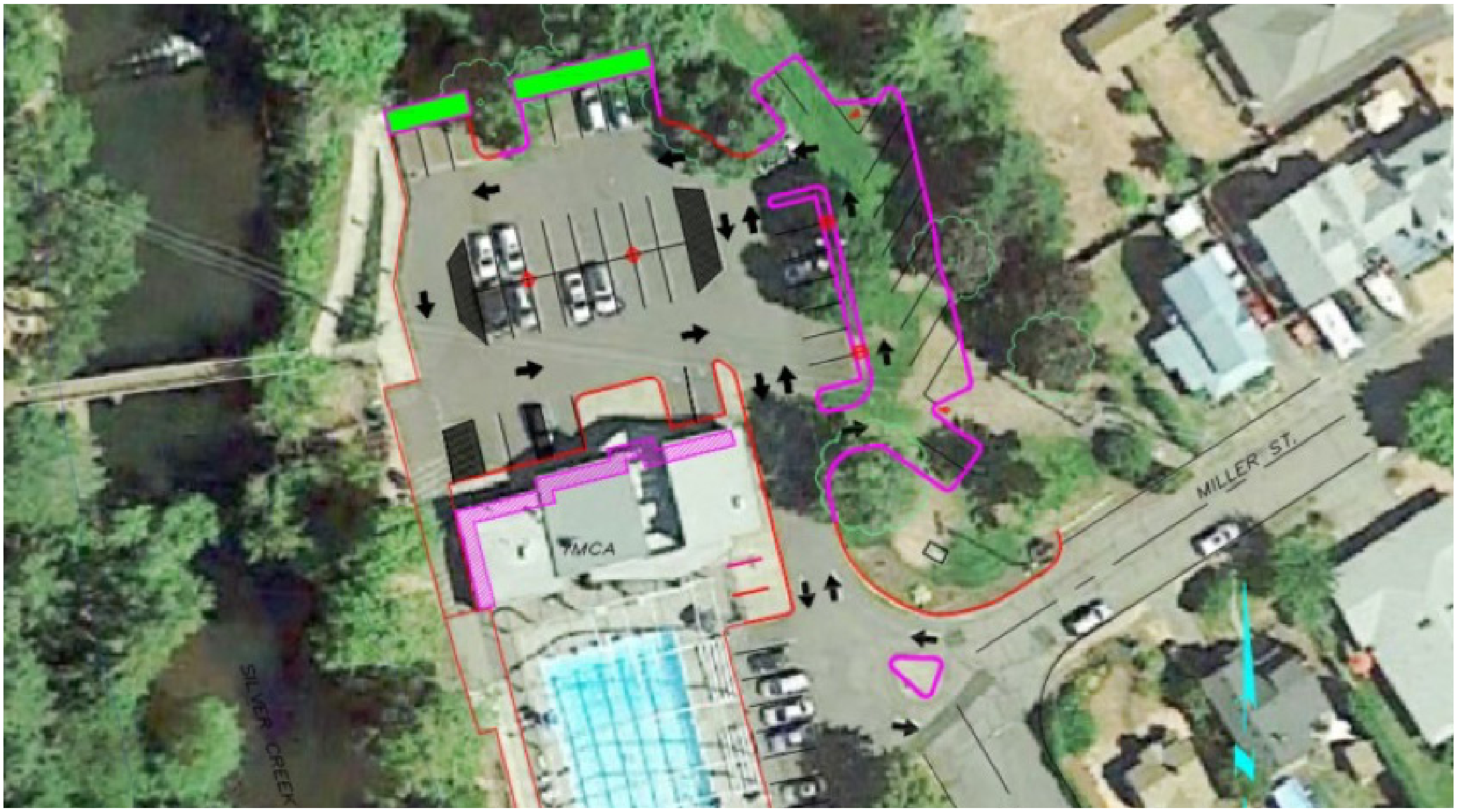

Design Report: Stormwater Improvements

Spring 2020
Silverton

Gary Reyes • Gunter Roehrig • Jacob Ellston
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Civil & Environmental Engineering Capstone

UNIVERSITY OF OREGON · Portland State UNIVERSITY · CITY OF SILVERTON · SCI Sustainable Cities Institute · SCYP Sustainable City Year Program

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About SCI

The Sustainable Cities Institute (SCI) is an applied think tank focusing on sustainability and cities through applied research, teaching, and community partnerships. We work across disciplines that match the complexity of cities to address sustainability challenges, from regional planning to building design and from enhancing engagement of diverse communities to understanding the impacts on municipal budgets from disruptive technologies and many issues in between.

SCI focuses on sustainability-based research and teaching opportunities through two primary efforts:

1. Our Sustainable City Year Program (SCYP), a massively scaled university-community partnership program that matches the resources of the University with one Oregon community each year to help advance that community's sustainability goals; and

2. Our Urbanism Next Center, which focuses on how autonomous vehicles, e-commerce, and the sharing economy will impact the form and function of cities.

In all cases, we share our expertise and experiences with scholars, policymakers, community leaders, and project partners. We further extend our impact via an annual Expert-in-Residence Program, SCI China visiting scholars program, study abroad course on redesigning cities for people on bicycle, and through our co-leadership of the Educational Partnerships for Innovation in Communities Network (EPIC-N), which is transferring SCYP to universities and communities across the globe. Our work connects student passion, faculty experience, and community needs to produce innovative, tangible solutions for the creation of a sustainable society.

About SCYP

The Sustainable City Year Program (SCYP) is a year-long partnership between SCI and a partner in Oregon, in which students and faculty in courses from across the university collaborate with a public entity on sustainability and livability projects. SCYP faculty and students work in collaboration with staff from the partner agency through a variety of studio projects and service-learning courses to provide students with real-world projects to investigate. Students bring energy, enthusiasm, and innovative approaches to difficult, persistent problems. SCYP's primary value derives from collaborations that result in on-the-ground impact and expanded conversations for a community ready to transition to a more sustainable and livable future.

About Silverton, Oregon

The first settlers came to the banks of Silver Creek, following timber and water power, in the 1800s. Silverton was incorporated in 1885. The young town was a trading and banking center of prominence and ranked among the most progressive towns of western Oregon.

By 1921, Silverton industries were producing exports for other areas and even some foreign countries. The Fischer Flour Mills on South Water Street was among the exporters. Power for the mill was obtained by damming Silver Creek at a point near the present pool, diverting water into a millrace that ran along the creek to the mill and then dumped back into the creek.

The development and opening of the Oregon Garden in the 1990s signify the success of a partnership between the Garden, a private enterprise attracting tourists to botanical displays, and the city of Silverton. The Oregon Garden's expansive wetlands area has benefited from the City's excess reclaimed water since 2000, while the community benefits from trade the Garden draws to the area. Silverton was recognized for these reuse efforts as a "Community Water Champion" by the National Water Reuse Association in 2018.

Today, approximately 10,380 residents call the city of Silverton home. In addition to the Oregon Garden, the City features a historic downtown, hospital, community pool, and access to nature activities including nearby Silver Falls State Park.

Executive Summary

The City of Silverton is a small rural community in Marion County approximately 12 miles northeast of Salem. The City is named after Silver Creek, which runs through town and is the primary feature of the project site radiating from YMCA's Silverton Community Swimming Pool. The City utilizes indigenous water supply to serve community needs, with two intakes in Abiqua Creek and as well as an intake at Silver Creek adjacent to the YMCA Pool. Downtime at this intake must be minimized so as to not compromise the City's water supply if the other intake goes down or if it is needed to fill excess demand. Silver Creek is also critical habitat for steelhead, a native migratory fish, so water quality control must be addressed and National Marine Fisheries guidelines must be considered. The main purpose of intake improvement is to increase pipe capacity 150% from two cubic feet per second (cfs) to five cfs. As the initial leg of pipe from the intake goes under the YMCA Pool parking lot, the City is taking the opportunity to update the pool parking lot up to code for pool use. The scope of the 2020.SILV.01 team's work includes the expansion of this parking lot.

The city of Silverton requires low impact design methods that are economically feasible while mitigating surface runoff and limiting tree removal as much as possible. To minimize costs of the parking lot expansion, the new parking lot design retains the majority of existing asphalt. Working closely with Keller Associates engineer Shannon Williams, the 2020.SILV.01 capstone team designed several iterations of the parking lot to preserve as many trees in the green area surrounding the existing lot as possible while extending the lot to the east and north. The final design indicates two 12-inch diameter ash trees east of the existing lot would be removed to make room for an additional twelve parking spaces, increasing available parking 24% from 44 to 56. An additional eight-inch pine tree would be removed from the northwest corner of the lot to install a rain garden. The rain garden would filtrate water runoff from the lot, which would still primarily be impervious asphalt. To further mitigate environmental impact of the expansion students recommended that the pine and ash trees be replaced with four saplings due to their advanced growth.

Students recommended that the expanded area of the lot to the east be paved with permeable asphalt to improve water filtration. The analysis question for this project was how to pave the extended portion of the lot. Non-permeable asphalt, permeable pavers, and a no-build option were also considered for the additional lot area. Weighing the accessibility, safety, environmental, aesthetic, and economic implications of using each material, including cost and maintenance, students determined that permeable asphalt would be the optimal material for the expansion.

To ensure adequate filtration of lot overflow water, students designed two rain garden areas for the northern side of current. The total area of the proposed duel rain garden areas is 560 square feet, adequately filtering for the 14,000 square feet of impervious pavement at a design infiltration rate of 2.5 inches per hour. Paired with the previous lot pavement, filtration for the expanded lot should be adequate to keep runoff from polluting Silver Creek.

The city of Silverton, Oregon is updating its city parks and recreational facilities as part of their Parks and Recreation Master Plan. The Master Plan incorporates improvements to the YMCA Community Swimming Pool. The improvements include the expansion of the existing parking lot and onsite mitigation of stormwater runoff. The Portland State Capstone team, in collaboration with Keller Associates, developed a design to offer the most suitable solution possible for the city of Silverton and the community center. This report describes the existing conditions, project location, stakeholders, alternative analysis, and selection criteria, determining the best option for the City.

1.0 Project Understanding

The purpose of the Silverton's Parks and Recreation Master Plan is to add value to their greenspaces, parks, and recreational facilities. These resources are essential for maintaining a sense of community, health, and a state of well-being for Silverton's residents.

The City is looking to invest in the swimming pool facility (which is under contract with the YMCA), to enhance community connectivity and services to its residents. The YMCA facility is a popular city attraction year-round. However, the facility sees its peak capacities during the summer months. With the existing parking lot configuration, the facility faces limited capacity to effectively manage all pool-goers during the peak season.

The City is planning a project that will include onsite stormwater runoff mitigation and the expansion of the existing parking lot configuration at the YMCA Pool. The existing parking lot consists of 44 standard parking stalls and three ADA accessible stalls. An existing bike rack with a capacity for seven bikes is located southeast of the main entrance. The current stormwater system includes a catch basin with an oil filtration system that drains into Silver Creek, located west of the YMCA Pool.

After assessing the current conditions, students pursued an option that will expand the parking lot to the northeast of the lot (currently part of Old Mill Park). Additionally, a more sustainable approach will govern the proposed stormwater runoff mitigation, maintaining a low impact design characteristic.

Completed work to date includes existing condition assessment, low impact design research, and minimal CAD design work to delineate the proposed expansion. The design will follow City of Silverton codes and Design Standards, Americans with Disabilities Act (ADA), and Standard Local Operating Procedures.

1.1 EXISTING SITE CONDITIONS

The YMCA Pool is located southwest of city hall in the heart of downtown Silverton. The existing parking lot conditions consist of 44 standard parking stalls and three ADA-compliant stalls. The existing bike rack has a capacity for seven bikes. The parking lot is graded to drain towards the northwest corner of the lot where the stormwater infrastructure exists. The stormwater infrastructure consists of one catch basin and three manholes that house an oil filtration system, treating runoff before it drains into Silver Creek.

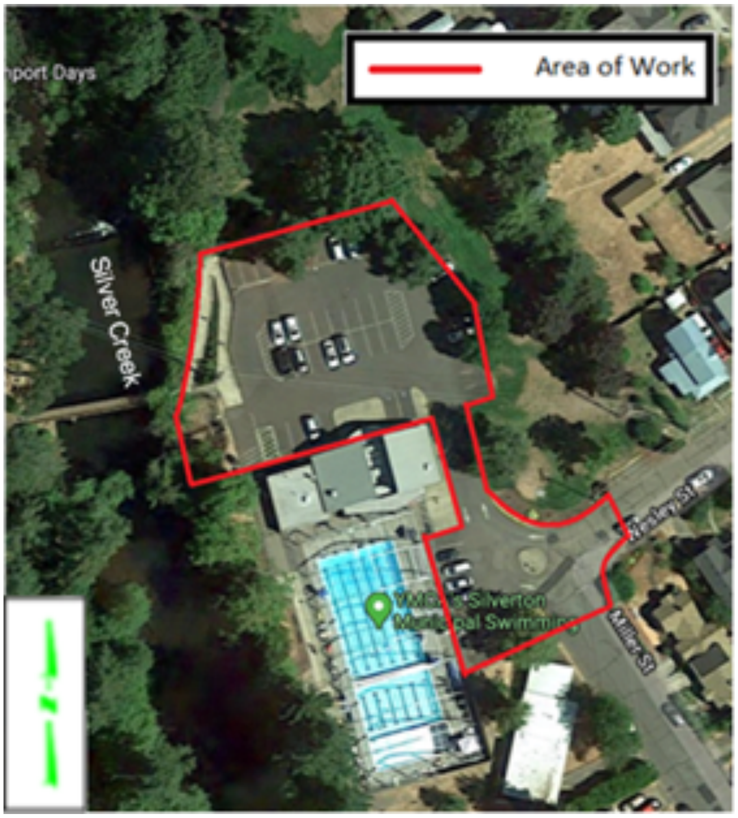

FIG. 1
Aerial of site location and work area.

1.2 STAKEHOLDERS

The project has several stakeholders with different levels of involvement as described below.

- **City of Silverton:** The City will be funding and taking ownership of the project. Upon completion, the City will provide future maintenance and address questions from the public.
- **Keller Associates:** Keller Associates is the main consulting firm for this project and will be the engineer of record. They will also oversee the project both during the design and construction phases.
- **Homeowners:** During the construction phase, temporary parking lot closures may affect street parking in nearby areas. Furthermore, construction noise in the area may disturb nearby residents.
- **Local Businesses:** During the construction phase, local businesses may experience disturbances due to material deliveries and heavy machinery used during the expansion of the parking lot.

- **Silverton Residents, Pool Users:** The primary goal of the project is to expand the pool's parking lot. During construction, the parking lot will close temporarily. However, the completion of the project will expand the parking lot's capacity and in turn improve vehicle access to the pool.The primary project beneficiaries will be the residents of Silverton and YMCA pool users. The completion of the project will increase water resources for the City while also improving the YMCA facility.

2.0 Alternatives Analysis

Students conducted an alternatives analysis to rate certain criteria for four alternative options concerning the pavement type proposed for the project. The alternatives included no build, non-permeable asphalt, permeable asphalt, and permeable parking stalls incorporated with permeable asphalt. The following sections define each alternative, review the selection criteria, and highlight the final decision.

2.1 CONSIDERED ALTERNATIVES

The considered alternatives are described below.

2.1.1 Alternative 1: No Build

The no build option maintains the existing parking lot configuration. The option mitigates the need for expansion or any additional stormwater improvements.

2.1.2 Alternative 2: Non-Permeable Asphalt

Alternative 2 paves an expanded lot with standard asphalt. Standard pavement is considered a non-permeable surface, which increases the amount of uncaptured/untreated runoff. In this option, runoff would be treated via the existing oil filtration system and new rain gardens incorporated into the parking lot expansion.

