the team.

Throughout our design project, work must proceed according to the established schedule (see Appendix A). Any alterations to the schedule must be noted and accounted for in order to mitigate risks in the quality and timeliness of work. While unexpected delays and issues may arise, staying ahead of or on schedule minimizes their impacts. Though not fully considered in the final version of our project, in the real work, once the design is complete, there would be additional constraints in the construction and material acquisition processes. For example, the construction schedule may be constrained by the stability of the supply chain. Cost is another constraint that would have more influence in a real-world application of our/the design. A final assumption that we made in this design process is that the objectives of the project remain stable, with stakeholders refraining from making changes that alter the project's scope.

Time management, as mentioned above, is a major constraint on our project. Variability in team member schedules could challenge our ability to meet our goals for this project in a timely manner. In addition, this project presents us with an opportunity to learn from the unique skills each team member brings to the table. Coordination of design elements, reporting and documentation, meetings with our industry partner and advisor, and overall progress are critical for the success of this project.

2.1.2 Scientific, Engineering, and Mathematical

In order to meet the goals laid out in Section 1.2, we must have the knowledge or willingness to learn how to use various modeling programs (Civil 3D, SWMM, VRRM, etc.), how to follow regulations (ADA, VDOT, VESCH, VSWHB), and how to use mathematical concepts to design individual components. Each team member brings unique experience with these foundational tools, but there is also much to learn throughout the design process.

2.1.3 Data Collection

Data on the parcel of land, regulations, standards, requirements of stakeholders, rainfall patterns, and more is required to accurately model the site and develop a comprehensive design. This information was collected from many sources, including our industry partner, NOAA Atlas 14, VDOT Appendix F, SWMM Manual, Virginia Stormwater Management Handbook (VSWHB), Virginia Erosion and Sediment Control Handbook (VESCH), and the web soil survey. Much of this is publicly available online, though some, like the base map site file, were provided by our industry partners from their own land surveys.

2.1.4 Complexity Analysis

The major complexities that our team faces in the design process are conflicting technical issues, no obvious one solution, involvement from multiple disciplines, and the development of sub-problems. Various modeling softwares have been used in the project, each challenging our technical knowledge of the software, which must be corrected through troubleshooting or reading manuals. In some cases, there is no single or best design, at which point the team must decide on which direction to go. Engineering inherently involves creativity in finding solutions, which can be seen in our stormwater management and roadway designs in sections 2.2.4 and 2.2.7. Additionally, our team expects to run into the complexity presented by no obvious existing solution. The design process of building a fire station and a parks and recreation facility includes reliance on regulations and standards that must be followed. However, there is also significant creative freedom in the way the engineering team decides to position each design feature. For example, the parking lot for the parks and recreation center have no clear correct place in which the facility should be located, thus the team discusses various options and decides how to proceed/move forward Throughout the project there are multiple disciplines involved – stormwater management, site development, construction management, and regulatory compliance, to name a few. Each has its own goals and associated challenges that must be taken into account to reach the best possible cohesive design. This can lead to sub problems or conflicts between the goals of the disciplines. For example, stormwater management is easier when less land is disturbed, but the trail must span the length of the parcel with accompanying facilities. This was managed by routing the trail to avoid wetlands and positioning facilities close to the main road and by the fire station to isolate disturbances that land use change and construction cause.

The greatest strategy in mitigating and managing the complexities described is communication. Technical issues can be difficult for a single engineer to solve; however, a creative solution can arise when the whole team is involved. In our project specifically, one way we adapted the design process to accommodate uncertainties was consulting our industry partners for assistance in navigating Civil 3D. Some unexpected challenges have been scheduling conflicts between group members and inclement weather conditions that prevented in-person meetings. To counteract this, we dedicated more time in the following weeks to catching up on the project.

2.1.5 Factors/Broader Constraints

The project has an impact on public health as the fire station and parks and recreation facility will provide nearby residents with rapid emergency medical response to ensure quick treatment of urgent health problems. Firefighters are also trained to respond to disasters and hazardous situations that arise to protect the public. Many classes or educational programs are implemented at local fire stations, offering a variety of training to residents, such as CPR and first aid classes. Overall awareness of various health issues increases through the construction of a fire station. The parks and recreation center of this project provides space for physical activity, which benefits local physical and mental health. Exposure to green spaces helps reduce anxiety and stress, while walking can improve heart health and decrease obesity.

Safety risks and mitigation strategies are essential. Potential risks mitigated by this design include decreasing delays in emergency response due to inadequate access or layout of the fire station section and structural integrity concerns during emergencies or natural disasters. For parks and recreation facilities, common hazards include trip-and-fall risks from uneven surfaces, equipment safety, and security concerns due to insufficient lighting or surveillance. To mitigate these risks, the design adheres to ADA and VDOT standards. Pathways for both the fire station and the parks and recreation areas comply with ADA maximum running and cross slope grades of 1:20 and 1:48, respectively, and use materials that prevent tripping and slipping. The equipment used meets ASTM and CPSC safety standards. Additionally, installing proper lighting and surveillance systems post construction will address security concerns. Ongoing maintenance and emergency preparedness plans, combined with community involvement, further ensure safety throughout the project. By following these engineering standards and best practices, safety risks will be minimized, providing a secure environment for both emergency responders and the public.

