



Sandy Avenue Conversion

Spring 2021
Troutdale

Evan Kristof

PSU Civil & Environmental Engineering Capstone

Spring 2021

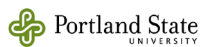
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PORTLAND STATE UNIVERSITY



Acknowledgments

Our project team would like to thank our clients, Chris Damgen and Amber Shackelford, for their help and support of our project. We would like to thank the Troutdale City Council and Citizens' Advisory Committee for providing crucial feedback to guide the project's decisions. Our team would like to thank Roger Geller from PBOT for his expertise in bicycle maneuver and traffic control. We would like to thank Nathan Jenks from BPA for his expertise in geotechnical solutions. We extend our gratitude to Dr. Avinash Unnikrishnan and Dr. Arash Khosravifar for providing us additional guidance on data collection and analysis. Lastly, we would like to thank our instructor, Evan Kristof, for providing us with the necessary tools and support to complete this project.

This report was prepared as part of a class project for the Civil and Environmental Engineering Project Management and Design course at Portland State University. The contents of this report were developed by the student authors and do not necessarily reflect the views of Portland State University. The analyses, conclusions, and recommendations contained in the report should not be construed as an engineering report or used as a substitute for professional engineering services.

This report represents original student work and recommendations prepared by students in the Sustainable City Year Program for the City of Troutdale. Text and images contained in this report may not be used without permission from the University of Oregon.

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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 City of Troutdale

Troutdale is a dynamic suburban community in Multnomah County, situated on the eastern edge of the Portland metropolitan region and the western edge of the Columbia River Gorge. Settled in the late 1800s and incorporated in 1907, this “Gateway to the Gorge” is approximately six square miles in size with a population of nearly 17,000 residents. Almost 75% of that population is aged 18-64.

Troutdale’s median household income of \$72,188 exceeds the State of Oregon’s \$59,393. Troutdale’s neighbors include Wood Village and Fairview to the west, Gresham to the south, and unincorporated areas of Multnomah County to the east.

For the first part of the 20th century, the city remained a small village serving area farmers and company workers at nearby industrial facilities. Starting around 1970, Troutdale became a bedroom community in the region, with subdivisions and spurts of multi-family residential housing occurring. In the 1990s, efforts were made to improve the aesthetics of the community’s original core, contributing to an award-winning “Main Street” infill project that helped with placemaking. In the 2010s, the City positioned itself as a jobs center as it worked with stakeholders to transform a large superfund area to one of the region’s most attractive industrial centers – the Troutdale-Reynolds Industrial Park.

The principal transportation link between Troutdale and Portland is Interstate 84. The Union Pacific Railroad main line runs just north of Troutdale’s city center. The Troutdale area is the gateway to the famous Columbia River Gorge Scenic Area and Sandy River recreational areas, and its outdoor pursuits. Troutdale’s appealing and

beautiful natural setting, miles of trails, and parkland and conservation areas draw residents and visitors alike. The City’s pride in place is manifested through its monthly gatherings and annual events, ranging from “First Friday” art walks to the city’s long-standing Summerfest celebration each July. A dedicated art scene and an exciting culinary mix have made Troutdale an enviable destination and underscore the community’s quality of life. Troutdale is home to McMenamins Edgefield, one of Portland’s beloved venues for entertainment and hospitality.

In recent years, Troutdale has developed a robust economic development program. The City’s largest employers are Amazon and FedEx Ground, although the City also has numerous local and regional businesses that highlight unique assets within the area. Troutdale’s recent business-related efforts have focused on the City’s Town Center, where 12 “opportunity sites” have been identified for infill development that respects the small-town feel while offering support to the existing retail environment. The next 20 years promise to be an exciting time for a mature community to protect what’s loved and expand opportunities that contribute to Troutdale’s pride in place.

Course Participants

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EXECUTIVE SUMMARY

SE Sandy Avenue is located in a suburban neighborhood acting as a local collector street that serves as a secondary route to navigate a steep hill. Historically, Troutdale has been attempting to create a trail connecting Gresham and Troutdale with a 40 mile loop since 1903. SE Sandy Ave has been considered a candidate for one of the trail alignments. Other initiatives such as the Sandy River Access Plan have interest in completing the 40 mile loop, and improve the accessibility of underserved communities to this unique institution.