2.1.3 Alternative 3: Permeable Asphalt for the Expanded Area

Alternative 3 utilizes an environmentally friendly approach that implements Best Management Practices (BMPs), which would allow the design to be considered a low impact design (LID). The expanded parking area would be paved with permeable asphalt. Permeable asphalt allows runoff to be infiltrated directly through the pavement and into the soil below, treating water before it reaches the water table. Permeable surfaces minimize pooling that would otherwise be generated by non-porous asphalt in the lot.

2.1.4 Alternative 4: Permeable Paver Stalls and Permeable Asphalt

Alternative 4 is also an environmentally friendly option that allows the design to be considered a LID. The design includes two permeable material types: permeable asphalt and permeable pavers. As described in Alternative 3, permeable asphalt guides runoff into the soil below, allowing water treatment before reaching the water table. In addition to the asphalt, each stall would incorporate permeable paving bricks that also treat runoff while improving visual aesthetics. The pavers require less maintenance than asphalt and can be easily repaired individually.

2.2 SELECTION CRITERIA

This project maintains a variety of design options that will ideally meet Silverton's expectations. Considerations include the parking lot expansion and the effects of increased stormwater runoff created by an increase in impermeable surface area. The team's top priorities were to create an efficient parking design that will increase parking capacity without disrupting traffic flow and mitigate the increased stormwater runoff with sustainable infrastructure. Students developed a list of selection criteria to provide an understanding of how each design will meet the qualifications of these two priorities. The criteria are access, safety, environmental, aesthetics, maintenance, and cost. The following subsections will define each criterion and briefly explain how and why each design option received its score. Each section will receive a score from 1 to 5 and the description of said scores can be found in Table 2.1.

2.2.1 Access

Access considers several different aspects pertaining to the ability of traffic to move through the lot. The first consideration pertains to the ability of personal vehicles to safely and efficiently move through the parking lot. Will these vehicles have ample parking to use during peak pool-going hours? The second consideration pertains to pedestrian and bicycle access. Is the space safe for pedestrians and bicyclists? Do bicyclists have easy access to bike parking? The third consideration pertains to ADA-compliant parking options to accommodate those with disabilities. The final consideration pertains to how well the designs incorporate room for emergency access. Design access will not vary from Alternatives 2 through 4 so it received a weight of 1.

- Alternative 1 (No-Build) received the Lowest accessibility score. This option meets some of the accessibility criteria, however, ADA requirements are not met because there are not a sufficient number of ADA-compliant spaces. Therefore, this option was given a score of 2.
- Alternative 2 (Non-Permeable Asphalt) increases the number of ADA compliant spaces and the number of general spaces. However, the number of spaces fails to meet standards of the pool at maximum capacity. The possible pooling of water also affects accessibility. Therefore, Alternative 2 was given a score of 3 indicated it is neutral for this category.
- Alternatives 3 (Permeable Asphalt, Expanded Area) and 4 (Permeable Asphalt and Parking Stalls) alleviate the pooling issues but having the same layout that does not satisfy space requirements for pool capacity. Therefore, these options were given a score of 4, meeting most criteria.

2.2.2 Safety

Safety relates to access but holds distinct characteristics and was scored separately. Students considered the vehicle safety in each design including how effectively users can park and maneuver without interfering with each other. Pedestrians and cyclists must also be able to easily navigate the design when entering and exiting the pool facility. Finally, crime must be considered as parking lots can be magnets for a variety of crimes. Safety will be ranked according to the visibility throughout the parking lot and the amount of lighting incorporated in the design. Even though safety is important when considering the designs, it received a weight of 1 because it does not heavily affect the scope of the project and the safety will not vary from changes of paving material.

- Alternative 1 will add no additional lighting to deter criminal activity, however the basic layout of the current parking lot is such that drivers can maneuver within the lot reasonably safely. Alternative 2 adds additional lighting to deter crime. However, the possibility of ponding due to differential settlements decreases safety. Alternatives 1 and 2 were given a score of 3.
- Alternatives 3 and 4 reduce the possibility of ponding and were given a safety score of 4, meeting most requirements but not getting a score of 5 as 1-way lanes limit maneuverability.

2.2.3 Environmental

The environmental criterion examines how well the design's ability to mitigate stormwater runoff. The increase in the impermeable surface area poses a risk to overwhelm the current runoff management system. The design should consider green water infrastructure options that not only capture runoff but help infiltrate and treat runoff. Ultimately this criterion was based on how effectively the design captures and treats water to reduce its impact on Silver Creek. Environmental aspects were a main focus when deciding between design options as students believe this parking lot expansion is an opportunity to create better stormwater management. The environmental criterion received a weight of 2.5.

- Alternative 1 receives an environmental score of 2, having some environmental management features that could be better managed. The new parking lot layout adds rain gardens to improve stormwater management and planting strips to support wildlife.
- Alternative 2 utilizes these features, however its non-permeable pavement is poorer environmentally relative to other alternatives. Therefore, this option was determined to be neutral with a score of 3.
- Permeable pavement options have the lowest environmental impact, thus Alternatives 3 and 4 received a score of 5.

2.2.4 Aesthetics

Students considered aesthetics when grading the designs. Since the site will be heavily used by the community, students sought an attractive design that can be enjoyed by the users. This grade was based purely on the visual appeal of each design. Students gave this criterion a weight of 1 because it is not of major importance to the design function.

- Alternative 1 scored the lowest with a score of 2. The current site is not visually appealing and when compared to the enhanced features of other options it is aesthetically lacking.
- Alternatives 2 and 3 both received a score of 4. Both designs will look relatively the same as there is not a large difference in looks between porous and non-porous asphalt.
- Alternative 4 scored the highest with a score of 5 as the addition of pavers enhances the visual appeal of a parking lot by incorporating designs similar to brick.

2.2.5 Maintenance

Maintenance is a frequently overlooked design aspect. Students envisioned a design that requires very little maintenance for both short- and long-term scenarios. When deciding on a score, students considered the following categories. First, the roadway surface should require very little cleaning and should not be subject to unconventional failures leading to potholing. Next, the green infrastructure should be free of maintenance outside of the normal cleaning that is required. Lastly, students considered the additional maintenance that could be added from the incorporation of new plants, trees, and landscaping. Maintenance received a weight of 1.5 as the variability of required upkeep changes immensely in each design.

- For Alternative 1 students scored Maintenance as a 3. The current site is showing signs of deterioration, suggesting increases in required maintenance are necessary to maintain the integrity of the driving surface.
- Alternative 2 scored the highest with a score of 4, as the non-porous pavement requires less cleaning and the new pavement should have increased integrity.
- Alternative 3 received a score of 1, as the porous pavement requires increased cleaning to maintain its ability to infiltrate and treat runoff. It is also subject to an increased failure rate from moving vehicles.
- Alternative 4 received a score of 2 as it still requires increased cleaning frequency, but the incorporation of pavers increases the lifespan of the stalls and if needed can be replaced individually instead of across whole sections.

2.2.6 Cost

Cost is an important factor when considering designs as ambitious designs often increase costs considerably. To score Cost, students examined several factors, the first being the cost of labor. Cost of labor includes the overall length of construction and amount of work required by the contractor. Secondly, design feasibility must be factored in as it must be deemed possible for a contractor to efficiently complete the scope of work. Lastly, material cost needs to be considered as increased design complexity can often increase overall material costs. Therefore, the cost was an overall driving factor in this project receiving a weight of 3.

- Alternative 1 received a score of 5 as it would require no additional costs to leave the site as-is. For the remaining three alternatives students only compared the difference in the pavement as the overall layout would not be changed and would not affect the cost between the three.
- Alternative 2 received a score of 4. This option required basic asphalt paving, which is the most cost-effective of the three pavement options for both material and labor costs. The alternative is also considered feasible.
- Alternative 3 acquired the score of 3 as both material and labor costs would increase slightly while remaining feasible.
- Alternative 4 received a score of 2. Both the material and labor costs will rise significantly from the addition of porous pavers. This alternative was also considered slightly less feasible than other alternatives.

2.2.7 Pugh Matrix

The following tables define the meaning of each score (1-5) and illustrate how students' overall design choice was derived. Students selected the design alternative with the highest tallied score as the best fit design for the project. As described above, the team scored the criteria for each alternative. After the criteria were scored, all of the scores were totaled. The highest scoring alternative was Alternative 3, permeable asphalt for the entire lot (Table 2.2). Since Alternative 3 had the highest rank, it was deemed to be the preferred alternative.

Score	Description
1	Does not meet the criteria description
2	Barely meets the criteria description
3	Neutral (meets some but not all)
4	Meets most of the criteria description
5	Meets the entire criteria description

TABLE 2.1
Description of Scoring

Criteria	Weight	Design Alternatives								
		Alternative 1: No-Build		Alternative 2: Non-Permeable Asphalt		Alternative 3: Permeable Asphalt for Expanded Area		Alternative 4: Permeable Paver Stalls and Permeable Asphalt		Preferred Alternative
		Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted	
Access	1	2	2	3	3	4	4	4	4	3 & 4
Safety	1	2	2	3	3	4	4	4	4	3 & 4
Environmental	2.5	2	5	3	7.5	5	12.5	5	12.5	3 &4
Aesthetics	1	2	2	4	4	4	4	5	5	4
Maintenance	1.5	3	4.5	3	4.5	1	1.5	2	3	1 & 2
Cost	3	5	15	4	12	3	9	2	6	1
Total		16	30.5	20	34	21	35	22	34.5	3
Final Rank		4		3		1		2		

TABLE 2.2
Scores of each design alternatives

3.0 Facility Design

The following section will discuss the final design proposal that will be submitted. It is organized into the following sections: overall design, mitigation of increased runoff, mitigation of current run, and additional issues that arose.

3.1 DESIGN CRITERIA

The design criteria for the parking lot expansion considers the implementation of BMPs, ADA, and city of Silverton requirements. Incorporating innovative stormwater management into the parking lot design requires using "best management practices" or LID.

3.2 EXPANSION OF PARKING LOT

To address the lack of current parking spaces in the lot, students propose to expand the current design to the east. The proposed design includes a one lane route that will add an additional 11 spaces to the parking lot while maintaining the majority of the existing spaces (Appendix D, 6). Additionally, the current travel directions will change from two-way to one-way with the exception of the main entrance. Overall, the new design will be about 18,530 SF and will total of 56 parking spaces.

3.3 MITIGATION OF INCREASED RUNOFF

As discussed in the prior section, the parking lot will have an increased area of about 4,530 square feet (SF). The increase leads to additional stormwater runoff that needs to be managed in an effective manner. Student alternatives analysis considered several options including porous pavement, porous pavement with permeable pavers, and impermeable asphalt. Ultimately, Alternative 3 was chosen, which included the incorporation of porous asphalt in the expanded section.

To ensure the porous pavement can manage the increased runoff, students used HydroCAD to produce a runoff analysis. Students designed the porous asphalt with no underdrain as the detailed geotechnical report provided by GeoEngineers found that soil on the site has an infiltration rate of 0.5 inches per hour (in/hr). The storm was modeled as a 10yr Type IA 24-hr storm, which represents storms of low intensity but long duration, a common occurrence in the Pacific Northwest. Finally, students adjusted the time frame to 30 hours to adhere to the performance approach listed in the City of Portland's Stormwater Management Manual.

Overall, students concluded that the porous pavement could effectively manage the increased runoff based on the analysis. By examining the hydrograph, the peak runoff is 0.05 CFS and the overall flow returns to zero within the 30-hour time frame, proving the design will handle the runoff (Appendix E, 13-18).

3.4 MITIGATION OF CURRENT RUNOFF

Two parking sections were designed for this project. One is the additional parking area proposed that will use porous asphalt on the east side of the existing impervious asphalt.

For the impervious asphalt, there is approximately 14,000 SF calculated for the analysis. To treat the runoff for this section, students proposed two planters to mitigate the water runoff.

These planters would be located on the north side of the lot (Appendix D, 7). The Presumptive Approach Calculator (PAC) was used to estimate the size of the planter needed to mitigate the runoff. A geotechnical report from GeoEngineers specifically for this site showed that the soil has an infiltration rate of 0.5 in/hr. This value was used for calculations as well as the Open Pit Falling Head method with a 10-year storm requirement.

The final proposed size for the planter is 560 SF. This area was distributed in two planter facilities. The resulting size for the planter located on the NE corner of the lot is about 7′ by 27′ and next to it, another planter with dimensions of 7′ by 53′ (Appendix D, 7). A hierarchy category 3 and facility configuration C were chosen for maximum efficiency. The calculations performed suggested a 543 SF planter. However, the actual size of the two planters combined is greater than the minimum required area by the PAC method, which makes the design capable of infiltrating the estimated runoff (Appendix E, 2).

3.5 ADDITIONAL PROBLEMS THAT AROSE

Within the parking lot design process, an additional complication arose that required the team to complete electronic turning templates to analyze the existing and proposed conditions of the parking lot configuration and traffic flow. The electronic turning templates are CAD-based and illustrate or simulate vehicular paths that include starting, turning, and ending maneuvers of a vehicle. They are used to verify that access to and from the parking lot will not generate any complications. Students generated electronic turning diagrams for two types of vehicles (in accordance with AASHTO 2018 vehicle library dimensions) that include passenger and emergency vehicles. These are the main two types of vehicles that the parking lot configuration needs to accommodate (Appendix D, 9-10).

3.6 CONSTRUCTION COST

The construction costs for the project are relatively preliminary and will need further work as the project develops. There are many different types of costs associated with the project, including labor, equipment, demolition, installation, materials, and temporary signage and barricades among others. Labor costs include work done by all the contractors throughout the construction of the project. Equipment costs include drilling vehicles for site investigation, pavers for the asphalt, and compact excavators for the removal of curb, earth, and light poles. Newly installed items for the project include six new light poles, approximately 4,530 SF of porous pavement, and a rain garden for all runoff collected from the existing pavement. Material costs include asphalt, concrete, light poles, subgrade, and PVC pipe. Other costs include temporary signage and barricades to help keep the public safe distance. A detailed list showing each item and its cost can be found in Appendix A (1-3).

3.7 CONSTRUCTION SCHEDULE

The construction schedule for the YMCA Pool parking lot will occur in four phases with a pre-construction phase zero.

- Phase 0 includes pre-construction activities such as design, planning, design approval, contract execution, and phase review. Phase 0 assumes that a team working on this type of design may take about 12 days to produce a design.

- Phase 1 is the period of construction. The first task is equipment mobilization followed by demolition of the area where the new design will be implemented. Site grading will provide the necessary slope for water runoff to be captured by the planter on the north side and by the porous asphalt in the new east area. Piping will facilitate stormwater management following the details provided in Appendix D for the planter. In this phase, any utility such as gas or electric conduit must be securely moved if necessary. The east side of the parking lot has a tree that must be removed for the expansion to take place. On the north side, the vegetated area will be reduced to about 8′ by 16′; design efforts were taken to conserve existing trees in this area.
- In Phase 2, all concrete work for the curb, planter, and light pole foundations is scheduled to be completed in approximately six days. The details for these three items are given in Appendix D. Additionally, ground preparation is scheduled in this phase, where a geosynthetic layer will be placed above soil followed by coarse aggregate and lastly by porous asphalt.
- In Phase 3, striping work begins. Details are provided in Appendix D and will include all ADA stalls as well as van accessible stalls. Both new vegetated areas and new planters require landscaping. Details for the planter layers are shown in Appendix D. Students suggest an additional bike rack be installed in the existing area for bikes. Light installation is scheduled for this phase. The foundation for the light poles is sufficient to sustain a maximum pole height of 30 feet.
- In Phase 4, the project will be finalized. Cleaning and inspection are included in the finalization process.

4.0 Regulatory Compliance and Permitting

This section describes the regulatory agencies considered for the stormwater improvement project.