This project will improve the quality of life for local residents and visitors who are looking for a recreational activity to fill their time in Chesterfield. Having a modern fire station decreases emergency response time and increases access to critical medical care and asset fire protection for people in the surrounding area. Individuals benefit from the increased local recreational facilities through the trail system on this plot and eventually through the connection to larger regional trail systems. In addition, all of these facilities will meet ADA accessibility requirements to ensure equitable access to all groups and ranges of ability. Design decisions were strongly influenced by ADA standards, prioritizing meeting them over the easiest or quickest solutions. Other relevant design decisions related to welfare was to face the exits of the fire bays towards the main road exit to deliberately reduce engine and ambulance response time to calls.

The project does not have any international applications as the development would only impact the local residents. Additionally, the local jurisdictional guidelines and standards would be utilized, as well as sustainability goals.

This project may have some impact on local culture by providing a space for people to meet. The establishment of local culture can be facilitated by public places like parks, but there is not a lot of influence from the specific culture of the area in the design of the fire station because it is so heavily based on safety and functionality.

The development of this parcel into a fire station and parks and recreation trail connection addresses equity and social engagement and provides aid for underserved and vulnerable populations. The parks and recreation area is free and accessible. The trail and pavilions added along the path help to promote social engagement by giving a free and accessible venue for people to host events and meet up. There is access to a larger trail system that also provides exercise opportunities for all. The fire station itself is paid for by the county and ensures access to anyone in the area that needs it, regardless of any social factors. Because both aspects of the design are government-funded and open to the public, this design helps to promote better equity, accessibility, engagement, and safety to all those in the county.

The environmental factors associated with our design are largely related to the soil and sediment plan we have for our design, which aims to minimize soil erosion and sediment runoff during the construction and post-construction phases of the project. This has been done in compliance with regulations with the goals of protecting the nearby bodies of water and the integrity of the soil. Additionally, a large focus of our design is the stormwater management of runoff volume and water quality. We will be adding over an acre of impervious land cover to the site, and due to the nature of the site being multi-use, we must reduce runoff and total phosphorus through our stormwater design (see section 2.2.7 and appendix D6). Additional environmental impacts include some forest and turf to impervious surfaces for the fire house and roads; this is somewhat made up for by the conservation of the nearby trail and wetlands, which will serve as a recreational area for people.

There are minimal economic factors in our design process as the design is being funded and implemented by the county government, so the cost considerations are covered by the necessity for these facilities. Costs would be taken into account in the real world; however, that was beyond our goals for this project. No extremely expensive design choices were made. Long-term feasibility of the design comes from the government continuing to fund the fire station and parks and recreation that they funded. The fire station is a public necessity that is worth the investment.

2.2 Design Process

2.2.1 Overall

To begin this project, the team determined the legal requirements and regulations put into place by the Americans with Disabilities Act (ADA) and the Virginia Department of Transportation (VDOT) to ensure that the design for the entrances, exits, and parking lots met state and federal requirements in addition to those put forth by Dewberry (our industry partner). See Appendix C for details on each specific regulation and standard. The team also determined the buildable area on the parcel. All of this was done before any design on the plot to maximize efficiency.

2.2.2 Buildable Area

The property assigned to this project has a 50' setback from adjacent properties (zoned R-7, C-2, and C-3; see Appendix D1) except the boundary with the road, which will have a 10' setback following the requirements of Chesterfield County, Virginia Planning Department. Additionally, the wetlands area may be developed with the proper permissions and precautions but should generally be avoided. See Figure 2.2.2.1 and Appendix C1. Using these guidelines, we drew an outline on the property with the proper setbacks to use in designing the site layout. No features of our final design cross the setback boundaries.

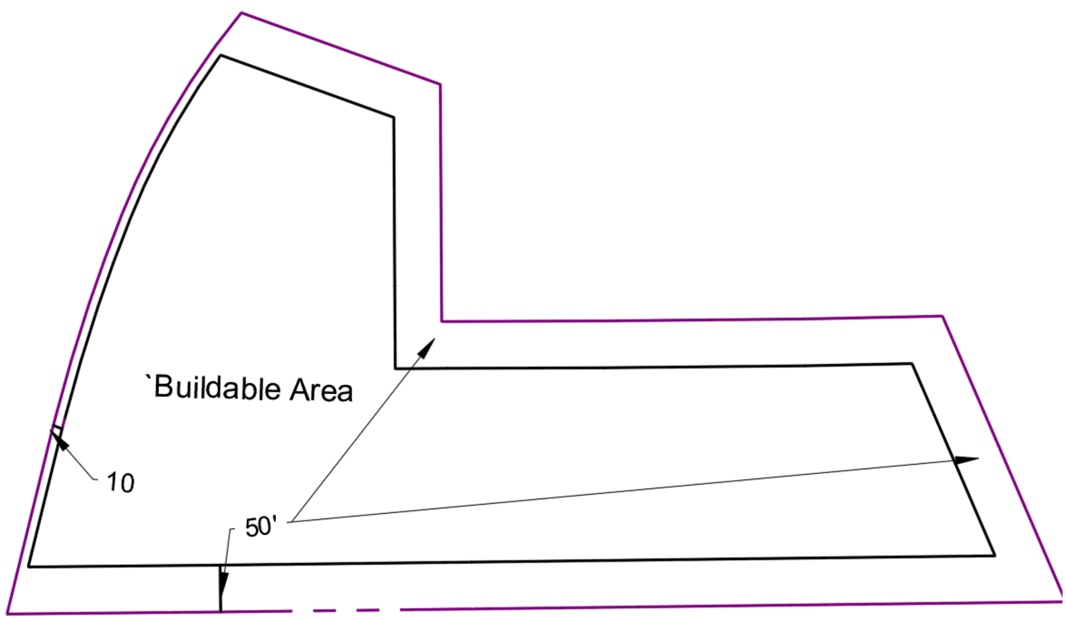

Figure 2.2.2.1: plan view of buildable area that guided where design elements were placed.