A geotechnical study in 2018 conducted by the engineering firm Shannon & Wilson found that the hillside along SE Sandy Ave between SE 3rd Street and SE 4th Street was unstable and susceptible to landslides. There is a distressed area of pavement near the SE 4th St intersection. The cracking likely began sometime prior to 2001. Shannon & Wilson recommended some form of treatment to be completed on the hillside to prevent catastrophic damage from occurring. However, due to the hillside conditions, a geotechnical solution involving mitigation of the slope would be a high expense.

The 2021 Troutdale Sandy Ave Conversion (SAC) PSU Capstone group was tasked to propose alternative transportation and geotechnical solutions. Four transportation and three geotechnical alternatives are outlined in this report. With the City of Troutdale's input, the SAC team's alternative analysis found that a conversion to a multi-use road featuring one lane of motor vehicle traffic and a two-way cycle track would best serve the community. This solution is a balance of cost, safety, and accessibility that allows local residents vehicle access to their homes while also enhancing the safety of cyclists. Three intersections would undergo changes to accommodate the new cycle track at SE 3rd St, SE 4th St, and SE 8th St intersecting with Sandy Ave. The northbound motor vehicle travel lane would remain intact while the southbound lane would be converted into the cycle track. The direction of traffic was chosen due to the location of emergency vehicle facilities and their ability to gain access to locations along Sandy Ave. For the geotechnical solutions, a design roadmap is outlined in this report. The solution chosen was a reinforcement to the distressed pavement using geosynthetic mesh along the segment of Sandy Ave between 3rd St and 4th St. Cost and client opinion drove the design decision. This solution enables the City of Troutdale to make a short term fix to fracturing pavement. A roadmap laying out the steps, expectations, concerns, and construction information is included within this report. This report outlines a preliminary design at 30% completion. The team acknowledges that the proposed design solution shall be revised and modified.

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INTRODUCTION

This report will detail the proposed conversion of the SE Sandy Ave project requested by the City of Troutdale and fulfilled by Portland State University 2021.TROUT.04 capstone group. The following sections will outline the existing conditions, project alternative solutions, and facility design.

1.0 PROJECT BACKGROUND

The City of Troutdale has requested a 30% design for the reclassification or reconfiguration of SE Sandy Ave due to slope instability. SE Sandy Ave is a local collector street that serves as a popular secondary route to navigate a steep hill in Troutdale, OR. The relatively low-grade slope of Sandy Ave presents long-term erosion concerns. The road has been identified by the City of Troutdale for partial or full closure to regular vehicular traffic and conversion to either a one-way road or enhanced bike, pedestrian, and vehicle pathway. The site is located south of Troutdale Town Center, at Sandy Ave between SE 3rd St and SE 8th St, and favored by cyclists and motorists alike. Construction and geotechnical solutions may be cost-prohibitive given the hillside conditions.

1.1 EXISTING SITE CONDITIONS

The project location is at SE Sandy Ave, south of Troutdale’s town center between SE 3rd St and SE 8th St as shown in Figure 1. A detailed drawing can be found in Appendix G. Sandy Ave is a two way single road with a pedestrian sidewalk shown in Figure 2. The current road conditions are susceptible to long term erosion concerns due to the road’s location on a steep hillside. The current design features a narrow two way road with no bike lane assist. The road is a customary bike route for neighborhood residents and commuters. Due to this factor, maintaining use of the road for bicycle travel use should be considered.