4.1 CITY OF SILVERTON (CITY ENGINEERING DESIGN STANDARDS)

The City of Silverton has municipal standards and requirements for construction and design. Design standards include parking layout, disabled stalls, bike corrals, and the required amount of parking spaces for a recreational building.

4.2 OREGON TRANSPORTATION COMMISSION (STANDARDS FOR ACCESSIBLE PARKING PLACES AUGUST 2018)

The Oregon Transportation Commission (OTC), in accordance with the Oregon Revised Statute (ORS) 447.233, adopted standards for accessible parking spaces on January 22, 1992. ORS 447.223 states that all new construction and re-striping of accessible parking spaces must comply with state requirements. Students reviewed and incorporated these regulations, which included stripe thickness, stripe locations, height for disabled stall signs, and signage types, among others.

4.3 DEPARTMENT OF ENVIRONMENTAL QUALITY

The Oregon Department of Environmental Quality (DEQ) is an environmental regulatory agency. It provides National Pollution Discharge Systems (NPDES) permits for Section 401 Water Quality Certification for Post-Construction Stormwater Management. Any design proposed in this project will create minimal runoff into Silver Creek, in compliance with DEQ requirements.

5.0 Conclusion

The proposed design focuses on expanding the existing YMCA pool parking lot while using the design as an opportunity to incorporate green infrastructure that mitigates and treats stormwater runoff.

The expansion will increase the total number of parking spaces from 44 to 56 while maintaining an efficient and safe layout for both passenger and emergency vehicles to navigate through the lot. The main benefit of this design is the addition of green infrastructure. By removing the oil separator from the existing lot and incorporating infiltration planters, runoff can be treated for any contaminants it is carrying. Furthermore, the porous pavement serves the same treatment purpose for runoff while removing any ponding that may occur from traditional pavement. The project's major limitation was not being able to incorporate more parking spaces due to the green space surrounding the existing lot. Students avoided the removal of large trees and felt that protecting the current trees outweighed additional parking spaces.

As the city of Silverton and Keller Associates move forward on the project, students would like to highlight some next steps to complete the design. There are several important factors that still need to be considered and/or designed. First, the grading of asphalt in the area highlighted on sheet 4 of the plan set needs to be measured. Second, the routing of the planters' outflow pipes to the existing pipes of the removed oil separator need to be designed to account for stormwater during large events. Lastly, the right-of-way boundaries are assumed and will need to be verified before construction.

References

References pertaining to project research used for the project report are listed below. These references contain web links where the information can be retrieved and accessed for any further clarification.

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Appendices

The following appendices are attached.

A. CONSTRUCTION COST ESTIMATE

This section presents the list of materials and construction activities with estimated costs.

B. CONSTRUCTION SCHEDULE

This section presents a list of tasks, subtasks in a Gantt chart for the estimated time for preconstruction and construction.

C. DEMOLITION PLAN

This section provides details on the steps/precautions needed before construction begins.

D. DRAWINGS

Preliminary design sheets for proposed design.

E. CALCULATIONS

This section includes supporting calculations done for the light pole foundation bearing capacity, infiltration planter runoff capacity and planter bearing capacity of the walls and HydroCAD runoff analysis for the porous pavement.

F. QC CHECKLIST

This section presents a quality control checklist to ensure the rubric and group requirements are met.

Appendix A

Construction Cost Estimate

Cost Estimate Report

Date: 05/31/2020

Stormwater Improvement Project

Year 2020 Quarter 2

Unit Detail Report

Prepared By: Melissa Boell   Portland State University

LineNumber	Description	Quantity	Unit	Total Incl. O&P	Ext. Total Incl. O&P
Division 01 General Requirements					
015433200100	Rent excavator diesel hydraulic crawler mounted 1/2 CY capacity, Incl. Hourly Oper. Cost.	4.00	Day	$702.11	$2,808.43
015433200482	Rent backhoe-loader attachment, compactor, 20,000 lb., Incl. Hourly Oper. Cost.	3.00	Day	$227.00	$680.99
015433201910	Rent grader, self-propelled, 30,000 lb, Incl. Hourly Oper. Cost.	2.00	Day	$1,745.79	$3,491.58
015433203000	Rent roller, vibratory, tandem, smooth drum, 20 H.P., Incl. Hourly Oper. Cost.	2.00	Day	$420.46	$840.93
015433204880	Rent loader, skid steer, wheeled, 10 CF, 30 HP, Incl. Hourly Oper. Cost.	2.00	Day	$269.85	$539.70
015433401680	Rent barricade, portable with flasher 25 to 50 units, Incl. Hourly Oper. Cost.	3.00	Month	$64.13	$192.39
015433404020	Rent paver bituminous, rubber tires 8'wide 50 HP, diesel, Incl. Hourly Oper. Cost.	1.00	Day	$907.98	$907.98
Division 01 General Requirements Subtotal					**$9,462.00**
Division 02 Existing Conditions					
022113090020	Topographical survey, conventional, minimum	2.00	Acre	$660.75	$1,321.50
023213100020	Subsurface investigation, boring and exploratory drilling, initial field stake out & determination of elevations, for borings	1.00	Day	$1,309.00	$1,309.00
024113176000	Demolish, remove pavement & curb, remove concrete curbs, plain, excludes hauling and disposal fees	130.00	L.F.	$5.22	$678.60
024119250020	Selective demolition, saw cutting, each additional inch of depth over 3"	40.00	L.F.	$1.37	$54.80
024210202500	Deconstruction of wood components, posts, up to 2 stories, excludes handling, packaging or disposal costs	40.00	L.F.	$1.27	$50.80
Division 02 Existing Conditions Subtotal					**$3,414.70**

LineNumber		Description	Quantity	Unit	Total Incl. O&P	Ext. Total Incl. O&P
Division 03	**Concrete**					
033053401020		Structural concrete, in place, column (4000 psi), square, up to 2% reinforcing by area, 36" x 36", includes forms(4 uses), Grade 60 rebar, concrete (Portland cement Type I), placing and finishing	12.00	C.Y.	$1,175.50	$14,106.00
Division 03	**Concrete Subtotal**					**$14,106.00**
Division 07	**Thermal and Moisture Protection**					
071713100100		Bentonite, rolls, with geotextile fabric both sides, 3/8" thick	4,530.00	S.F.	$3.07	$13,907.10
Division 07	**Thermal and Moisture Protection Subtotal**					**$13,907.10**
Division 10	**Specialties**					
101453200100		Signs, stock, aluminum, reflectorized, high intensity, .080" aluminum, 24" x 24", excludes posts	3.00	Ea.	$151.05	$453.15
Division 10	**Specialties Subtotal**					**$453.15**
Division 26	**Electrical**					
260505100100		Conduit, rigid galvanized steel, 1/2" to 1" diameter, electrical demolition, remove conduit to 10' high, including fittings & hangers	40.00	L.F.	$3.02	$120.80
265613103000		Light poles, anchor base, aluminum, 20' high, excl concrete bases	6.00	Ea.	$1,901.50	$11,409.00
Division 26	**Electrical Subtotal**					**$11,529.80**
Division 31	**Earthwork**					
311313203100		Selective clearing and grubbing, 8" to 12" diameter, remove selective trees, on site using chain saws and chipper, excludes stumps	3.00	Ea.	$420.00	$1,260.00
Division 31	**Earthwork Subtotal**					**$1,260.00**
Division 32	**Exterior Improvements**					
321216140020		Asphaltic concrete paving, parking lots & driveways, 6" stone base, 2" binder course, 1" topping, no asphalt hauling included	4,530.00	S.F.	$2.78	$12,593.40
321613130300		Cast-in place concrete curbs & gutters, concrete, wood forms, straight, 6" x 18", excludes concrete	560.00	L.F.	$10.92	$6,115.20
321723130500		Painted pavement markings, acrylic waterborne, white or yellow, 8" wide, less than 3,000 LF	400.00	L.F.	$0.67	$268.00
323333100012		Planters, precast concrete, sandblasted, 48" diameter, 24" high	5.00	Ea.	$772.50	$3,862.50
329313100012		Ground cover, plants, pachysandra, excludes preparation of beds	5.00	C	$200.00	$1,000.00
Division 32	**Exterior Improvements Subtotal**					**$23,839.10**
Division 33	**Utilities**					

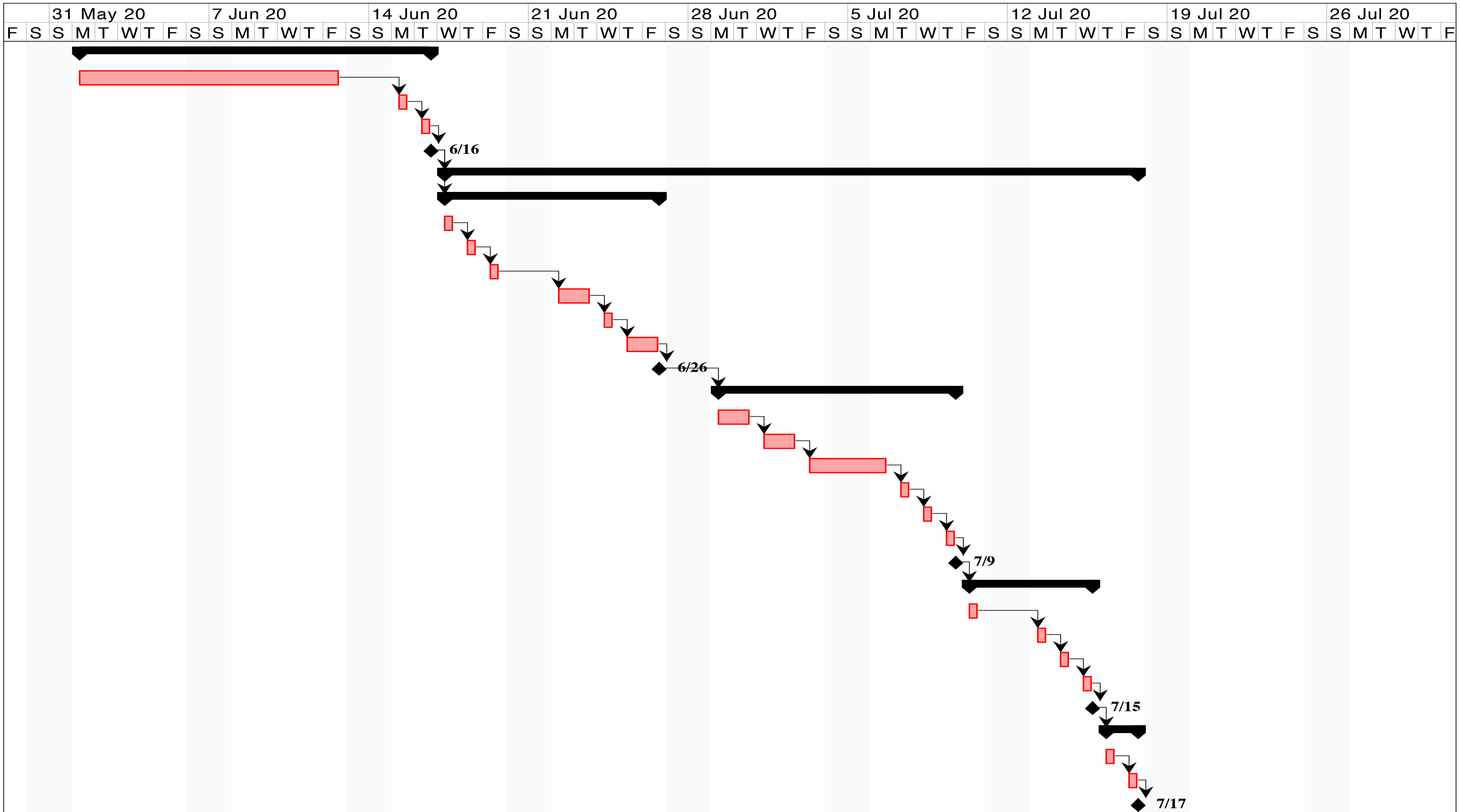
LineNumber	Description	Quantity	Unit	Total Incl. O&P	Ext. Total Incl. O&P
334211402040	Public storm utility drainage piping, corrugated metal pipe, galvanized and bituminous coated with paved invert, 20' lengths, 16 ga., 8" diameter, excludes excavation and backfill	15.00	L.F.	$19.51	$292.65
Division 33 Utilities Subtotal					**$292.65**
Subtotal					**$78,264.50**
General Contractor's Markup on Subs				**0.00%**	**$0.00**
Subtotal					**$78,264.50**
General Conditions				**0.00%**	**$0.00**
Subtotal					**$78,264.50**
General Contractor's Overhead and Profit				**0.00%**	**$0.00**
Grand Total					**$78,264.50**

Appendix B

Construction Schedule

Figure B.1 Construction Schedule.

1000	**Phase 0 Preconstruction (c06/01/20 to 06/16/20, Duration 12 days)**			
Task	**Title**	**StartDate**	**Finish Date**	**Duration**
1010	**Design and planning**	06/01/20	06/12/20	10 days
1020	**Design approval**	06/15/20	06/15/20	1 day
1030	**Contract execution**	06/16/20	06/16/20	1 day
1040	**Phase exit review**			
2000	**Construction (06/17/20 to 07/15/20, Duration 21 days)**			
Task	**Phase 1 (8 days)**	**StartDate**	**Finish Date**	**Time**
2010	**Equipment mobilization**	06/17/20	06/17/20	1 day
2020	**Erosion control**	06/18/20	06/18/20	1 day
2030	**Demolition & Removal**	06/19/20	06/19/20	1 day
2040	**Grading**	06/22/20	06/23/20	2 days
2050	**Underground piping (Stormwater)**	06/24/20	06/24/20	1 day
2060	**Utilities (light poles)**	06/25/20	06/26/20	2 day
2070	**Phase exit review**			
Task	**Phase 2 (9 days)**	**StartDate**	**Finish Date**	**Time**
3010	**Concrete work (Curbs)**	06/29/20	06/30/20	2 days
3020	**Concrete work (Planter walls)**	07/01/20	07/02/20	2 days
3030	**Concrete work (Light pole foundation)**	07/03/20	07/06/20	2 days
3040	**Ground preparation**	07/07/20	07/07/20	1 day
3050	**Geosynthetic mesh**	07/08/20	07/08/20	1 day
3060	**Asphalt installation**	07/09/20	07/09/20	1 day
3070	**Phase exit review**			
Task	**Phase 3 (3 days)**	**StartDate**	**Finish Date**	**Time**
4010	**Stripping work**	07/10/20	07/10/20	1 day
4020	**Landscape planter and green areas**	07/13/20	07/13/20	1 day
4030	**Bike rack installation**	07/14/20	07/14/20	1 day
4040	**Light installation**	07/14/20	07/15/20	1 day
4050	**Phase exit review**			
Task	**Phase 4 (2 days)**	**StartDate**	**Finish Date**	**Time**
4040	**Project clean up**	07/15/20	07/15/20	1 day
4050	**Project completion & inspection**	07/26/20	07/16/20	1 day
4060	**Phase exit review**			


31 May 20
7 Jun 20
14 Jun 20
21 Jun 20
28 Jun 20
5 Jul 20
12 Jul 20
19 Jul 20
26 Jul 20
F S S M T W T F S S M T W T F S S M T W T F S S M T W T F S S M T W T F S S M T W T F S S M T W T F S S M T W T F S S M T W T F
6/16
6/26
7/9
7/15
7/17

Appendix C

Drawings

CITY OF SILVERTON, OREGON
STORMWATER IMPROVEMENTS

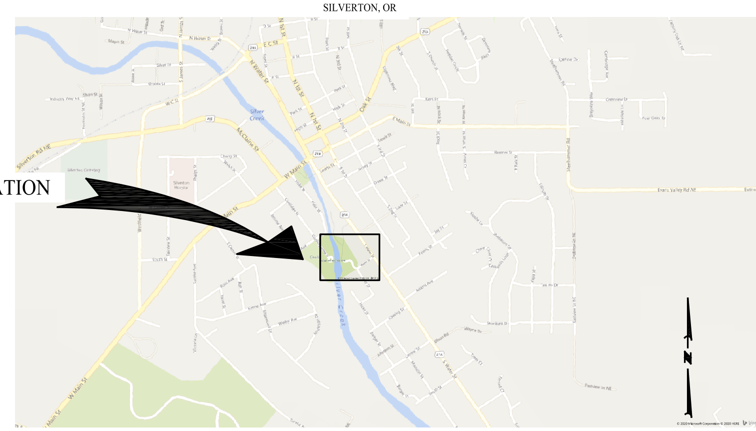
2020.SILV.01 PLANS FOR PROPOSED PROJECT
JUNE - 2020

ATTENTION:
Oregon Law Requires You To Follow Rules Adopted By The Oregon Utility Notification Center. Those Rules Are Set Forth In OAR 952-001-0010 Through OAR 952-001-0090. You May Obtain Copies Of The Rules From The Center.