2.2.3 Demolition Plan

None of the existing structures and roadways on the site were needed for the final design. All are to be demolished in the first phase of construction to make room for the fire station, parks and recreation facilities, and all accompanying amenities. See Figure 2.2.3.1 for a visualization.

Figure 2.2.3.1: Demolition plan view, all buildings, roadways, and features outlined in bold will be demolished at the start of the construction phase.

2.2.4 Site Plan

From here, the team worked on a demolition plan and a site plan. The first goal of the site plan was to place the fire station building's footprint in a way that allowed emergency vehicles to exit quickly and return to their bays. Ease of fueling and maneuvering around the building was also considered. Once the approximate location of the building was determined, a large apron was designed on either side of the bays. A fueling station and dumpster were put on the back apron (further from the main road) in order to allow refueling to occur as trucks returned from calls, preventing congestion of bay exits on the front apron.

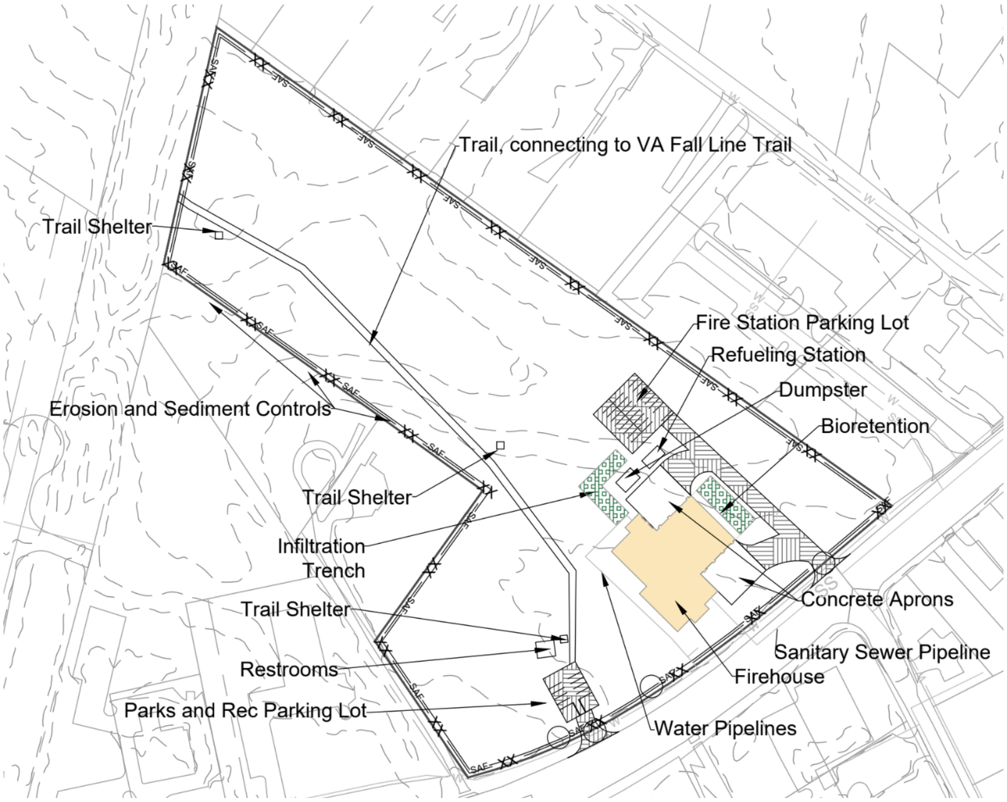

Figure 2.2.4.1: Site plan final layout with annotations of key features. Note that there are 2 fire hydrants connected to the water pipeline, at the front and back of the fire house. Each trail shelter is 10' by 10', the concrete aprons are each 60' by 60', and there are 24 parking spaces for the fire house and 10 for the parks and recreation area.

Then, the team placed the fire station parking lot, focusing on keeping it close to the building without impeding the exits from the bays or the required buffer zone at the edge of the property. Being close to the building minimizes the land disturbance during and after construction, which improves stormwater management, as well as erosion and sediment control. Once the parking lot was in place, a road could be designed to connect it and the aprons on the truck bays to the main road. Here, the required minimum turn radius was used to ensure that trucks can pull in and out without reversing. The road and entrance were designed according to VDOT standards (see Appendix C).

In conjunction with the design of the fire station section of this project, the team also worked on the recreational facilities. The first task was to determine ADA and VDOT requirements (similar to those for the fire station area; see Appendix C for more information). Then the parking lot was placed, this time close to the main road to minimize the connection road length and land disturbance. A trail connecting to the Virginia Fall Line trail was mapped from the parking lot to the far edge of the parcel. Restroom facilities were placed near the parking lot to increase accessibility and decrease disturbance from construction on the site. Three shelters were placed along the trail at various intervals, one being right next to the parking lot for increased accessibility.

There were many iterations of the site plan before the above described version was selected. The one selected best met the requirements for minimal land disturbance, accessibility for people and emergency vehicles, and feasibility. With the site plan finalized, the team moved on to more detailed plans for various parts of the project: grading, erosion and sediment control, utilities, and stormwater management.