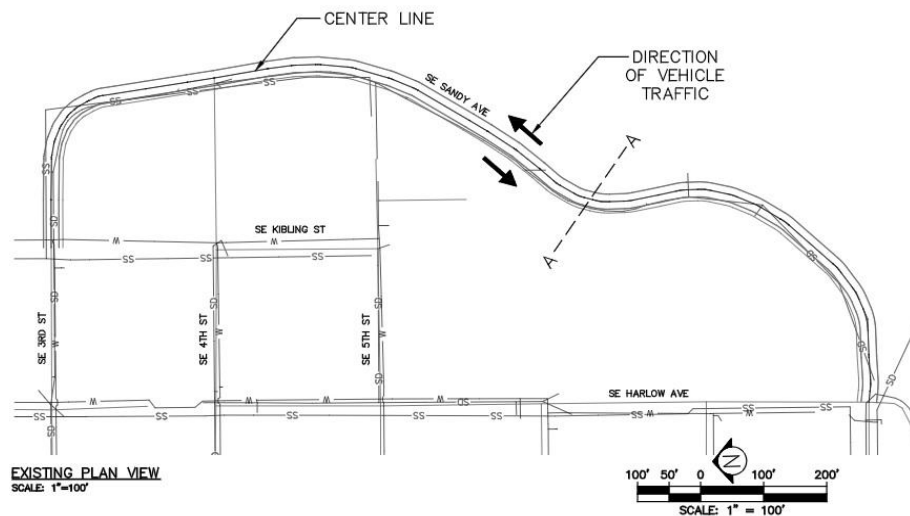


Figure 1: Project scope that extends from SE 3rd St to SE 8th St

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Figure 2: Photo taken near 6th St looking south west on SE Sandy Ave

According to a Shannon & Wilson geotechnical survey report (2018), Sandy Ave traverses generally north-south along the top of a steep east facing bluff. The distressed area of pavement is located at the intersection of SE 4th St. Accurate tension cracks are visible here and extend 35 feet along the roadway, occupying up to about half of the northbound travel lane, further constituting a shoulder instability. The cracking began some time prior to 2001. The cracks do not appear to have significant vertical offsets. Near the cracking, there is a 7 feet wide shoulder that appears to be depressed a foot lower stretching approximately 60 feet long. Stratigraphically, Sandy Ave was constructed above fill, Cataclysmic Flood Deposits, the Troutdale Formation, and Sandy River Mudstone. Based on the survey observations and review of published geologic mapping, the westernmost landslide mapped by Burns and others (2012) was likely caused by oversteepening and oversaturation of Cataclysmic Flood Deposits. The oversaturation occurred before the roadway was constructed. SE Sandy Ave was likely built along the old headscarp of the existing slope failure.

1.2 STAKEHOLDERS

This section will list out the stakeholders that may be affected by changes to Sandy Ave.

1.2.1 City of Troutdale

The City of Troutdale is responsible for accepting the proposed designs along with maintaining any changes and installations made.

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1.2.2 Local Residents

Local residents along the corridor will be largely impacted by the design. There is a single household on the corner of SE 3rd St and SE Sandy Ave that requires the usage of SE Sandy Ave to access their driveway. Other locals use the street to gain closer access to the highway as well as using SE Sandy Ave as an alternative route to avoid the steep hillslope of SE Buxton Road, SE Dora Ave, and SE Harlow Ave.

1.2.3 Emergency Vehicle

Emergency vehicle access up and down the collector street will be impacted by the design.

1.2.4 Oregon Metro

The Metro has a priority of completing the 40-mile trail that connects Troutdale to Portland. Sandy Ave is identified as a potential road to be connected to the trail. If there are minimum requirements necessary for inclusion into the trail system those should be considered.

1.2.5 Cyclists and Pedestrians

Sandy Ave has a low speed limit and the lowest grade along the hillside, leading it to be popular among cyclists who tend to prefer Sandy Ave over the main roads. The sidewalk is frequently used by pedestrians. When school is in session, Sandy Ave may be used more frequently by teachers, students, and parents. Design features that add to or detract from non-motorist safety and access are a primary concern with these stakeholders.

2.0 ALTERNATIVES ANALYSIS

In order to address the slope stability concerns along Sandy Ave, a number of alternative road configurations were examined in order to determine the ideal solution to the city’s concerns. This alternatives analysis involves the evaluation of design criteria identified by the client against a couple of configurations of street and multi-use trail along with a no build option. The ranking of criteria consist of cost, safety, public approval, longevity, cyclist and pedestrian use, and seasonal versatility. This section is broken down into the alternatives (2.1), description of the evaluation criteria (2.2), and their rankings (2.3).