LET'S ALL WORK TOGETHER TO MAKE THIS JOB SAFE

SILVERTON, OR

PROJECT LOCATION



VICINITY MAP
NO SCALE

INDEX OF SHEETS

SHEET NO.	DESCRIPTION
1	COVER PAGE
2	GENERAL NOTES
3	EXISTING PARKING LOT PLAN
4	DEMOLITION PLAN
5	PROPOSED PARKING LOT ADDITION
6	STRIPING PLAN
7	DETAILS SHEET 1 (RAIN GARDEN/LIGHTING)
8	DETAILS SHEET 2 (PARKING STALL/ROAD)
9	PASSENGER VEHICLE TEMPLATE
10	EMERGENCY VEHICLE TEMPLATE

△	DATE	REVISION	BY

DO NOT SCALE THIS DRAWING FOLLOW DIMENSIONS. INDICATED SCALES CORRECT ONLY FOR FULL SIZE SHEET (22"X34")

CITY OF SILVERTON • EST 1854 • OREGON'S GARDEN CITY

KELLER ASSOCIATES

Maseeh College of Engineering and Computer Science
PORTLAND STATE UNIVERSITY

DRAFTER: GRR CHECKER:
DESIGNER: REVIEWER:

STORMWATER IMPROVEMENTS
2020.SILV.01

COVER PAGE
INDEX OF SHEETS

SHEET NO. 1/10

PLAN_SHEETS_2.DWG

PLOT DATE: 5/23/2020 PLOT TIME: 9:45 PM USER: GREYES

GENERAL NOTES

1. All Construction, materials, and workmanship shall conform to the latest standards and practices of the City of Silverton, Oregon and the "Standard Specifications for Road and Municipal Construction."

   - 1) Unless otherwise approved by the Public Works Director, materials shall conform to the minimum requirements outlined herein and as shown on the Standard Details. This listing is not intended to be complete nor designed to replace the City's Public Works Construction Standards (PWCS).
   - 2) In the case of conflicts between the provisions of these design standards and the PWCS, the more stringent as determined by the Public Works Director shall apply. Acceptable materials shall be as outlined in these Design Standards.
   - 3) It is not intended that materials listed herein are to be considered acceptable for all applications. The design engineer shall determine the materials suitable for the project to the satisfaction of the Public Works Director.

2. Where existing services must be interrupted, the Contractor shall obtain approval from the construction manager's officer and notify all customers that are to be affected as to the date, time, and duration of the interruption. Notification must be done 24 hours in advance of the interruption. The Contractor shall schedule construction to provide minimum interruption of services as determined by the inspector. Under no circumstances will the Contractor schedule a water main shut down without the required 24 hour notice. The Contractor shall not operate the City of Silverton's water facilities without approval from the construction inspector.

3. All materials shall meet the applicable specifications in the City of Silverton standards. Before any native material is used, tests results shall be provided to the City inspector indicating that the material meets the specifications. Backfill material shall be compacted to 95% of the maximum relative density.
4. The Contractor shall notify the City of Silverton's construction manager's office, County, ODOT and all utility companies a minimum of 48 hours prior to the start of construction. Inspections and approval of the construction will be by the City construction manager's officer. A satisfactory pressure and bacteriological test for any water construction is required for approval.and comply with all other requirements of ORS 757.541 to 757.571.

5. The Contractor shall have all existing utilities properly located prior to commencing excavations. The Contractor shall, at a minimum, call 48 hours before beginning excavations.

6. The existing underground utilities shown on these plans were all that had been constructed at the time these plans were completed. Additional underground construction may have occurred before construction of this project was started. Notice shall be given to the owners of the facilities not less than two business days or more than 10 business days before excavation.

7. All construction within existing City of Silverton right-of-way shall have an approved traffic control plan prior to any on-site construction activity.

8. Pre-paving as-builts shall be submitted to the City of Silverton Development Review Services Department and City inspector for sanitary sewer, storm sewer, and storm facilities prior to paving.

9. Any significant deviations from the plans will require a request from the applicant's engineer and approval from the City's Transportation Division engineer(s) and City inspector.

10. Should any item of archeological interest be found during development, you are required to stop work and notify the planning case manager immediately. Failure to do so could result in a felony conviction.

11. Soil and subgrade construction requires inspector approve proof roll and/or testing prior to rocking and prior to paving.

12. All traffic control plans & measures shall be approved by the agency with jurisdiction and in place prior to any construction activity. Contractor shall erect and maintain barricades, warning signs, traffic cones (and all other traffic control devices required) per City, County and ODOT requirements in accordance with the current MUTCD (including Oregon amendments). Access to driveways and buildings shall be maintained at all times for residential, fire and emergency vehicles.

13. Record Drawings. The Contractor shall maintain one complete set of approved drawings on the construction site at all times whereon he will record any approved deviations in construction from the approved drawings, as well as the station locations and depths of all existing utilities encountered (whether or not existing utilities are shown on the construction drawings). These field record drawings shall be kept up to date at all times and shall be available for inspection by the City upon request. Information on the field record drawings shall include reference measurements and materials type.

CITY OF SILVERTON • EST 1854 • OREGON'S GARDEN CITY

KELLER ASSOCIATES

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△	DATE	REVISION	BY

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STORMWATER IMPROVEMENTS
2020.SILV.01

GENERAL NOTES SHEET

SHEET NO. 2/10

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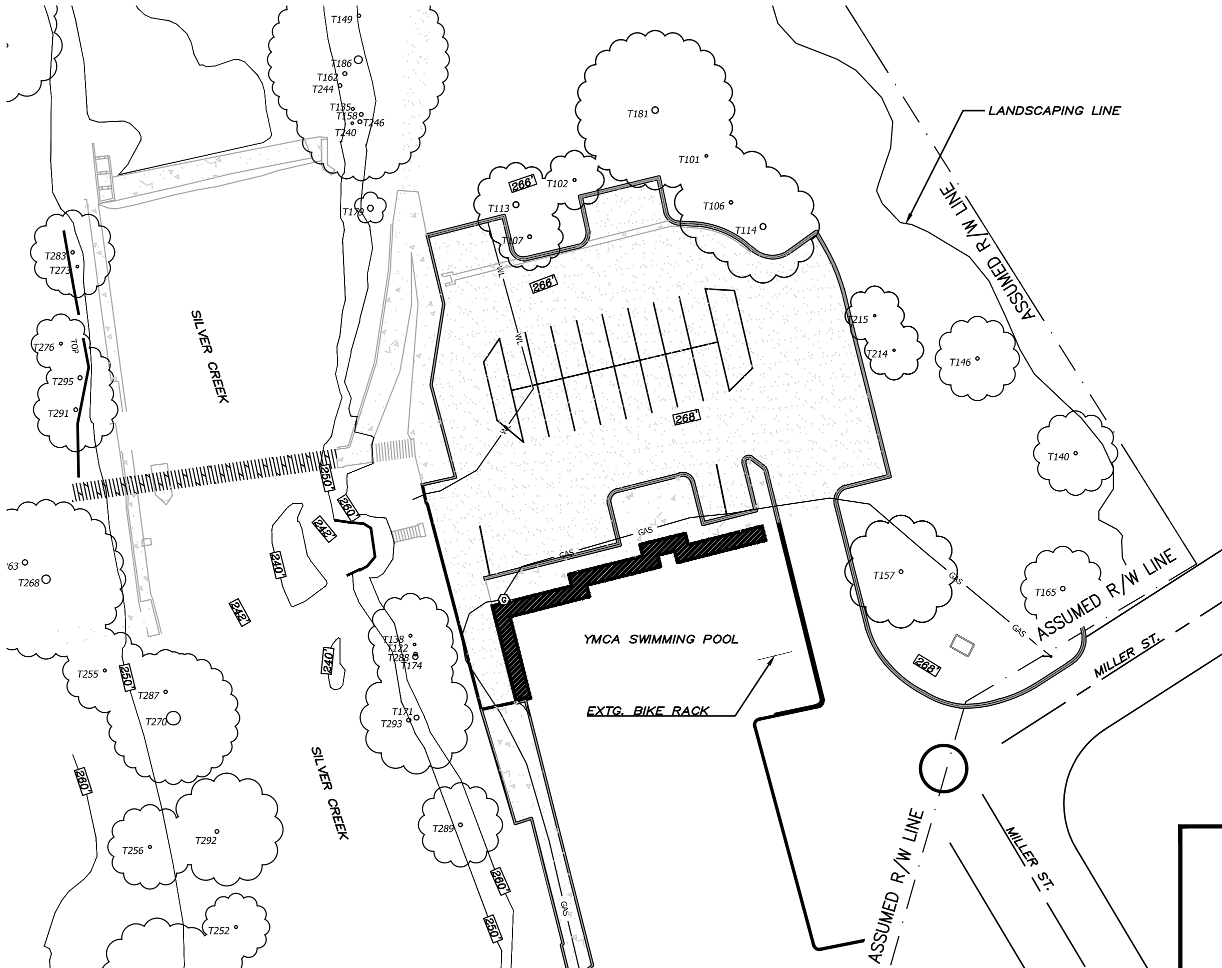

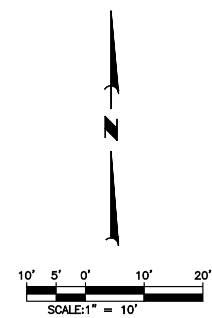

NOTE:

EXTG. PARKING STALL CONDITIONS @ ∠90° VARY IN LENGTHS.

R/W IS ASSUMED. VERIFY FOR ACTUAL LOCATION.

LEGEND

- EXTG. CURB
- ASSUMED R/W LINE
- EXTG. CONCRETE PATH
- EXTG. PARKING STRIPING

EXTG. YMCA PARKING LOT PLAN
SCALE: 1" = 20' 0"

DO NOT SCALE THIS DRAWING FOLLOW DIMENSIONS. INDICATED SCALES CORRECT ONLY FOR FULL SIZE SHEET (22"X34")

△	DATE	REVISION	BY

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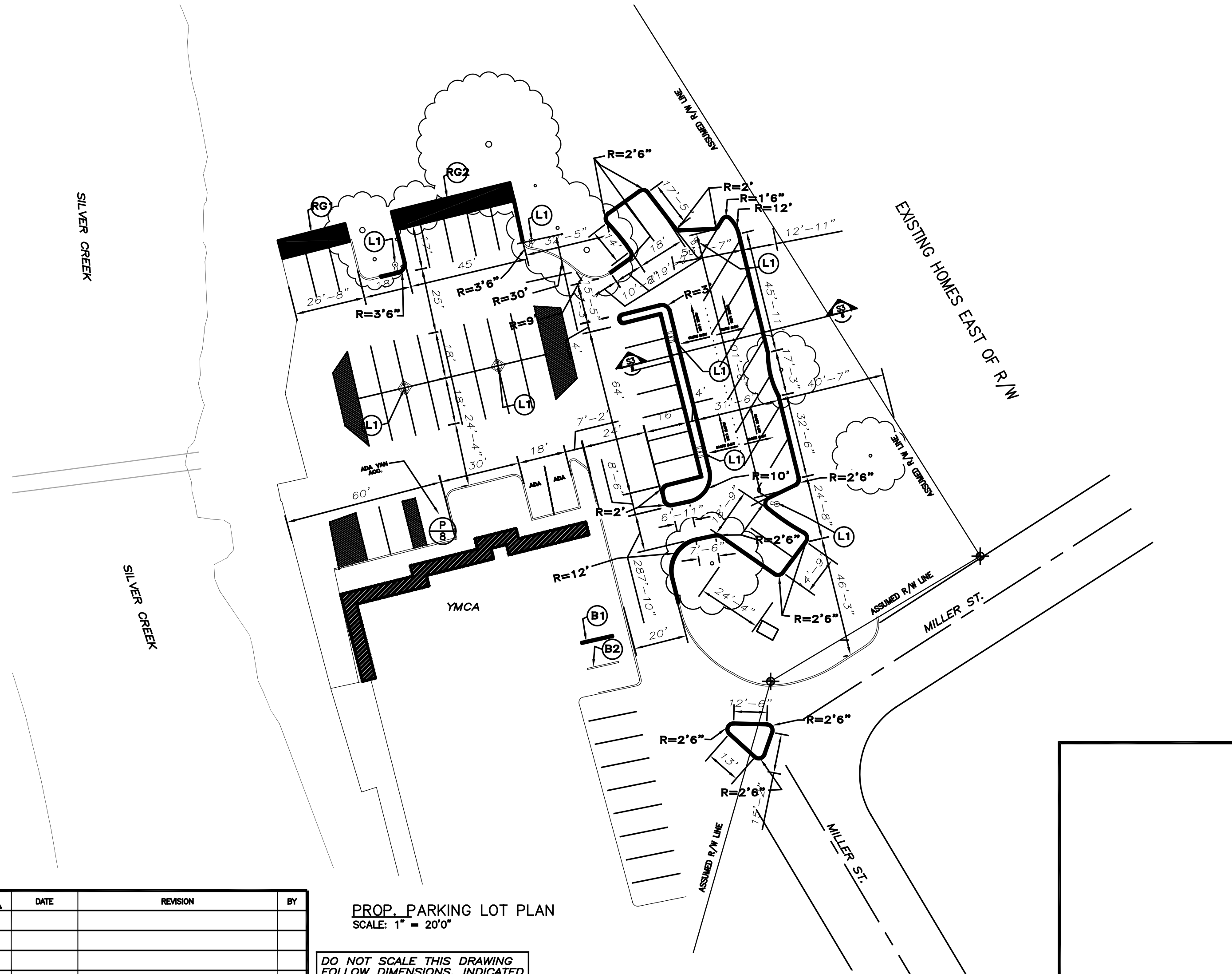
2020.SILV.01

EXISTING PARKING LOT PLAN VIEW

SHEET NO. 3/10

PLAN_SHEETS_2.DWG

PLOT DATE: 5/23/2020 PLOT TIME: 9:11 PM USER: GREYES



PROP. PARKING LOT PLAN
SCALE: 1" = 20'0"

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△	DATE	REVISION	BY

PLAN_SHEETS_2.DWG

PLOT DATE: 5/23/2020 PLOT TIME: 9:20 PM USER: GREYES

N

20' 10' 0' 20' 40'
SCALE: 1" = 20'

PARKING

57 PARKING SPACES OVERALL
45 EXISTING PARKING SPACES
12 PROPOSED PARKING SPACES

(SEE DETAIL SHEET 9 FOR PROP. PARKING SPACE DIMENSIONS).