2.2.5 Grading Plan

Once the site layout was finalized, grading was done to comply with ADA and VDOT standards. Parking lots were graded with a maximum running slope of 1:20, a cross slope of 1:48, and a minimum width of 36 inches. These specifications apply to both the Fire Station Area (Figure 4, Appendix D) and the Parks and Recreation Area (Figure 5, Appendix D). Roads in both areas adhere to VDOT standards, featuring a 3:1 slope, a minimum turning radius of 26 feet, and a width of 24 feet. These criteria were implemented for the entrance road to the parking lots at both the Parks and Recreation Area (Figure 4, Appendix D) and the Fire Station Area (Figure 5, Appendix D). Additionally, grading was done for the trail depicted in Figure 6 in Appendix D, following the same VDOT requirements as the roads but with a width of 10 feet. For the design in the future, adjustments will be made for grading per Dewberry, such as the squared spaces for truck access in the Fire Station Area, and ensuring that the area is relatively flat or within 5% slope.

Figure 2.2.5.1: Grading plan view for the fire house (top left), parks and recreation parking lot (bottom left), and trail (right).

2.2.6 Erosion and Sediment Control Plan

The erosion and sediment control plan outlines the methods of erosion control to be used on the construction site. These practices were found in the Virginia Erosion and Sediment Control Handbook (VESCH) written by the Virginia Department of Environmental Quality (VaDEQ). The handbook establishes minimum standards for controlling sedimentation from land-disturbing activities. Although there is a certain amount of naturally occurring erosion, major problems can occur when excessive amounts of sediment enter waterways. The VESCH aids in properly managing any damage that happens, specifically with construction sites as the primary source of sediment pollution.

The methods used for this project were a safety fence, super silt fence, construction entrance, temporary seeding, and permanent seeding. The safety fence acts as a protective barrier to prevent unsafe access to the site, while the super silt fence acts as a temporary sediment barrier to detain small amounts of sediment. A construction entrance is a stone pad with filter fabric that reduces the amount of mud transported onto public roads from the site. The seeding refers to a vegetative cover on disturbed areas, which helps reduce damage from sediment and runoff downstream. There are temporary and permanent seeding, where temporary seeding is implemented on areas that will not be brought to the final grade for more than 14 days and permanent seeding on areas left dormant for a period of more than a year.

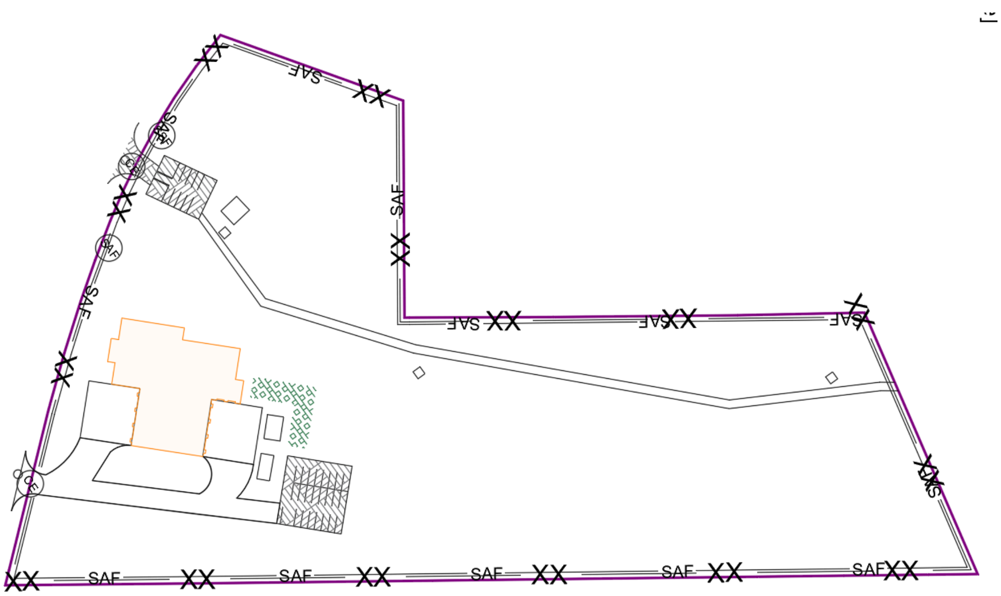

Figure 2.2.6.1: Plan view of Erosion and Sediment control plan during construction. This features a safety fence (SAF) and a silt fence (XX) around the border of the site, and 2 construction entrances with wash racks (circle).

2.2.7 Stormwater Management Plan

For stormwater, the team attempted to model pre-existing conditions in ArcGIS Pro, however, this was abandoned due to the incompatibility of the basemap file with ArcGIS tools. The goal was to determine the area of each land use accounted for in the Virginia Runoff Reduction Method (VRRM) – forest, mixed open, managed turf, and impervious cover – crossed with underlying soil hydrologic soil group (HSG). HSG and land use greatly affect runoff volume; thus, having the area of each land use combined with each HSG allows for the most effective stormwater management plan to be designed. ArcGIS was used as the team had experience with it, however, it did not function with the CAD files from Civil 3D, and the conversion to geodatabase files failed. The team shifted to learning how to use Civil 3D to combine the land use and HSG data. This involved drawing polygons for each land use using satellite images and separate polygons for each HSG using data from the Web Soil Survey [SOURCE!!]. Each overlap of these polygons represented a unique combination of VRRM land use and HSG. A third set of polygons was drawn for each of these, then the previous two sets were deleted. A color coding and hatching scheme was implemented to show each unique land use and HSG combination. Civil3D provided area data for each of these polygons (see Appendix D6.81 and D6.8.2 for calculations and results). The area of each land use and HSG combination was used to calculate a composite curve number to be used in a Stormwater Management Model (SWMM) to calculate runoff for 1, 2, 5, and 10-year storm events (Appendix D6.11.1, D6.11.2, and D6.11.3). Models were created for pre-development, pre-best management practice (BMP) implementation, and post-BMP implementation.