2.1 ALTERNATIVES CONSIDERED

This section includes a description of all alternatives considered, including the benefits and drawbacks of each alternative. A summary of all the alternatives can be found in Appendix H.

2.1.1 Alternative: No-Build

No-build would be a continuation of the current roadway conditions at Sandy Ave, where the proposed design is not constructed. Traffic lanes in both north and south directions are maintained and no multi-use trail is added shown in Figure 3. No geotechnical work is done to improve slope stability, which would lead to the continued degradation of the slope. This option also does not allow for the improvement of pedestrian and bicycle access.

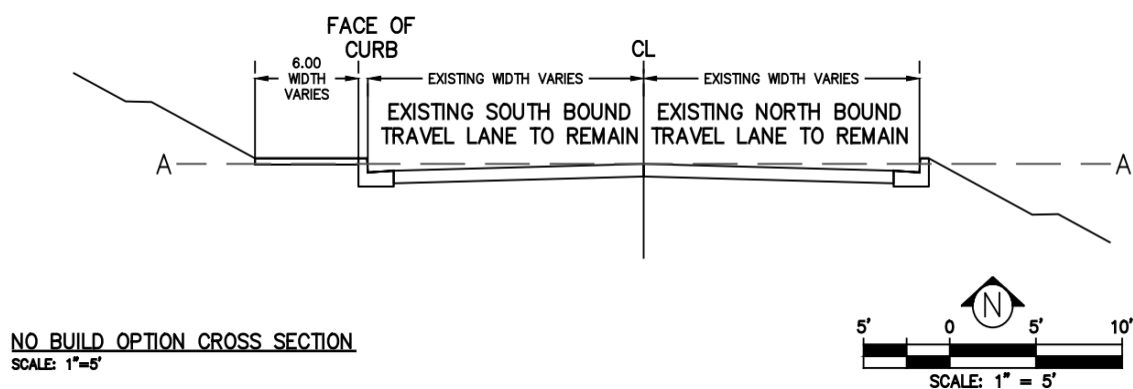


Figure 3: Typical Section of Alternative “No-Build”

2.1.2 Alternative: Geotechnical Stabilization of Sandy Ave

The slope on the east side of Sandy Ave would need considerable work to prevent future landslides from compromising sections of the roadway. The work would include, but not limited to, soil excavation, construction of a retaining wall, and installation of drainage

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pipng. This option prolongs the life of Sandy Ave significantly by fixing the slope instability, and also maintains the existing traffic patterns shown in Figure 4. However, this alternative is an expensive option and does nothing to improve the pedestrian and bicycle accessibility.

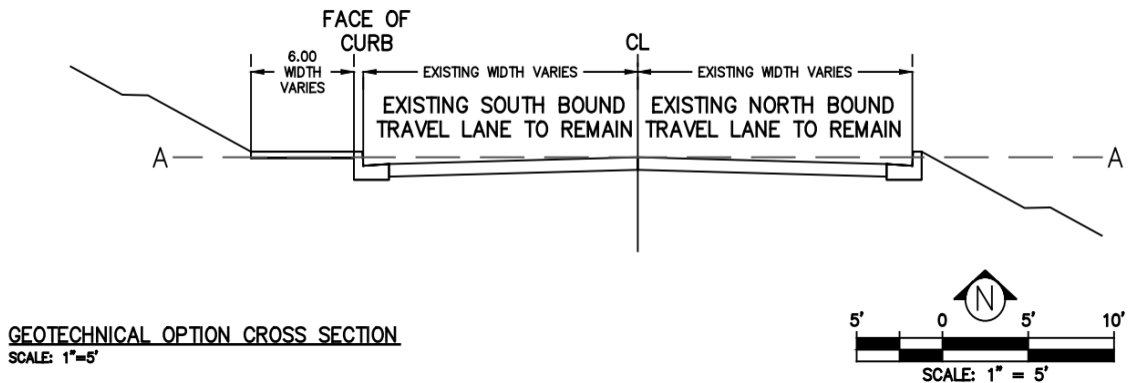


Figure 4: Typical Section of Alternative “Geotechnical Stabilization of Sandy Ave”