LEGEND

DETAIL	CALLOUT	DESCRIPTION
F1/8	L1	LIGHT POLE FOUNDATION DETAIL PG. 8.
RG/7	RG1	INSTALL 6'X25'RAIN GARDEN PER DETAIL PG. 8
RG/7	RG2	INSTALL 6'X45'RAIN GARDEN PER DETAIL PG. 8
	B1	EXISTING BIKE RACK
	B2	PROPOSED BIKE RACK
		PROPOSED CURB
		PROPOSED PARKING SPACE STRIPING
		EXTG. CURB
		ASSUMED R/W LINE
		ASPHALT CROWN

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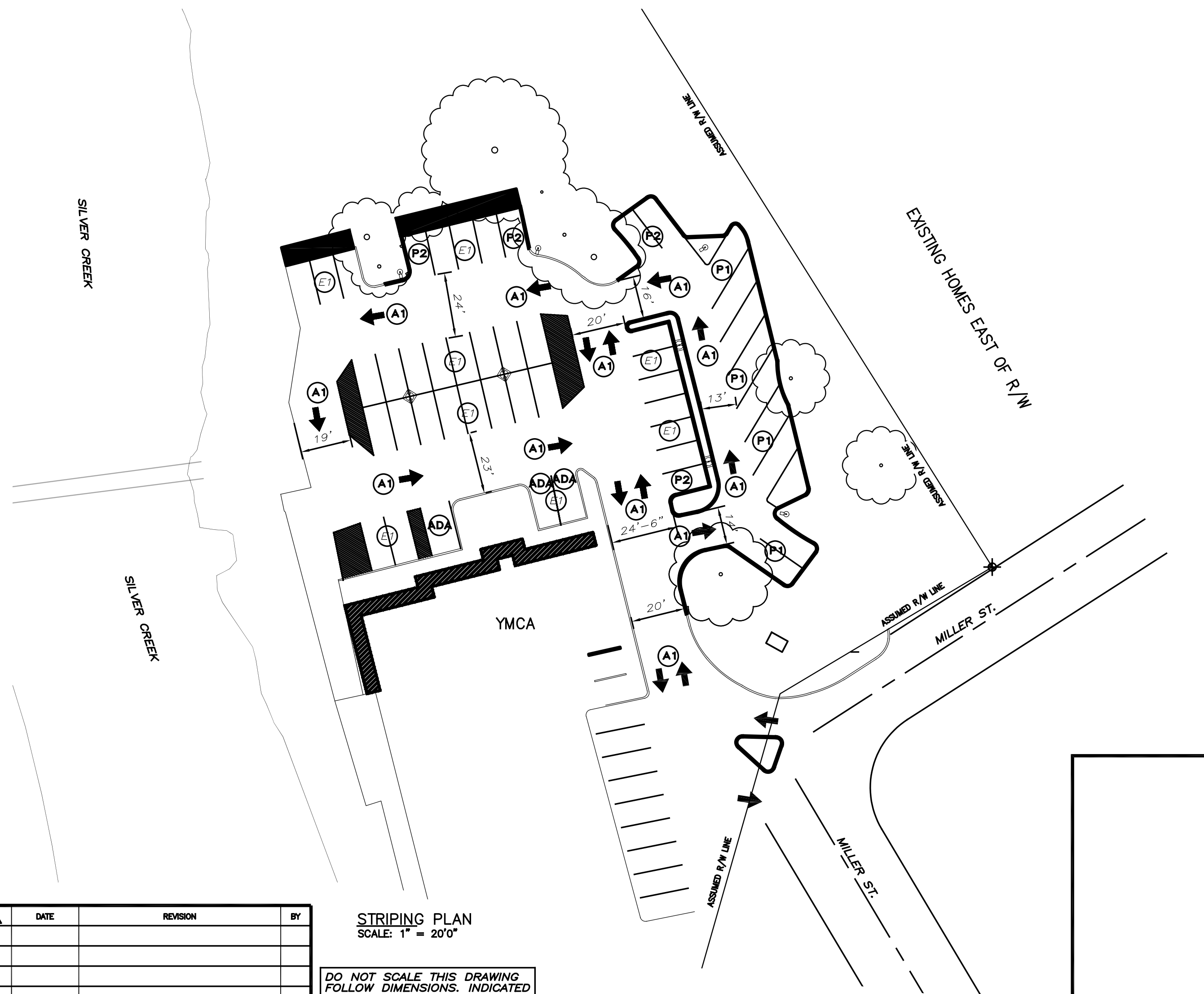
PROPOSED PARKING LOT EXPANSION

SHEET NO. 5/10



STRIPING PLAN
SCALE: 1" = 20'0"

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N

20' 10' 0' 20' 40'
SCALE:1" = 20'

PARKING
.
57 PARKING SPACES OVERALL
45 EXISTING PARKING SPACES
12 PROPOSED PARKING SPACES

(SEE DETAIL SHEET 9 FOR PROP. PARKING SPACE DIMENSIONS).

LEGEND

DETAIL	CALLOUT	DESCRIPTION
	E1	EXTG. PARKING SPACE STRIPES 90° ANGLE
P2/8	P1	PROPOSED PARKING SPACE STRIPES 45° DIAGONAL
	P2	PROPOSED PARKING SPACE STRIPES 90° ANGLE
	A1	PROPOSED PARKING TRAFFIC DIRECTIONAL ARROWS
P/8	ADA	ADA PROP. PARKING SPACE
	(thick line)	PROPOSED CURB
	(line)	PROPOSED PARKING SPACE STRIPING
	(thin line)	EXTG. CURB
	(line)	ASSUMED R/W LINE

△	DATE	REVISION	BY

PLAN_SHEETS_2.DWG

PLOT DATE: 5/23/2020 PLOT TIME: 9:25 PM USER: GREYES

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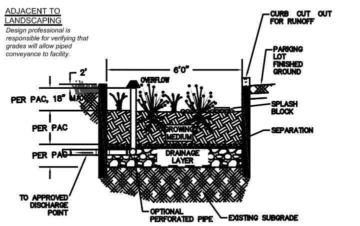
PROPOSED PARKING LOT STRIPING PLAN

SHEET NO. 6/10

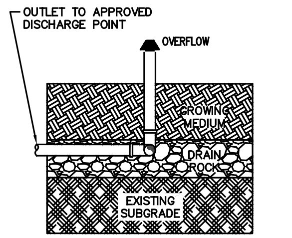
RAIN GARDEN DETAILS



1. Detail intended as an example. Detail must match PAC assumptions and/or design report.
2. Provide protection from all vehicle traffic, equipment staging, and foot traffic in proposed infiltration areas prior to, during, and after construction.
3. Dimensions:
   Width of planter: 24" minimum.
   Depth of planter (from top of growing medium to overflow elevation): per PAC calculations.
   Longitudinal slope of planter: 0.5% or less.
4. Setbacks:
   Planters must be 5-feet from property line and 10-feet from building foundations.
5. Planter Walls:
   Material must be concrete, unless otherwise approved.
6. Piping must be ABS Sch.40, cast iron, or PVS Sch.40. 3" pipe required for facilities draining up to 1500 s.f., otherwise 4" min. pipe. Piping must have 1% grade and follow the Uniform Plumbing Code.
7. Drain Layer:
   Per PAC calculations. Options include, but are not limited to drain mat, 3/4" washed rock, or other approved system.

   Separation between drain and growing medium:
   Use appropriate filter fabric or a gravel lens (3/4 – 1/4 inch washed, crushed rock 2 to 3 inches deep), or as per approved design.
8. Overflow:
   Inlet elevation must allow for 2" of freeboard, minimum.
   Protect from debris and sediment with strainer or grate.
9. Growing Medium:
   Use sand/loam/compost 3-way mix, or approved mix that will support healthy plants. 18" minimum depth if there is a drainage layer. If soils are well draining and there is not a drainage layer depth may be reduced as approved.
10. Vegetation: Refer to plant list in SWMM, Section 2.4.1. Minimum container size is #1 container. # of plantings per 100sf of facility area:
    80 herbaceous plants OR;
    72 herbaceous plants and 4 small shrubs.
11. Splash Block: Install 4-6" washed river rock or splash pad for erosion control at inlets and downspout.

RAIN GARDEN DETAIL RG/4
SCALE: 1 = 30



PARTIAL INFILTRATION

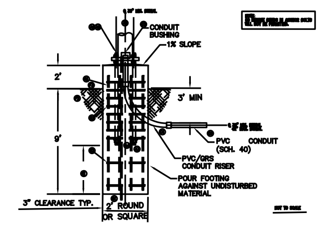
STORMWATER HIERARCHY CATEGORY 3 or 4

OVERFLOW AND UNDERDRAIN REQUIRED. SET UNDERDRAIN WITHIN DRAIN ROCK.
PAC CONFIGURATION C

NOTE: Hybrid facilities must be registered as a UIC designed under the presumptive approach.

PARTIAL INFILTRATION DETAIL RG/4
SCALE: 1 = 30

LIGHT POLE FOUNDATION PIER DETAIL



ANCHOR BOLTS:

A1 – (4) ASTM F1554 GR 36ANCHOR BOLTS PER SPECIFICATIONS
A2 – BOLT CIRCLE DIAMETER TO MATCH POLE BASEPLATE
A3 – ANCHOR BOLTS SHALL HAVE HEADS, OR NUTS WITH THE THREADS STAKED AT TWO PLACES BELOW THE NUT, EMBEDDED IN FOUNDATION
A4 – ANCHOR BOLTS SHALL BE 1" DIAMETER, 36" LONG WITH 33" EMBEDMENT IN CONCRETE.
A5 – BOLT PROJECTION AS RECOMMENDED BY THE MANUFACTURER.

CONDUIT:

C1 – CONDUIT SHALL BE RGS IN CONCRETE WITH 6" MIN. STUB-OUT
C2 – SERVICE AND FEED CONDUITS SHALL BE RGS OR PVC. AS REQUIRED.
C3 – STUB UP TO WITHIN 4" FROM HAND HOLE.

GROUND ROD:

G1 – GROUND OD SHALL BE MIN. 0.625" X 8FT LONG COOPER CLAD.

FOUNDATION:

F1 – THERE SHALL BE A MIN. OF 17" FOUNDATION BELOW THE ANCHOR BOLT HEADS.
F2 – THE FOUNDATION SHALL CURE A MIN. OF FOURTEEN(14) DAYS PRIOR TO POLE INSTALLATION OR TORQUING OF THE ANCHOR BOLTS.
F3– FILL SPACE BETWEEN TOP OF FOUNDATION AND THE LEVEL OF FINISHED GROUND WITH SAND AND CONCRETE AFTER FINAL POLE RAKING, ATTACHING GROUND CONNECTION TO THE POLE.

REINFORCEMENT:

R1 – VERTICAL REBAR SHALL BE 7-#6 EQUALLY SPACED INSIDE OF HOOPS.
R2– HOOPS SHALL BE #4 X 18" O.D., SPACED 4" O/C FROM TOP OF FOUNDATION TO END OF ANCHOR BOLTS.
R3 – HOOPS SHALL BE #4 X 18" O.D., SPACED 12" MIN. FROM THE ANCHOR BOLTS TO BOTTOM OF THE FOUNDATION.

POLE FOUNDATION DETAIL F3/4
NOT TO SCALE

Δ	DATE	REVISION	BY

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2020.SILV.01

RAIN GARDEN AND LIGHT POLE FOUNDATION DETAIL SHEET 1

SHEET NO. 7/10

PLAN_SHEETS_2.DWG

PLOT DATE: 5/23/2020 PLOT TIME: 9:24 PM USER: GREYES

PARKING SPACE STANDARDS PER SILVERTON CHAP 3

Table 3.3.300.F – Parking Area Layout

	PARKING ANGLE ∢°	CURB LENGTH	STALL DEPTH SINGLE D1	STALL DEPTH DOUBLE D2	AISLE WIDTH ONE WAY A1	AISLE WIDTH TWO WAY A2	BAY WIDTH ONE WAY B1	BAY WIDTH TWO WAY B2	STRIPE LENGTH
Standard Space (See Figure 3.3.300.F(2) for ADA space requirements)	90° Compact	9 ft. 8 ft.	18 ft. 16 ft.	36 ft. 32 ft.	23 ft. 23 ft.	23 ft. 23 ft.	59 ft. 55 ft.	59 ft. 55 ft.	18 ft. 16 ft.
	60°	10 ft.	20 ft.	40 ft.	17 ft.	18 ft.	57 ft.	58 ft.	23 ft.
	45°	12 ft.	18 ft. 6 in.	37 ft.	13 ft.	18 ft.	50 ft.	55 ft.	26 ft. 6 in.
	30°	17 ft.	16 ft. 6 in.	33 ft.	12 ft.	18 ft.	45 ft.	51 ft.	32 ft. 8 in.
	0°	22 ft.	8 ft.	16 ft.	12 ft.	18 ft.	28 ft.	34 ft.	8 ft.

Important cross-references: See also Article 2: Land Use (Zoning) Districts, for parking location requirements for some multifamily and commercial land uses; Chapter 3.1 SDC, Access and Circulation, for driveway standards; and Chapter 3.2 SDC, Landscaping, Street Trees, Fences and Walls.

Figure 3.3.300.F(1) – Parking Area Layout

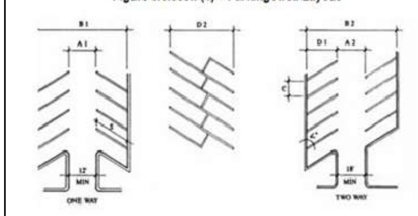
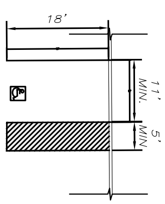


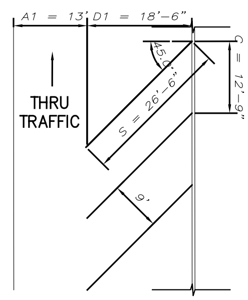
Figure 3.3.300.F(2) Disabled Person Parking Requirements

ADA VAN PARKING SPACE PROPOSED.



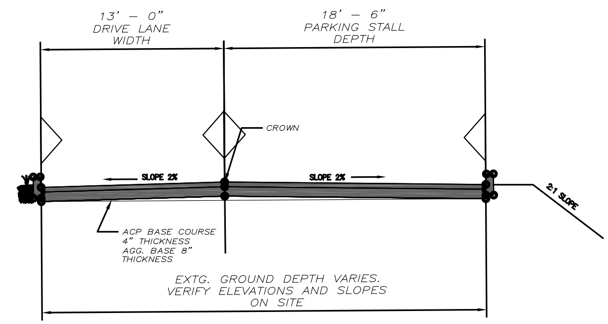
ADA PROP. PARKING STALL (P/4)
SCALE: 1" = 5'-0"

DIAGONAL PROPOSED PARKING SPACES



DIAGONAL PARKING DIMENSIONS DETAIL (P2/4)
SCALE: 1" = 5'-0"

ROAD SECTION AT PARKING LOT ADDITION



DETAIL (S3/4)
SCALE: 1" = 4'-0"

NOTE:

1. SIDE SLOPES ARE SHOWN AS VERT. TO HORIZ.
2. SEE PLANS FOR DIMENSIONS
3. TOP AS PAVEMENT THICKNESS OF 4"
4. AGG. BASE THICKNESS OF 8"
5. AGG. BASE SHOULD BE COMPACTED TO A MIN. OF PERCENT OF THE MDD AS DETERMINED BY ASSHTO T-180 OR ASTM D 1557 (MODIFIED PROCTOR).