Using the models above, the team selected BMPs that meet the stormwater management needs of the site, reduce phosphorus and runoff as required by the VRRM, and seamlessly blend into natural and managed landscaping of the parcel. An infiltration trench and a bioretention basin were the BMPs selected, see Figure 2.2.7.1 for a plan view of the placement within the site and Figure 2.2.7.2 for preliminary profiles of each BMP. Both were designed following the standards laid out by VSWHB. The VRRM with implementation of the infiltration trench and bioretention shows a reduction of 1.71 lb/yr for total phosphorus, exceeding the requirement by 0.33 lb/yr and a runoff reduction of 4,530 ft^3. These reductions meet our goal of reducing each by 80% from their pre-BMP values. Note that the bioretention does not meet the depth of soil required to be able to plant trees, thus only shrub and grassy vegetation may be used.

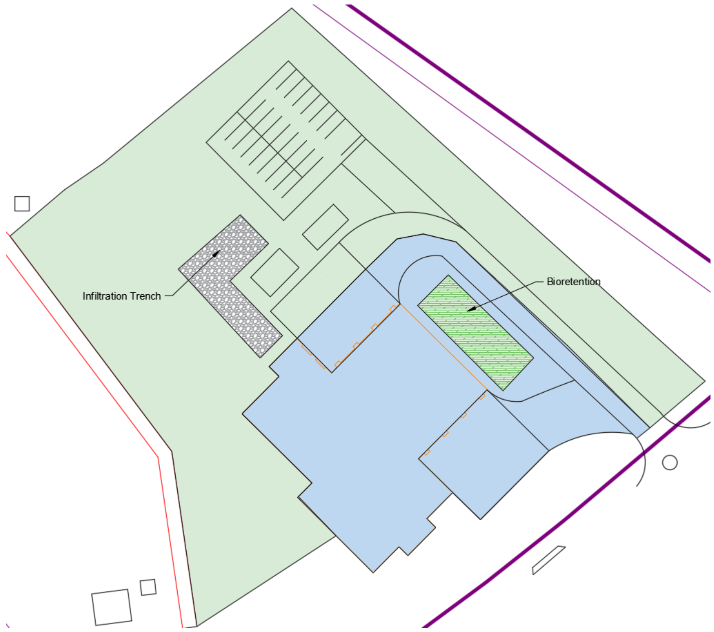

Figure 2.2.7.1: Plan view of BMPs for stormwater management. The bioretention has a surface area of 2300 ft^2 and the infiltration trench has a surface area of 2800 ft^2. The green area (77,000 ft^2 or 1.8 acres) drains to the infiltration trench and the blue area (31,000 ft^2 or 0.7 acres) drains to the bioretention basin.

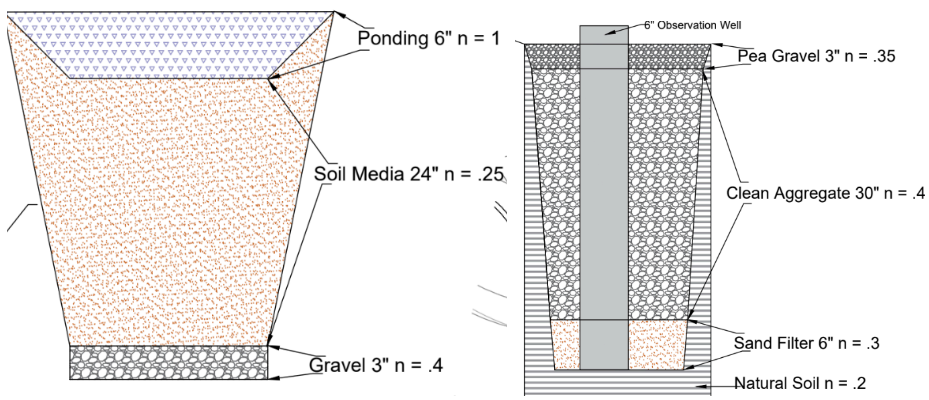

Figure 2.2.7.2: Profiles of bioretention (left) and infiltration trench (right), with depths and porosity of each media.

2.2.8 Utilities Plan

Due to time constraints in the project schedule, utilities were not focused on, however we did design both water and sanitary sewer plan view connections for the firehouse. The 6”water pipe connects to a 16” line on an adjacent property and to two fire hydrants at the front and back of the fire house. The sanitary sewer connects to a nearby manhole on West Hundred Road. No gas or electric lines have been designed yet.

Figure 2.2.8.1: Plan view of utilities layout for water pipes (W) and sanitary sewers (SS), with connections on nearby parcels.

3. Conclusion

We faced several challenges in the duration of this project, including lack of knowledge or skills, time management issues, and communication failures. To develop new knowledge and improve our skills (for example, using Civil 3D) we asked our industry partner for guidance on how to approach design problems and for feedback on each draft of components. As for time management, we did not anticipate needing to spend as much time as we ended up needing on written reports and assignments. This led to some last minute writing and prevented adequate editing. To address this we began to set deadlines for writing on reports within our group, usually two days before the assignment due date, which allowed us some time for editing. Communication did improve over the course of the project as we learned how each team member worked and established a routine for emailing our industry partner about weekly meetings.