2.1.3 Alternative: Conversion of Sandy Ave Into a Multi-Use Trail

This alternative consists of restricting the access of motor vehicles to Sandy Ave and converting the street into a multi-use trail accessible only to pedestrians and cyclists. This would reduce the loading that vehicles introduce to the roadway in areas of Sandy Ave that are prone to landslides. This alternative could include a complete redesign and reutilization of the space that Sandy Ave now occupies into a newly constructed trail shown in Figure 5. It could also be a simple closure of the access points of the road with restriping and resigning of the road to support pedestrian and cyclist use. This option has the potential of being the lowest cost alternative, outside the no build option. However, there is a considerable effect of existing traffic patterns which may produce negative feedback from the surrounding residents.

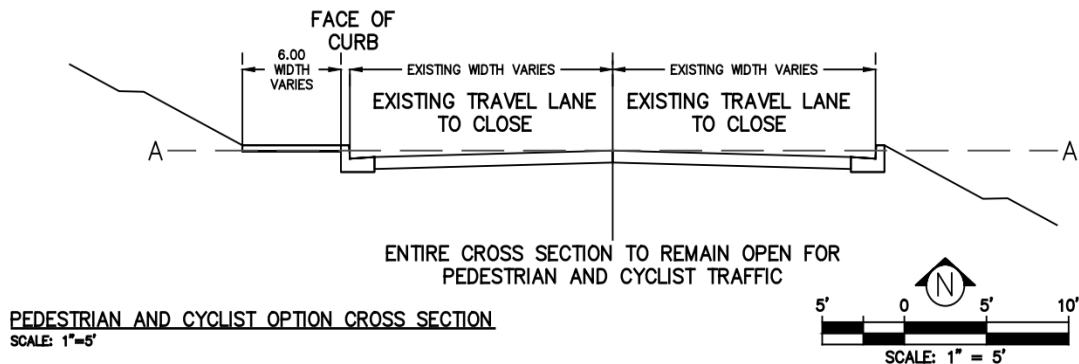


Figure 5: Typical Section of Alternative “Conversion of Sandy Ave Into a Multi-Use Trail”

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2.1.4 Alternative: Conversion of One Lane of Sandy Ave Into a Multi-Use Trail

This alternative would maintain one lane of the road as a one-way street, in either the north or south direction. The other lane would be converted into a multi-use trail that will exclusively accommodate both pedestrians and cyclists shown in Figure 6. This reduction of vehicle traffic would help prevent further degradation on Sandy Ave. Conversely, the reduction of vehicle access may generate negative community feedback due to the loss of a thoroughfare for vehicle traffic.

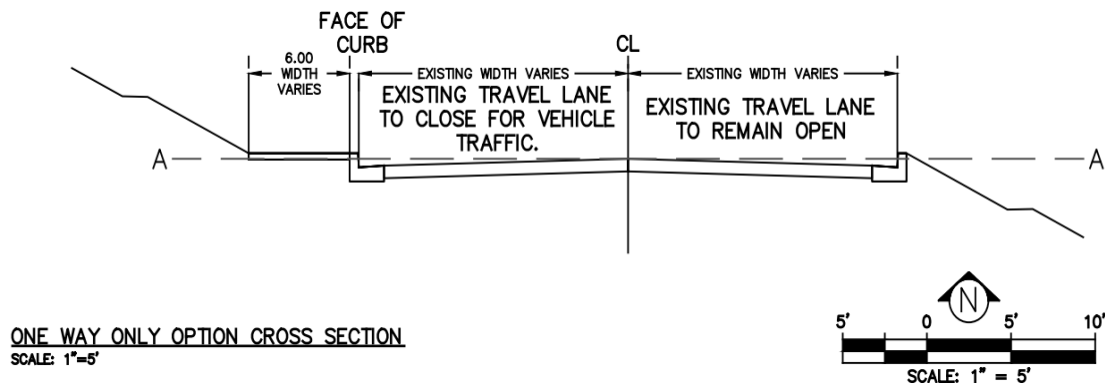


Figure 6: Typical Section of Alternative “Conversion of one lane of Sandy Ave Into Multi-Use Trail”

2.2 DESCRIPTION OF SELECTION CRITERIA: DESCRIPTION AND WEIGHT

This section describes the selection criteria and their weight in the Pugh matrix.