△	DATE	REVISION	BY

DO NOT SCALE THIS DRAWING FOLLOW DIMENSIONS. INDICATED SCALES CORRECT ONLY FOR FULL SIZE SHEET (22"X34")

Maseeh College of Engineering and Computer Science
PORTLAND STATE UNIVERSITY

DRAFTER: GRR CHECKER:
DESIGNER: REVIEWER:

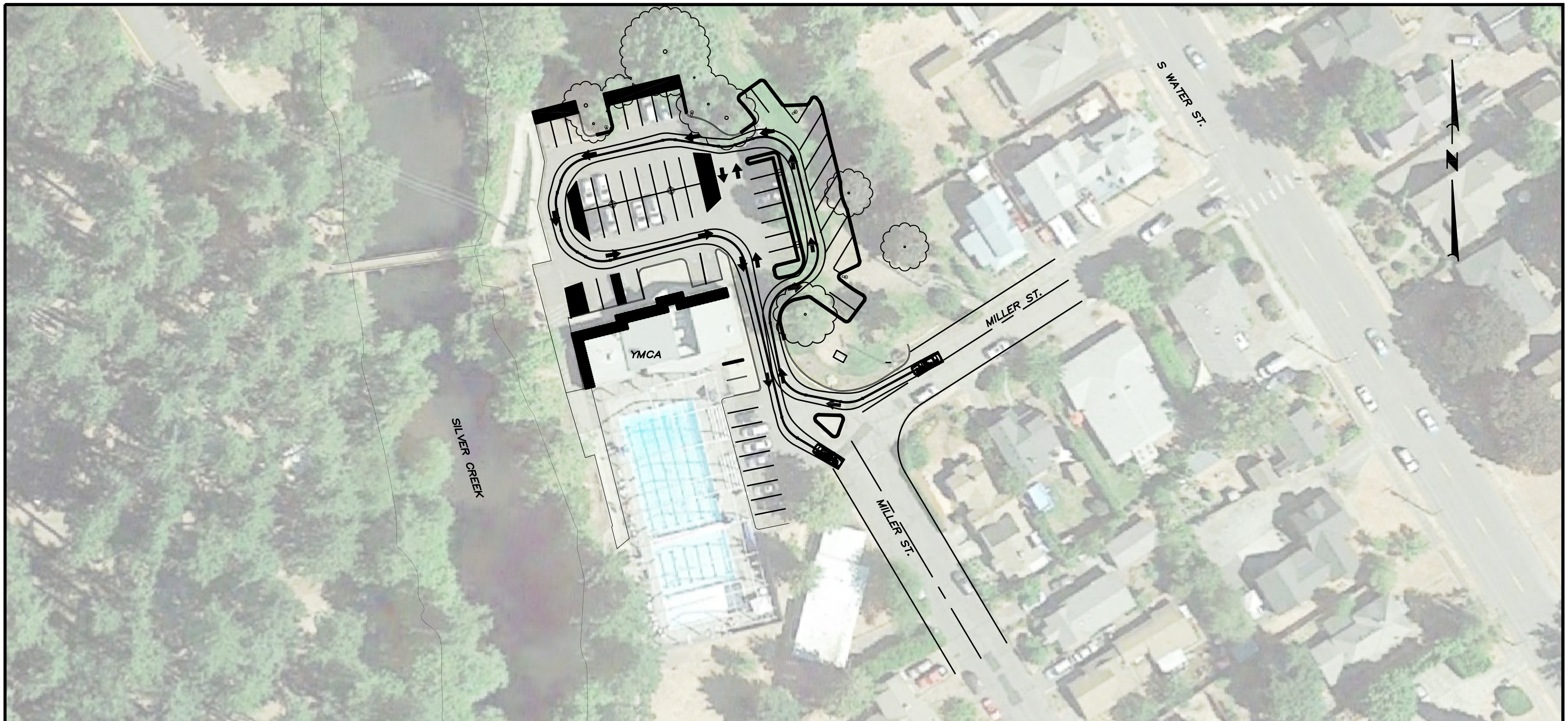
STORMWATER IMPROVEMENTS
2020.SILV.01

PARKING STALL DIMENSIONS AND ROAD SECTION DETAIL SHEET 2

SHEET NO. 8/10

PLAN_SHEETS_2.DWG

PLOT DATE: 5/23/2020 PLOT TIME: 9:26 PM USER: GREYES



LEGEND

- EXISTING CURB
- ASSUMED R/W
- PROP. TURNING TRAGECTORY
- PROP. CURB
- PROP. PARKING STALLS

△	DATE	REVISION	BY

DO NOT SCALE THIS DRAWING FOLLOW DIMENSIONS. INDICATED SCALES CORRECT ONLY FOR FULL SIZE SHEET (22"X34")

PLAN_SHEETS_2.DWG

PLOT DATE: 5/23/2020 PLOT TIME: 9:34 PM USER: GREYES

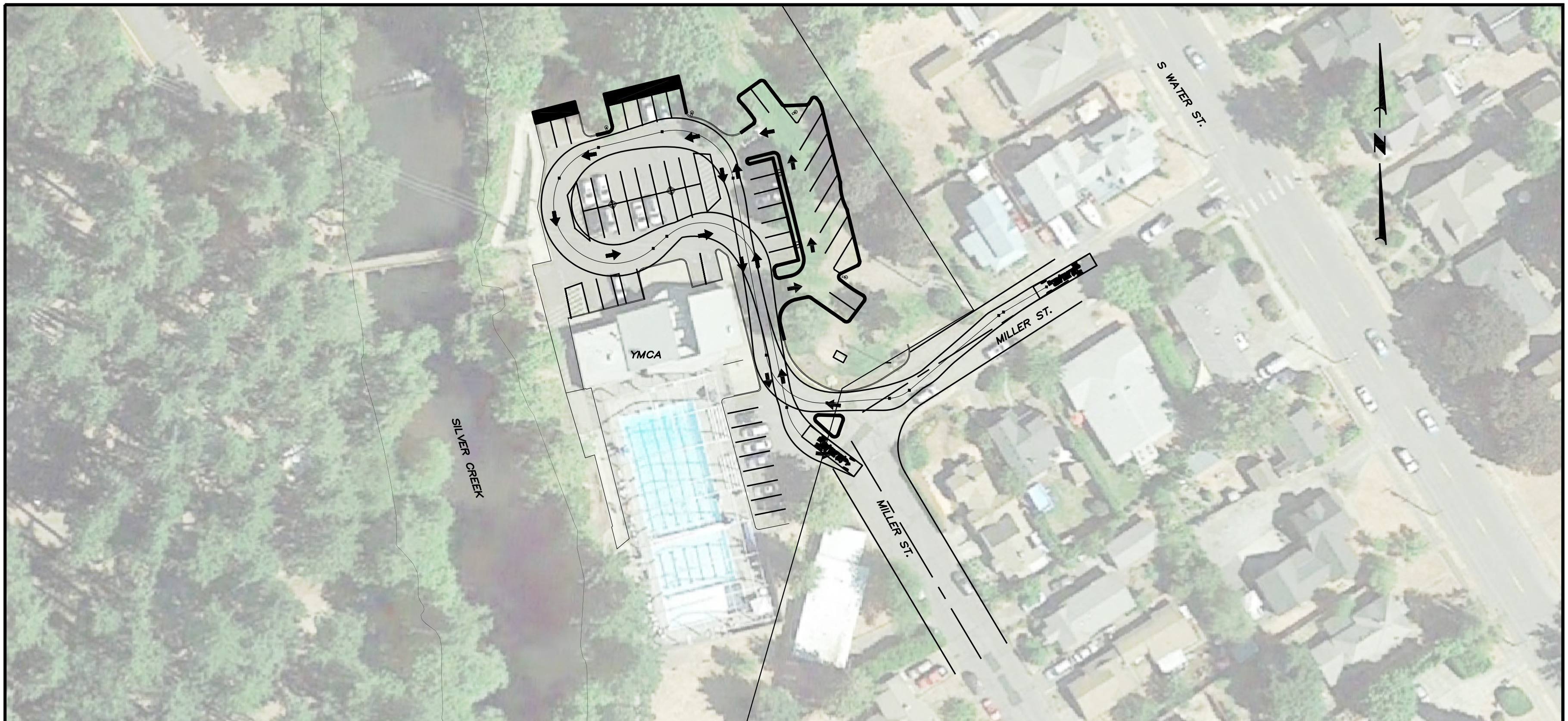
Maseeh College of Engineering and Computer Science
PORTLAND STATE UNIVERSITY

DRAFTER: GRR CHECKER:
DESIGNER: REVIEWER:

STORMWATER IMPROVEMENTS
2020.SILV.01

PASSENGER VEHICLE TURNING DIAGRAM

SHEET NO. 9/10



LEGEND

- EXISTING CURB
- ASSUMED R/W
- PROP. TURNING TRAGECTORY
- PROP. CURB
- PROP. PARKING STALLS

△	DATE	REVISION	BY

DO NOT SCALE THIS DRAWING
FOLLOW DIMENSIONS. INDICATED
SCALES CORRECT ONLY FOR
FULL SIZE SHEET (22"X34")

Maseeh College of Engineering and Computer Science
PORTLAND STATE UNIVERSITY

DRAFTER: GRR CHECKER:
DESIGNER: REVIEWER:

STORMWATER IMPROVEMENTS
2020.SILV.01

EMERGENCY VEHICLE
TURNING DIAGRAM

SHEET NO. 10/10

PLAN_SHEETS_2.DWG
PLOT DATE: 5/23/2020 PLOT TIME: 9:33 PM USER: GREYES

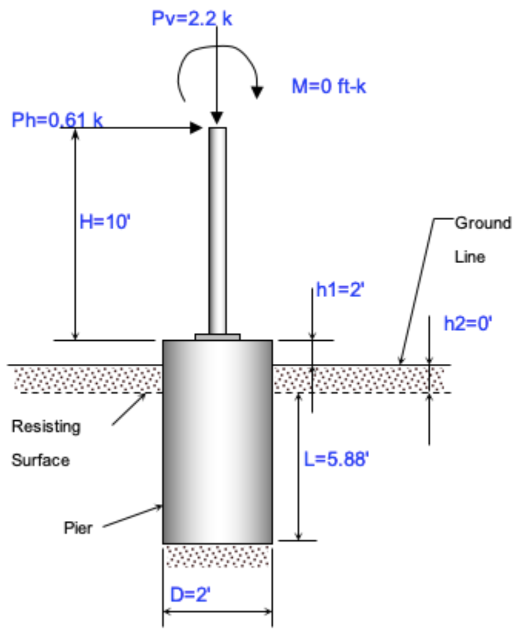
Appendix D

Calculations

D. Calculation

D.1 Light Pole Foundation Calculations
D.2 Infiltration Planter Analysis
D.3 Planter Wall Bearing Capacity Calculations.

POLE FOUNDATION ANALYSIS
For free-Top (unconstrained) Rigid Round Piers Using IBC Code Method
Subjected to Vertical Load, Horizontal Load, and/or Moment.



Nomenclature

Table A1. IBC 2012 - Presumptive Load Bearing Values

Class of Materials	Vertical Foundation Pressure (ksf)	Lateral Bearing Pressure (below natural grade) (ksf/ft.)
1. Crystalline bedrock	12.000	1.200
2. Sedimentary and foliated rock	4.000	0.400
3. Sandy gravel and/or gravel	3.000	0.200
4. Sand, silty sand, clayey sand, silty gravel and clayey gravel	2.000	0.150
5. Clay, sandy clay, silty clay, clayey silt, silt and sandy silt	1.500	0.100

Table A.2 PBOT Standard Street Light Pole Footing (Standard Drawing P-660) - Presumptive Values

Description	Value
1. Friction Angle f	26º
2. Effective Unit Weight	110 pcf

Table A.3 (AASHTO 2001) Wind Pressure

$$Pz = 0.00256(1.3V_{fm})^2 C_d C_h$$

Description

Fastest-mile wind speed	V_{fm}	120mph
Drag coefficient	Cd	1
Coefficient for height above ground	Ch	0.5
Design wind Pressure	Pz or Ph	608 psf

Input Data:

Pier Data:

Pier Foundation Diameter, D =	2.000	ft.
Pier Height Above Soil, h1 =	2.000	ft.

Soil Data:

Unit Weight of Soil, g =	0.120	kcf
Angle of Internal Friction, f =	26.00	deg.
- Depth to Resisting Surface, h2 =	0.000	ft.
Allow. Vert. Bearing Pressure, Pa =	3.000	ksf

Pier Loadings:

Axial Load, Pv =	2.200	kips
Horizontal Load, Ph =	0.610	kips
Distance from Ph to Top/Pier, H =	10.000	ft.
Externally Applied Moment, M =	0.000	ft-kips

Results:

Pier Embedment and Total Length:

Pe =	0.610	kips	Pe = Ph+(M/(H+h1+h2)) ("equivalent total" horizontal load)
Pba =	0.200	ksf	Pba = allowable lateral bearing pressure/ft. below grade (Table 1806.2)
S1 =	0.392	ksf	S1 = Pba*L/3 (allowable lateral soil pressure at 1/3 embedment depth)
A =	1.822		A = 2.34*Pe/(S1*D)
L =	5.88	ft.	L = 0.5*A*(1+SQRT(1+(4.36*(H+h1+h2)/A))) (IBC 2012 Eqn. 18.1)
Lt =	7.88	ft.	Lt = h1+h2+L (total length)

Pier End Bearing Pressure:

Af =	3.14	ft.^2	Af = p*D^2/4 (pier base area)	
Wf =	3.71	kips	Wf = (Af*Lt)*0.150 (pier weight)	
SPv =	5.91	kips	SPv = Pv+Wf (total vertical load)	
P(bot) =	1.882	ksf	P(bot) = SPv/Af	**Pa>=P(bot), O.K.**

Reference: 2012 International Building Code (IBC), Section 1807.3.2.1, pages 403-404

Infiltration Planter Analysis for size and infiltration capacity for a 2, 10- and 15-year storm event. Presumptive Approach Calculator (PAC) Data Sheets.

Designer's Statement

The Silverton Stormwater improvement infiltration Planter Analysis was prepared by Abraham Salazar, meeting City of Silverton minimum Standards and normal Engineering standards.