Throughout this year we used an iterative design process that allowed us to make mistakes, ask questions, receive feedback, and edit our designs until we were satisfied with them. See Appendix B for further information and examples.

One aspect of this project that I had not considered before was how much time it takes to be a manager and organize nearly everything. From sending weekly emails at a consistent time to tracking deadlines and progress to checking in with team members, this took a significant portion of my time spent on the project. It was perhaps almost as time demanding as the design components I worked on. That being said, it helped me grow as a leader and develop appreciation for why managers exist, even if they do not appear to be doing "real" engineering work.

If our team was to continue on this project, we have an idea of our next steps. For stormwater management we would go in depth into profile designs for both BMPs and design an underdrain for the infiltration trench (as required by VSWHB). We would design gas and electric utilities, as well as power pole placement on the site. As far as grading, some feature lines do produce inconsistent slope, especially along roads and near the firehouse. Adding cross-connecting feature lines would help to control cross slopes and improve surface transitions. The parking lot and green-outlined zones may also need slope adjustments. The dumpster pad would be leveled, and a retaining wall may be required where slopes exceed 3:1. These updates would enhance drainage, usability, and compliance. We could also dive deeper into the construction phases and materials required to actually make our design in real life.

One critical next step is to engage with the local community through town halls and opinion polls, especially concerning the parks and recreation section of this project. As this is meant to serve them, it is important to gather information on what they wish to see in their community. We could also conduct a study of the population using the VaDEQ website.

In conclusion, our team learned a lot through this project. We learned that we should design stormwater before doing grading, that time management is critical, and that civil 3D will always take longer than anticipated. We learned to ask as many questions as possible, as early as possible, even if it seems like a small thing, and that there is always something more to learn.

Appendices

Appendix A - Detailed Schedule

The schedule for this project is split into four main sections based on the final deliverables we plan to complete: demolition; site plan; stormwater, erosion and sediment control; and grading and utilities. Each of these four sections is then divided into subsections that represent phases towards their completion. In general, these subsections are a research phase, an evaluation with existing conditions in mind, a concept rough draft, iterations of the design, and the final draft of the design in the form of plan sheets. Each subsection is assigned to a team member or a group of two to three team members. Subsections are assigned to a group member or two to three group members based on each member's knowledge base, desired area for learning, and expected workload of the subsection. Demolition (including mapping existing conditions) was headed by Esther and Jeremiah; site plan by Emma, Jeremiah, and Greg (though everyone was involved in selecting concepts to present to our industry partner and the final draft); erosion and sediment control by Esther; stormwater by Scout, Greg, and Emma; grading by Jeremiah; and utilities by Esther. All group members filled in as needed under each section.

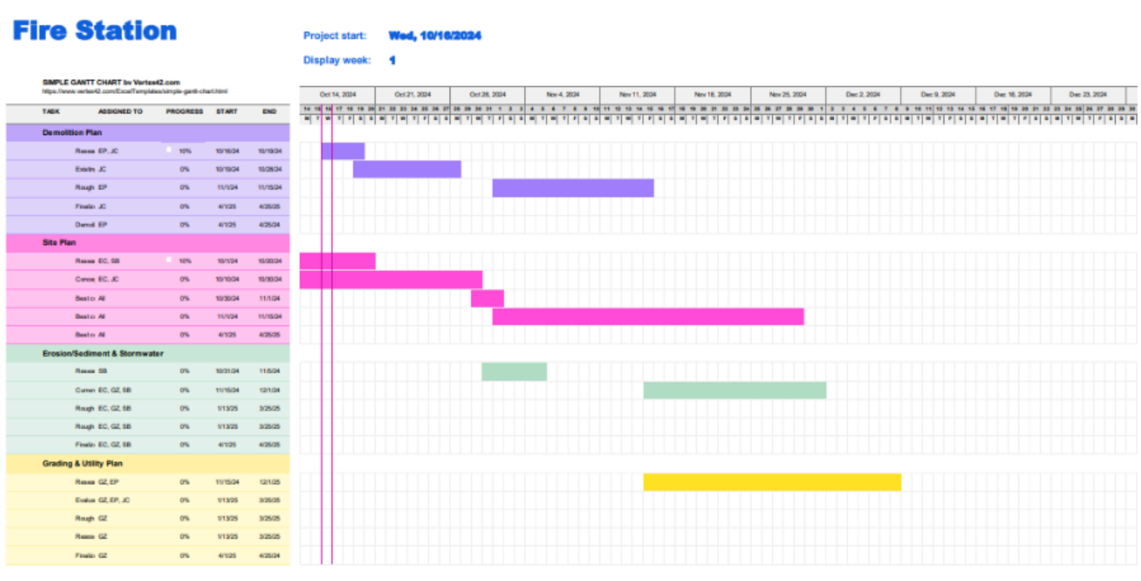

Figure A1: Original gantt chart, fall semester. Includes demolition plan (purple), site plan (pink), erosion and sediment control (green), stormwater management plan (green), grading plan (yellow), and utilities plan (yellow). This was our original plan, it was somewhat deviated from as we learned and the project developed.