2.2.1 Overview

The alternatives described in this document are evaluated using a Pugh matrix. This project uses a weighted scoring system within the matrix that allows each alternative to be numerically evaluated against each other. Six criteria and their relative importance were identified in meetings with the City of Troutdale. Criteria with higher importance were given a greater weight. The weights assigned are based on percentages. A higher score is indicative of that alternative being more favorable. For criteria with only three options, scores were adjusted to be weighted out of 4.

2.2.2 Cost

The cost criteria are based on the installation cost of the project. Cost is weighted at 25% of the total score. The lowest score of 1 is assigned to the cost bracket of any alternative that costs more than \$1 million. Conversely, the lowest cost bracket of less than \$100,000 is assigned the highest score of 4. Table 1 shows the overall scoring structure.

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Table 1: Scores corresponding to a given construction cost.

Cost	Score
> \$1,000,000	1
\$500,000 - \$1,000,000	2
\$100,000 - \$500,000	3
< \$100,000	4

2.2.3 Safety

This criteria outlines the safety of pedestrians, cyclists, and auto vehicle users as they operate on Sandy Ave. Emergency vehicle access is also considered in this section. Safety is weighted at 25% of the total score.

Current conditions was assigned a score of 1 due to concerns of the slope failing. A score of 2 should be given to an option that reduces the traffic along Sandy Ave while also indirectly improving cyclist and pedestrian safety. A score of 2 also allows for emergency vehicles to use the road. A score of 3 should be given to an alternative that promotes direct safety to cyclists and pedestrians. This option also significantly reduces the loading on the road due to cars, thus improving the slope concerns. A score of 4 should be given to an alternative that sustains the slope stability and prolongs the usage of Sandy Ave. Table 2 summarizes the scoring standards for safety.

Table 2: Scores corresponding to alternative impacts on safety.

Safety	Score
Current conditions	1
Promotes separation of automobile and pedestrian and cyclist. Emergency vehicles may still access Sandy Ave	2
Motor vehicles not permitted to enter Sandy Ave Alleviating loading of the street next to unstable slopes.	3
Property, street, and infrastructure are sustained	4

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2.2.4 Public Approval

The criterion of public approval refers to how well the public will accept the changes. Public approval has a weight of 15% based on discussion with the client. Alternatives that are less likely to meet objections from the public are ranked higher than alternatives that are more likely to be protested. At this stage in the project design, this score is in large part based on the assumption that a larger change will come with more people opposed to that change. At a later stage in the draft process, feedback from the Troutdale Citizen Advisory Committee will be incorporated.

Table 3 summarizes the scoring descriptions. A score of 1 represents the majority of the public disagreeing with the design. A score of 2 should be given to the alternative that would expect mixed views from the public. A score of 3 should be given to the option that the majority of the public would agree to the changes. Assuming that changes would be met with opposition, a score of 4 should be given to an option where no changes would be made to the roadway.

Table 3: Assumed public perceptions and the corresponding score.

Public Approval	Score
Majority of the public does not agree with the design	1
Mixed reviews from the public	2
Majority of the public agrees with the design	3
No changes made	4

Note: Changes are undesirable as a conservative estimate

2.2.5 Long Term Maintenance Cost

Since the Sandy Ave project is situated on slopes with questionable long term stability, alternatives that are likely to last longer after the initial investment is made is given a higher score. Longevity is quantified by evaluating long term maintenance costs. This is given a weight of 20% of the considered score. Table 4 summarizes the scoring descriptions.

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Table 4: Estimated annual maintenance costs and the corresponding scores.