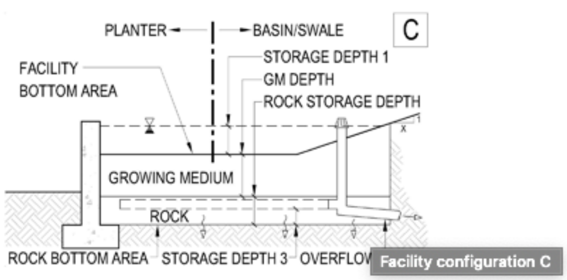
Project Name:	2020.SILV.01
Project Address:	421 S Water St Silverton, OR 97381
Designer:	Abraham Salazar
Last Modified:	5/20/20 1:27 PM
Company:	Portland State University
Report Generated:	5/20/20 1:27 PM
Catchment ID:	Infiltration Planter

PAC

Facility Details

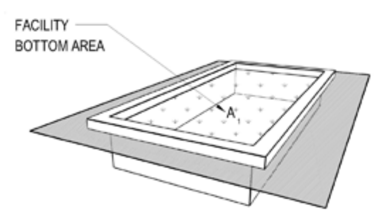
Facility Type Planter (Flat)

Facility Configuration C: Infl. with RS and underdrain (Ud)



Catchment ID:	1
Catchment Name:	Infiltration Planter
Catchment Impervious Area:	14,000 sq ft
Hierarchy Category:	3
Hierarchy Description:	Off-site flow to drainageway, river, or storm-only pipe system

Facility Shape



Results

Pollution Reduction

PASS

Overflow Volume	
Surface Capacity Used	**10%**
Rock Capacity Used	**0%**

Flow Control

PASS

	POST-DEVELOPMENT OUTFLOW (CFS)		PRE-DEVELOPMENT INFLOW (CFS)
2 year	0.077	≤ ½ of	0.198
5 year	0.216	≤	0.241
10 year	0.26	≤	0.285
25 year	0.303	≤	0.328

Project Summary

Infiltration garden for YMCA storm water improvements

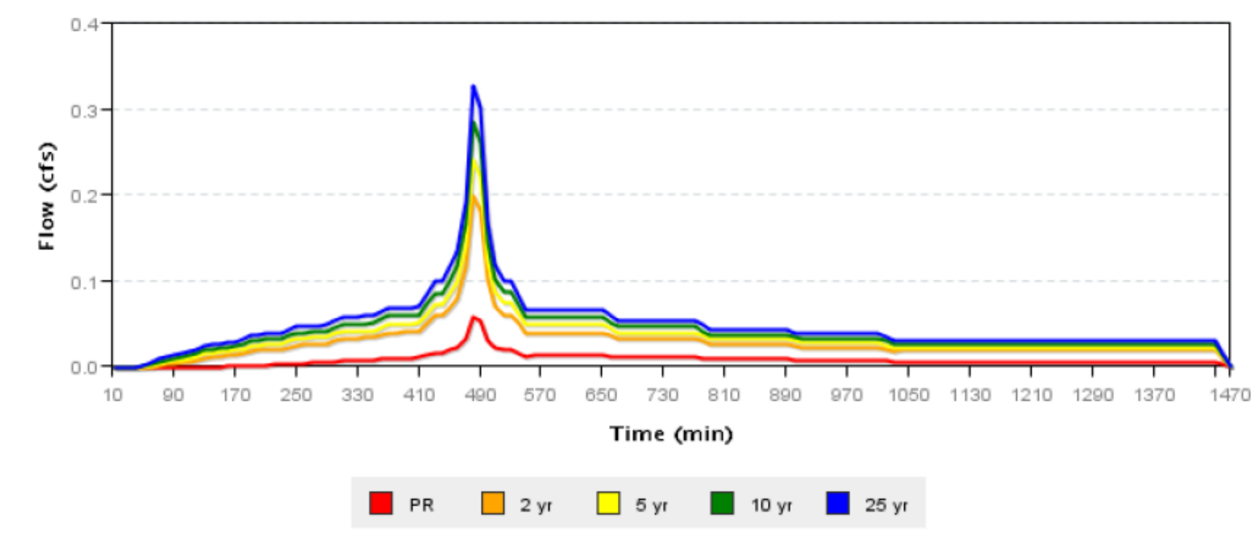
Catchment Name	Impervious Area (sq ft)	Native Soil Design Infiltration Rate	Hierarchy Category	Facility Type	Facility Config	Facility Size (sq ft)	Facility Sizing Ratio	PR Results	Flow Control Results
Infiltration Planter	14000	5.00	3	Planter (Flat)	C	543	3.9%	Pass	Pass

Catchment Infiltration Planter

Site Soils & Infiltration Testing Data	Infiltration Testing Procedure	**Open Pit Falling Head**
	Native Soil Infiltration Rate (I_{test})	**5.00**
Correction Factor	CF_{test}	**2**
Design Infiltration Rates	Native Soil (I_{dsgn})	**2.50 in/hr**
	Imported Growing Medium	**2.00 in/hr**
Catchment Information	Hierarchy Category	**3**
	Disposal Point	**B**
	Hierarchy Description	**Off-site flow to drainageway, river, or storm-only pipe system**
	Pollution Reduction Requirement	**Pass**
	10-year Storm Requirement	**N/A**

	Flow Control Requirement	**If discharging to an overland drainage system or to a storm sewer that discharges to an overland drainage system, including streams, drainageways, and ditches, the 2-year post-development peak flow must be equal or less than half of the 2-year pre-development rate and the 5, 10, and 25-year post-development peak rate must be equal or less than the pre-development rates for the corresponding design storms.**
	Impervious Area	**14000 sq ft 0.321 acre**
	Time of Concentration (Tc)	**5**
	Pre-Development Curve Number (CN_{pre})	**98**
	Post-Development Curve Number (CN_{post})	**98**

SBUH Results



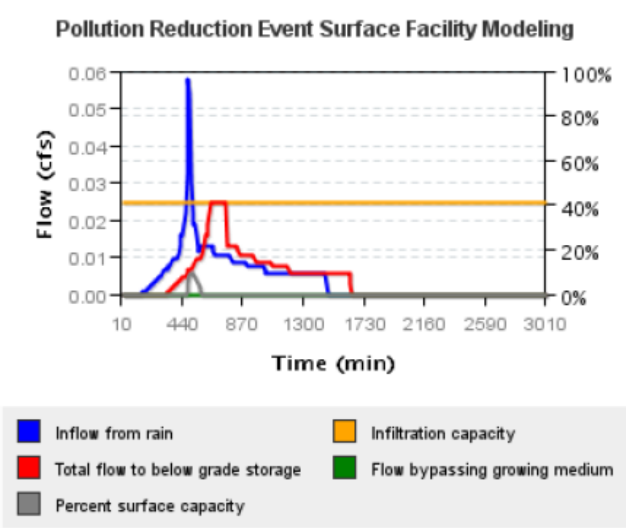
	Pre-Development Rate and Volume		Post-Development Rate and Volume	
	Peak Rate (cfs)	**Volume (cf)**	**Peak Rate (cfs)**	**Volume (cf)**
PR	0.058	731.539	0.058	731.539
2 yr	0.198	2533.242	0.198	2533.242
5 yr	0.241	3113.481	0.241	3113.481
10 yr	0.285	3694.589	0.285	3694.589
25 yr	0.328	4276.244	0.328	4276.244

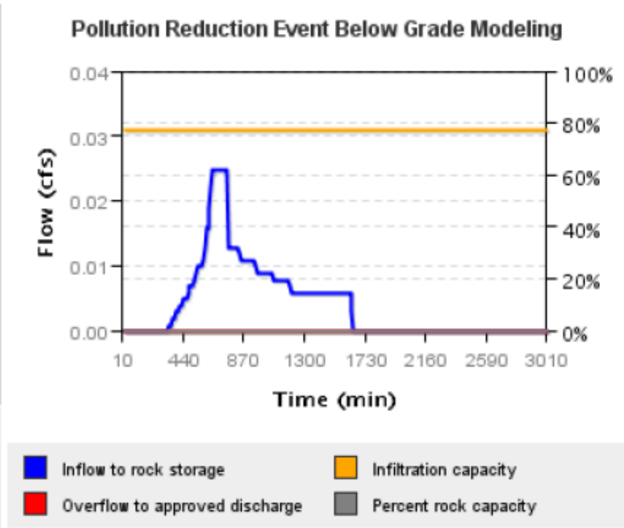
Facility Infiltration Planter

Facility Details	Facility Type	**Planter (Flat)**
	Facility Configuration	**C: Infl. with RS and underdrain (Ud)**
	Facility Shape	**Planter**
	Above Grade Storage Data	
	Bottom Area	**543 sq ft**
	Bottom Width	**6.00 ft**
	Storage Depth 1	**10.0 in**
	Growing Medium Depth	**18 in**
	Surface Capacity at Depth 1	**452.5 cu ft**
	Design Infiltration Rate for Native Soil	**0.031 in/hr**
	Infiltration Capacity	**0.025 cfs**
	Below Grade Storage Data	
	Rock Storage Depth	**18 in**
	Rock Porosity	**0.38 in**
	Storage Depth 3	**15.0 in**

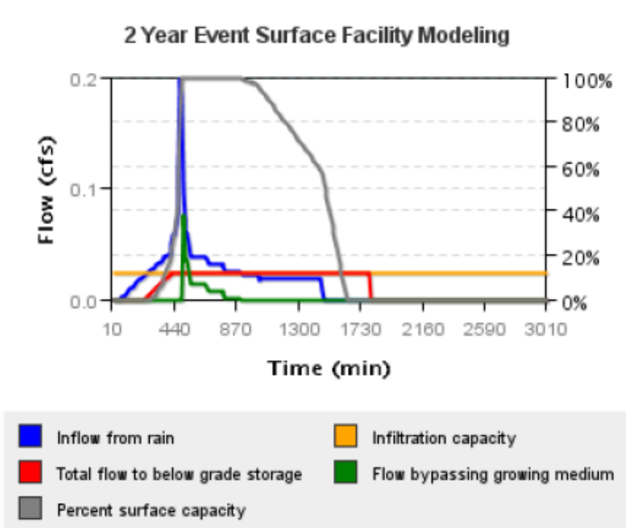
Facility Facts	Total Facility Area Including Freeboard	**543.00 sq ft**
	Sizing Ratio	**3.9%**
Pollution Reduction Results	Pollution Reduction Score	**Pass**
	Overflow Volume	**0.000 cf**
	Surface Capacity Used	**10%**
	Rock Capacity Used	**0%**
Flow Control Results	Flow Control Score	**Pass**
	Overflow Volume	**1219.882 cf**
	Surface Capacity Used	**100%**
	Rock Capacity Used	**0%**

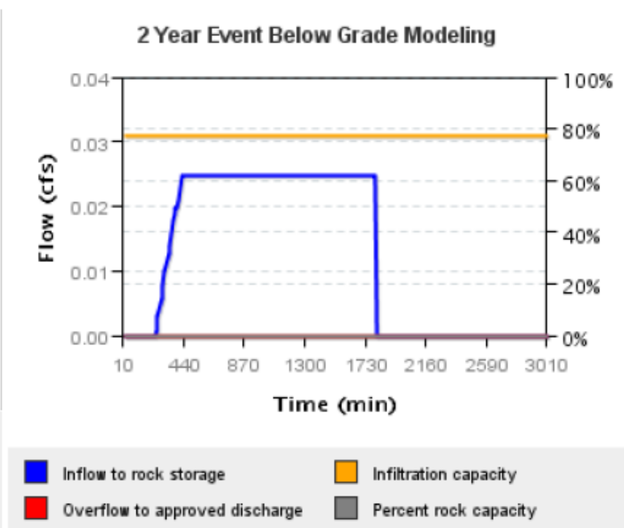
	Post-development outflow (cfs)		**Pre-development inflow (cfs)**	
2 year	0.077	≤ ½ of	0.198	**Pass**
5 year	0.216	≤	0.241	**Pass**
10 year	0.26	≤	0.285	**Pass**

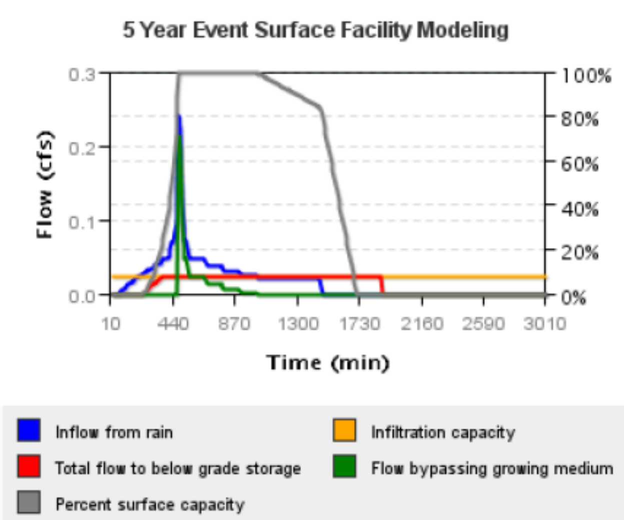


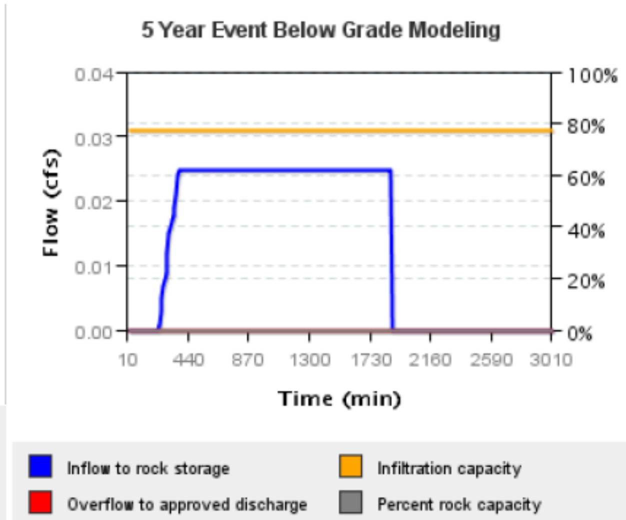


25 year	0.303	≤	0.328	**Pass**






5 Year Event Surface Facility Modeling
Flow (cfs)
0.3
0.2
0.1
0.0
100%
80%
60%
40%
20%
0%
10
440
870
1300
1730
2160
2590
3010
Time (min)
Inflow from rain
Infiltration capacity
Total flow to below grade storage
Flow bypassing growing medium
Percent surface capacity


5 Year Event Below Grade Modeling
Flow (cfs)
0.04
0.03
0.02
0.01
0.00
100%
80%
60%
40%
20%
0%
10
440
870
1300
1730
2160
2590
3010
Time (min)
Inflow to rock storage
Infiltration capacity
Overflow to approved discharge
Percent rock capacity

Analysis for Infiltration Planter Wall Design

Minimum footing width (B) was found and checked to satisfy requirements for design using Rankine's Theory for earth pressure coefficients.

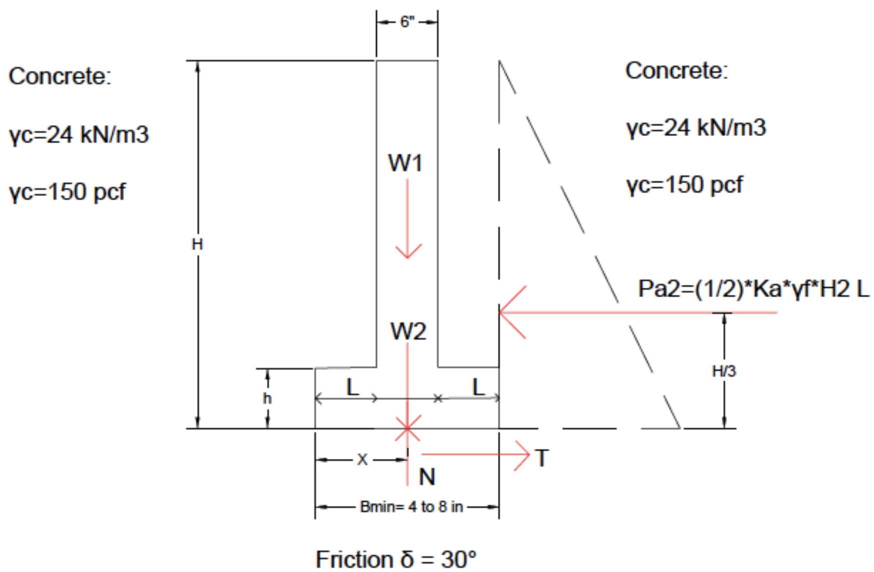


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Figure D.1 Planter wall

	Trial 1	Trial 2	Trial 3
Assumed B (in) =	4	6	8
Assumed B (m) =	0.1016	0.1524	0.2032
L (in) =	0	1	2
L (m) =	0	0.0254	0.0508
Wall height, h (ft) =	3.5	3.5	3.5
Wall height, h (m) =	0.97	0.97	0.97
γ_f (kN/m3) =	20.0	20.0	20.0
φ'_f (deg)=	36	36	36
γ_c (kN/m3) =	24	24	24
H (ft) =	4.5	4.5	4.5
H (m) =	1.37	1.37	1.37

Rankine active coefficient (Ka) = $\tan^2(45-\varphi'/2)$

Ka =	0.26	0.26	0.26
Surcharge q (kPa) =	0	0	0
Pa1 (kN) =q*Ka*H =	0.0	0.0	0.0
Arm of Pa1 to Point A (m) =	0.0	0.0	0.0
Pa2 (kN) = (1/2)*Ka*γf*H^2 =	4.9	4.9	4.9
Arm of Pa2 to Point A (m) =	0.46	0.46	0.46
V1 (kN) =	0.0	0.5	1.0
Arm of V1 to Point A (m) =	2.5	2.5127	2.5254
V2 (kN) =	0.0	0.0	0.0
Arm of V2 to Point A (m) =	2.5	2.5127	2.5254
W1 (kN) =	11.6	11.6	11.6
Arm of W1 to Point A (m) =	2.25	2.25	2.25
W2 (kN) =	30.0	30.3	30.6
Arm of W2 to Point A (m) =	1.25	1.2627	1.2754

$\Sigma F_{horiz} = 0$ -> T = Pa1 + Pa2

T (kN) =	4.9	4.9	4.9

$\Sigma F_{vert} = 0$ -> N = V1 + V2 + W1 + W2

N (kN) =	41.6	42.4	43.2

$\Sigma M_A = 0$ -> x = (V1*arm + V2*arm + W1*arm + W2*arm - Pa1*arm - Pa2*arm)/N

x (m) =	1.48	1.50	1.51

(a) Check overturning

e (m) = B/2 - x	-1.43	-1.42	-1.41
B/6 (m) =	0.02	0.03	0.03
e ≤ B/6 (Yes/No)	Yes	Yes	Yes

(b) Check sliding

AASHTO Table 3.11.5.3-1 using mass concrete on coarse sand:

δ (deg) =	30	30	30
Tult (kN) = N*tan(δ) =	24.0	24.5	25.0
$FS_{sliding}$ = (Tult)/(Pa1+Pa2) =	4.92	5.02	5.11
$FS_{sliding}$ ≥ 1.5 (Yes/No)	Yes	Yes	Yes

(c) Check bearing

Known: q_{ult} (kPa) =	650	650	650
B' (m) = B - 2*e =	2.95	2.99	3.03
q_{avg} (kPa) = N/B' =	14.1	14.2	14.3
$FS_{bearing}$ = q_{ult}/q_{avg} =	46.08	45.81	45.54
$FS_{bearing}$ ≥ 3 (Yes/No)	Yes	Yes	Yes

Therefore, the planter walls will be ok with thickness of: 4", 6" and 8". If 6" thick is used, more concrete can be saved.