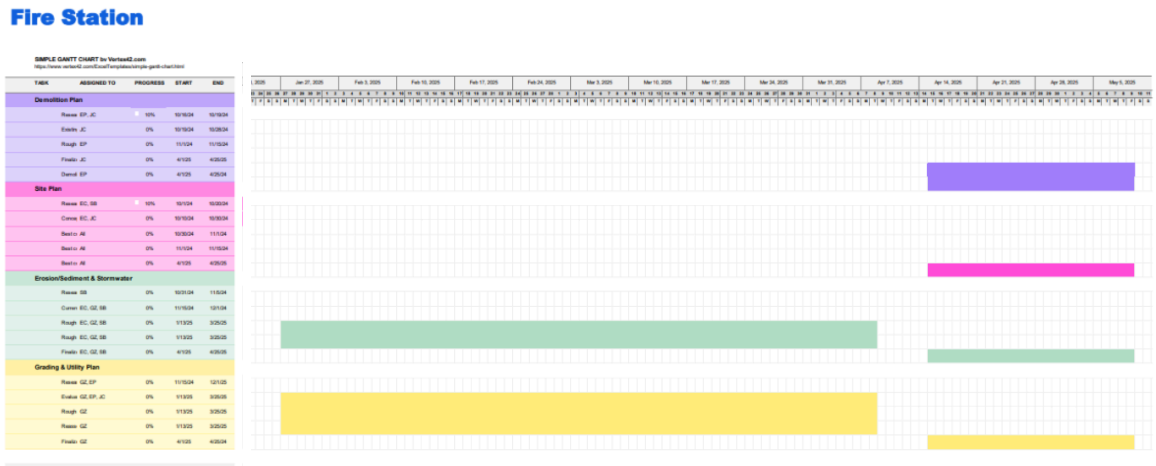

Figure A2: Original gantt chart, spring semester. Includes demolition plan (purple), site plan (pink), erosion and sediment control (green), stormwater management plan (green), grading plan (yellow), and utilities plan (yellow). This was our original plan, it was somewhat deviated from as we learned and the project developed.

Meetings with our industry partner and advisor were primarily scheduled by Scout, some weeks others responded to emails. Scout was also in charge of submitting our scheduling, scoping, complexity and a few other assignments on time, including making sure everyone had completed their parts. Emma did the same for a few assignments. Each group member was responsible for editing their parts and reading through the whole report before submission. See section 3 for a discussion of some of the challenges faced here.

We are on track based on the schedule outlined above, having completed the demolition/existing conditions and planning phase, the site plan phase, and the erosion and sediment control plan, and we are currently in the finalization stages for the stormwater and grading design phases (see Appendix D). The utility design is also in progress.

Appendix B - Design Evolution

This design has gone through several iterations. One of the primary areas of evolution was the orientation of the roadway and fire station house; we long debated how the fire station should be oriented to maximize fire station efficiency while minimizing the amount of road we must build in order to accommodate each orientation, until we finally landed on the final iteration for the overall design as can be seen in Figure 2.2.4.1, as well as in D3.1 and D3.2.

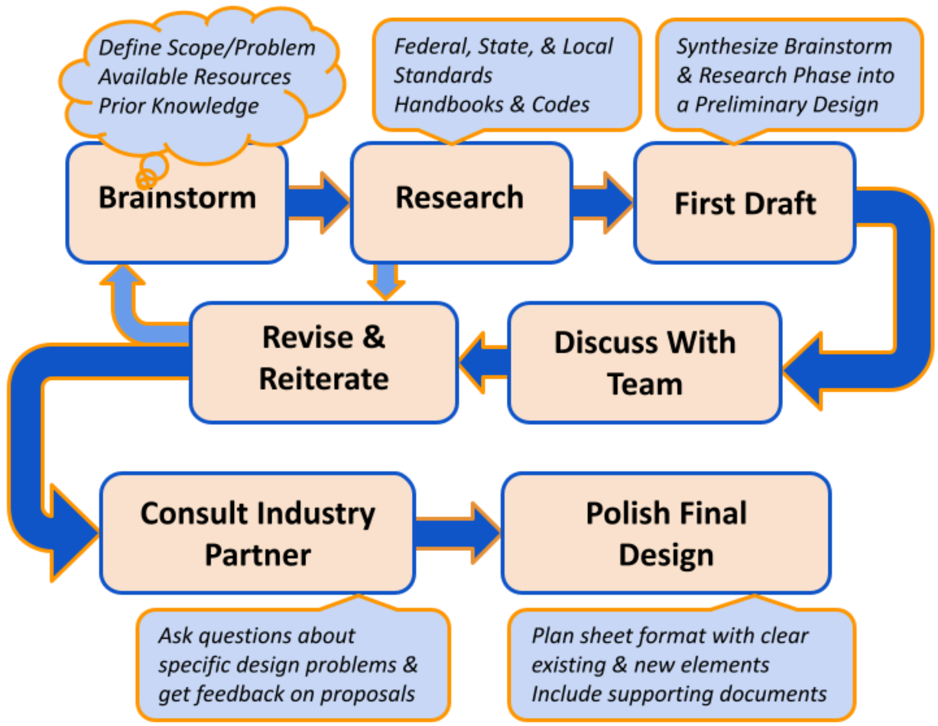

Figure B1. General iteration process followed for each design component in this project, as well as for technical reporting.

Note the difference in parking lot placement and total roadway/impervious area added to the site. In the abandoned concept there is much more potential that something on in the entrance may impede the exit of the fire trucks or ambulance in emergency situations. The bays are also rotated in a manner that does not offer efficient exits for trucks. In contrast, the selected site plan places the parking lot and entrance to the bays, as well as the dumpster and refueling station, behind the firehouse, preventing impediment for exiting trucks as much as possible. There is time when they return from emergencies to get through the entrance areas.

Figure B2: Abandoned (left) versus selected (right) site plan.