Appendix E

QC Checklist

Preparer	Checker	Checklist Item
x	x	**3.0 Facility Design**
x	x	3.1 Design Criteria
x	x	3.2 Mitigation of Increased Runoff
x	x	3.3 Mitigation of Current Runoff
x	x	3.4 Additional Problems that Arose
x	x	3.5 Construction Cost
x	x	3.6 Construction Schedule
x	x	**4.0 Regulatory Compliance and Permitting**
x	x	4.1 City of Silverton (City Design Standards)
x	x	4.2 Oregon Transportation Commission (Standards for Accessible Parking Places August 2018)
x	x	4.3 Department of Environmental Quality (DEQ)
x	x	5.0 Conclusion
x	x	References
x	x	**APPENDICES**
x	x	A: Construction Cost Estimate
x	x	B: Construction Schedule
x	x	C: Drawings
x	x	D: Calculations
x	x	E: QC Check list

Preparer	Name: Abraham S	Signature: ASR	Date: 5/30/2020

Checker	Name: Jacob E	Signature: J E	Date: 5/30/2020

Group Project	Capstone Team (2020.SILV.01)

Preparer	Checker	Checklist Item
x	x	**GENERAL**
x	x	Grammar and Spelling
x	x	Single, combined PDF
x	x	Descriptive file name
x	x	Consistent formatting
x	x	Cover Page
x	x	Project Title and ID
x	x	Team # and Name
x	x	Team Members and Names
x	x	Client Name
x	x	Relevant Figure and Description
x	x	Table of Content
x	x	All sections, subsections listed with page numbers
x	x	Appendices listed with numbers
x	x	**Executive Summary**
x	x	**1.0 PROJECT UNDERSTANDING**
x	x	1.1 Existing Site Conditions
x	x	1.2 Stake Holders
x	x	**2.0 Alternative Analysis**
x	x	2.1 Considered Alternatives
x	x	2.1.1 Alternative 1: No build
x	x	2.1.2 Alternative 2: Non-Permeable Asphalt
x	x	2.1.3 Alternative 3: Permeable Asphalt for the expanded Area
x	x	2.1.4 Alternative 4: Permeable Paver Stalls and Permeable Asphalt
x	x	2.2 Selection Criteria
x	x	2.2.1 Access
x	x	2.2.2 Safety
x	x	2.2.3 Environmental
x	x	2.2.4 Aesthetics
x	x	2.2.5 Maintenance
x	x	2.2.6 Cost

Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment 5S: PARKING LOT EAST Runoff Area=0.104 ac 100.00% Impervious Runoff Depth=3.60"
Tc=100.0 min CN=98 Runoff=0.05 cfs 0.031 af

Subcatchment 8S: Pre-Development Runoff Area=0.104 ac 0.00% Impervious Runoff Depth=1.34"
Tc=5.0 min CN=72 Runoff=0.03 cfs 0.012 af

Pond 4P: Pervious Pavement Peak Elev=-2.50' Storage=0.000 af Inflow=0.05 cfs 0.031 af
Outflow=0.05 cfs 0.031 af

Total Runoff Area = 0.208 ac Runoff Volume = 0.043 af Average Runoff Depth = 2.47"
50.00% Pervious = 0.104 ac 50.00% Impervious = 0.104 ac

Summary for Subcatchment 5S: PARKING LOT EAST

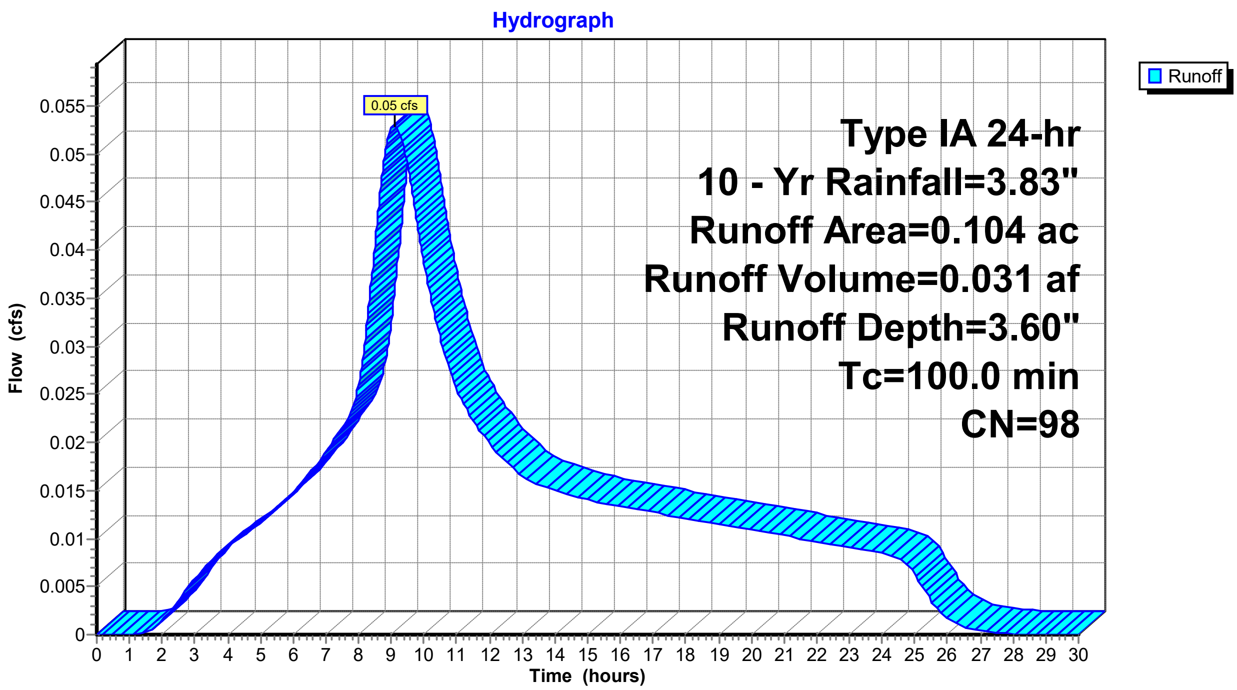
Runoff = 0.05 cfs @ 9.11 hrs, Volume= 0.031 af, Depth= 3.60"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type IA 24-hr 10 - Yr Rainfall=3.83"

	Area (ac)	CN	Description
*	0.104	98	
	0.104		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
100.0					**Direct Entry,**

Subcatchment 5S: PARKING LOT EAST



Summary for Subcatchment 8S: Pre-Development

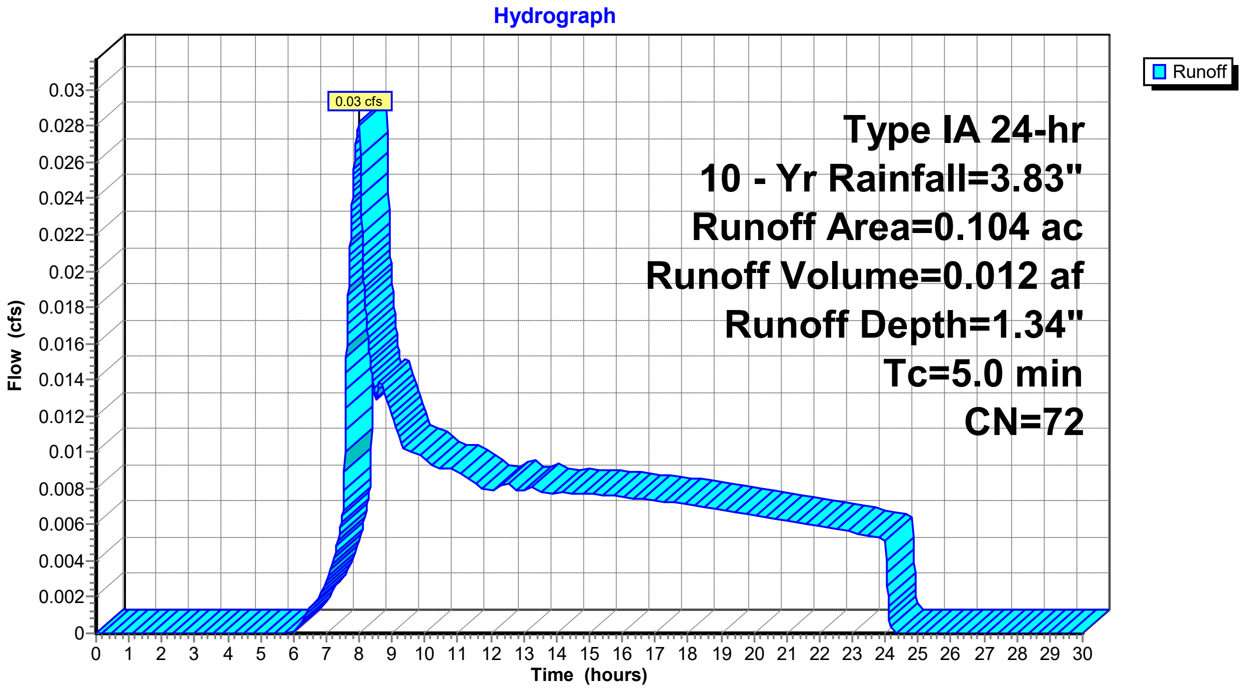
Runoff = 0.03 cfs @ 8.01 hrs, Volume= 0.012 af, Depth= 1.34"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type IA 24-hr 10 - Yr Rainfall=3.83"

	Area (ac)	CN	Description
*	0.104	72	Extg pervious, Pre-Lewis and Clark CN
	0.104		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 8S: Pre-Development



Summary for Pond 4P: Pervious Pavement

Inflow Area = 0.104 ac,100.00% Impervious, Inflow Depth = 3.60" for 10 - Yr event
Inflow = 0.05 cfs @ 9.11 hrs, Volume= 0.031 af
Outflow = 0.05 cfs @ 9.13 hrs, Volume= 0.031 af, Atten= 0%, Lag= 1.0 min
Discarded = 0.05 cfs @ 9.13 hrs, Volume= 0.031 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= -2.50' @ 9.13 hrs Surf.Area= 0.104 ac Storage= 0.000 af

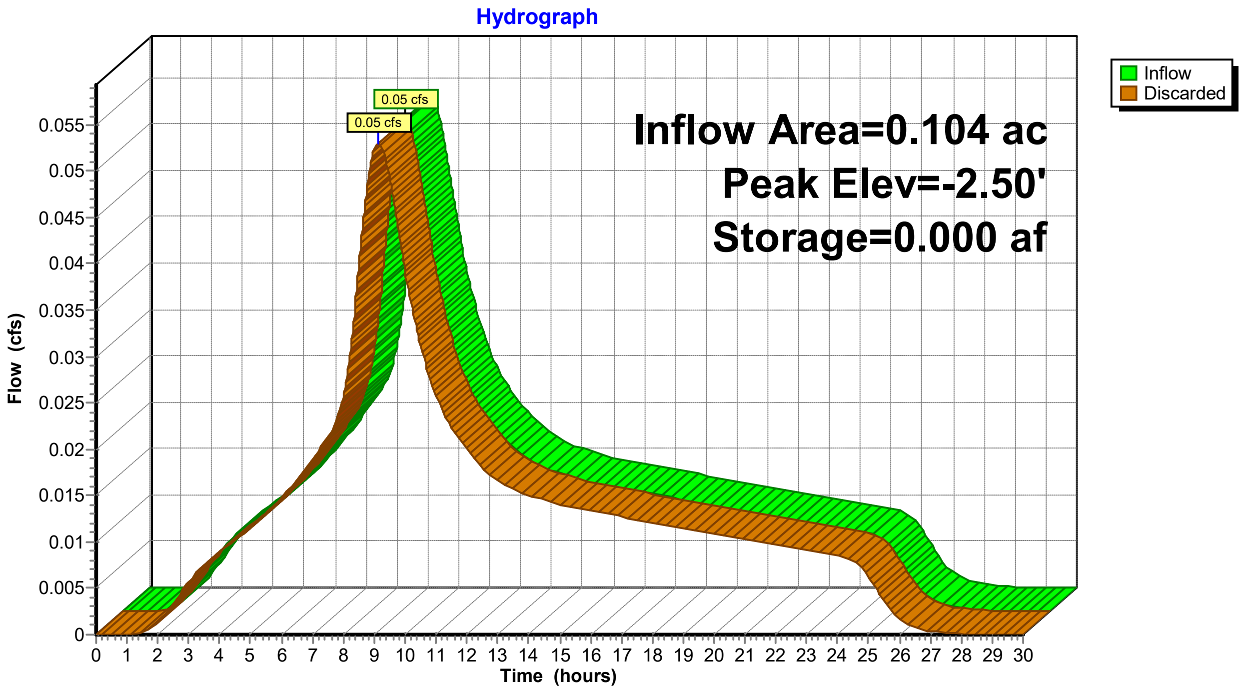
Plug-Flow detention time= 1.7 min calculated for 0.031 af (100% of inflow)
Center-of-Mass det. time= 1.7 min (749.7 - 748.0)

Volume	Invert	Avail.Storage	Storage Description
#1	-2.50'	0.062 af	**30.20'W x 150.00'L x 1.50'H Gravel Storage** 0.156 af Overall x 40.0% Voids

Device	Routing	Invert	Outlet Devices
#1	Discarded	-2.50'	**2.500 in/hr Exfiltration over Horizontal area**

Discarded OutFlow Max=0.26 cfs @ 9.13 hrs HW=-2.50' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.26 cfs)

Pond 4P: Pervious Pavement



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