We also went through a change in strategy for our approach to the stormwater design for this project. Initially, we were going to develop a SWMM model using ArcGIS Pro to map out runoff in the pre- and post-developed scenarios. However, we then decided to first develop the VRRM model and determine what BMPs we will make use of and to get an idea of the runoff conditions we will be dealing with. From there, we made both an undeveloped and developed (pre-BMP implementation) SWMM to better understand runoff from various storm events on the site (1, 2, 10, and 100 year 24 hour events). Once BMPs were designed, one for the developed site with BMPs SWMM was created and the same storms modeled.

Similar drafting and reiteration processes were followed for each section of the overall design. For further information about design selections and progress, see the Design section of the main report above.

Appendix C - Engineering Standards - section in progress

C.1 Buildable Area

Virginia's Department of Planning and Chesterfield County require that there be setbacks of 50' for properties zoned C-2, C-3, and R-7. It also requires a 10' setback from bordering roads. It stimulates that wetlands can be developed, but should generally be avoided.

C.2 Demolition Plan

All existing structures were demolished, no standards applied.

C.3 Site Plan

Virginia Department of Transportation's (VDOT) Appendix F: Access Management Standards requires that the minimum inside turn radius of entrance and exits for trucks be 26 feet. It also requires that two-way roads be at least 24 feet wide (12 feet per lane).

The Americans with Disabilities Act (ADA) requires that parking lots with 1-25 parking spaces have at least one accessible van parking lot that is, at minimum, 132 inches wide with accessible aisles on either side of the space that are a minimum of 60 inches wide. ADA also requires that these spaces be designated with a recognizable international symbol of accessibility and located the shortest possible distance from accessible entrances.

ADA also requires that weather shelters in the recreation side of the design have a clear floor space at least 60 inches by 96 inches. At least 20%, but no less than one of each type of outdoor constructed feature provided within a trailhead must be accessible.

C.4 Grading Plan

VDOT Appendix F requires that entrance and exits for trucks have a grade of no more than 8%.

ADA requires that parking lots, sidewalks, and other accessible surfaces must be graded with a maximum running slope of 1:20, a maximum cross slope of 1:48, and minimum width of 36 inches in the case of sidewalks.

C.5 Erosion and Sediment Control Plan

Regulations set forth by the Virginia Erosion and Sediment Control Handbook were followed in the designing of this component of the project.

C.6 Stormwater Management Plan

The Virginia Stormwater Management Handbook (VSWHB) provided guidance on design of BMPs. Section P-FIL-05 was used in designing the bioretention system to determine treatment volumes (eq P-FIL-05-1), surface area (eq P-FIL-05-2), drainage time for ponding area (P-FIL-05-4), and drainage time for treatment volume (eq P-FIL-05-5). All of these equations were used with Level 1 BMP assumptions and minimum media depths, meaning that no trees may be planted in this bioretention facility. Section P-FIL-04-1 was used to design the infiltration trench.

VRRM calculations provided a required runoff and total phosphorus reduction (1.38 lb/yr) which informed BMP selection and design.

Appendix D - Technical Deliverables

D.1 Buildable Area

D1.1 Buildable Area Plan Sheet
D1.2 Buildable Area Civil 3D dwg

D.2 Demolition Plan

D2.1 Demolition Plan Sheet
D2.2 Demolition Plan Civil 3D dwg

D.3 Site Plan

D3.1 Site Layout Sheet
D3.2 Site Layout Civil 3D dwg

D.4 Grading Plan

D4.1 Grading Sheets
D.42 Grading Civil 3D dwg

D.5 Erosion and Sediment Control Plan

D5.1 ESC Sheet
D5.2 ESC Civil 3D dwg

D.6 Stormwater Management Plan

D6.1 Stormwater Management Sheet
D6.2 Stormwater Civil 3D dwg
D6.2 ArcGIS downloadable file (attempt, switched to Civil 3D, see D6.8.1)
D6.4 VRRM Spreadsheet
D6.5 Bioretention Calculations *
* the final calculations used are denoted as SA3, the others were used for comparison of different options
D6.6 Infiltration Trench Calculations
D6.7 Time Series Data for 1, 2, 10, and 100 year 24 hour storms, NOAA Atlas 14 data
D6.8 Curve Number Calculations, Undeveloped Parcel
D6.8.1 Undeveloped Hydraulic Soil Group vs Land Use Mapping: .dwg, .pdf
D6.8.2 Developed Hydraulic Soil Group vs Land Use Mapping: .dwg, .pdf
D6.9 SWMM Input Values
D6.10 SWMM Print Outs for Undeveloped, Developed Pre-LID, and Developed with LIDs
D6.11 SWMM downloadable input files
D6.11.1 Undeveloped: 1 year, 2 year, 10 year, 100 year
D6.11.2 Developed Pre-LID: 1 year, 2 year, 10 year, 100 year
D6.11.3 Developed with LID: 1 year, 2 year, 10 year, 100 year

D.7 Utilities Plan

D7.1 Utilities Sheet
D7.2 Utilities Civil 3D dwg

D.8 Miscellaneous

D8.1 Complete Plan Set
D8.2 Original Information from Industry Partner
D8.2.1 Project Information, Buildable area guidance
D8.2.2 Base file .dwg, Soils file .dwg

Appendix E - Citations and Acknowledgements

Planning Dept Code Portal. Document Viewer | Planning Department Code Portal. (n.d.). https://online.encodeplus.com/regs/chesterfieldcounty-va/doc-viewer.aspx#secid-153

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