Long Term Maintenance Cost	Score
> \$9,000	1
\$7,000 - \$9,000	2
\$4,000 - \$7,000	3
< \$4,000	4

2.2.6 Cyclist and Pedestrian Usage

Utility to pedestrians and cyclists is important to increase community development. Factors such as trail width or ease of access could impact how valuable spacing of the trail will be to users. This criteria was given a weight of 10%. A score of 1.33 represents the current conditions of the street. Pedestrians are limited to a sidewalk and bicyclists share the road with automobiles without a dedicated bike lane. A score of 2.66 is a situation in which pedestrians and bicyclists are given improved multi-use path amenities, but some portion of the roadway remains occupied by motor vehicles. This would necessitate the use of crosswalks, barriers, and other traffic control devices in order to provide enhanced safety. An alternative in which motor vehicles do not have access to Sandy Ave minimizes the opportunity for conflicts with pedestrian and bike users of the trails and is thus given a score of 4. Table 5 summarizes the scoring descriptions.

Table 5: Scores corresponding to bike and pedestrian amenities and how they benefit users.

Cyclist and Pedestrian Usage	Score
Cyclist share the road with vehicles and pedestrians are limited to sidewalks	1.33
Cyclists will have a dedicated lane. Pedestrians will have expanded space. Vehicles still have one way access	2.66
Pedestrians and cyclists will have two lanes of traffic, and no vehicles along the roadway	4

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2.2.7 Seasonal Versatility

Troutdale frequently is affected by harsh winter conditions. Most drivers would prefer to use a gentler slope to travel to their destination. Sandy Ave has an average road grade of 4% to 5%. In comparison, the main roads such as Buxton Road and Harlow Ave have an average slope of 8% to 9%. Because of the steep slope that the neighborhood occupies, the relatively gentle grade of Sandy Ave compared to other through streets in the area may be important to preserve in the case of extreme winter weather events. It was given a weight of 5% to ensure that it is included into consideration while picking an alternative.

Having the option to use the shallower sloped road, Sandy Ave is a more ideal option for vehicular mobility during hazardous weather events. The option where both directions are available for vehicles to use should be given a score of 4. A score of 2.66 should be given to an option where vehicles must use an alternative route. A score of 1.33 should be given to any alternative that does not accommodate any type of traffic during harsh winter conditions. Table 6 visualizes the criteria assigned to the relative score.

Table 6: Versatility of the road configuration during inclement weather conditions and its corresponding score.

Seasonal Versatility	Score
Motor vehicles must use an alternative route.	1.33
Vehicles are able to access the road one-way.	2.66
Vehicles are able to access the road in both directions, and are not forced to use an alternative route	4

2.3 ALTERNATIVE RANKING

This section describes the rankings and attributes of the four alternatives for each selection criteria.

2.3.1 Cost

A no-build does not require any immediate capital investment, and cost is assumed to be \$0. In a geotechnical stability assessment of SE 2nd St and Sandy Ave completed by Shannon & Wilson Geotechnical and Environmental Consultants (2018), the cost of a retaining wall and resurfacing of the road section between 3rd and 4th streets would cost an estimated \$400,000. An Oregon Metro report (2017) on the 40-mile loop trail segment between Troutdale and Gresham specifies that construction of a one-way street with attached multi-use trails on Sandy Ave would cost around \$900,000. The construction cost of less than \$100,000 for a multi-use trail is based on a report from Weigland et al. (2013)

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that estimates the cost of a bike boulevard or greenway at \$9.49 per foot. For the 1,719 feet long section of Sandy Ave the considered design comes out to around \$16,000. A greenway cost estimate is used because the roadway considered is already paved and contains many of the features that a biker or pedestrian requires to make use of the space. Additional investment would only be required in the form of restriping and resigning the roadway, as well as installing the necessary traffic control devices required to restrict access to non-emergency vehicles.

Based on the alternatives analysis scoring criteria, the alternatives receive a score of 4 for no-build and conversion to multi-use trail, 3 for a geotechnical stabilization, and a 2 for a redesign into a one-way street with attached multi-use trail as shown in Table 7.

Table 7: Ranking of Estimated Total Construction Cost.

Alternative	Estimated Construction Cost
No Build	\$0
Geotechnical Stabilization of Sandy Ave	\$400,000
Conversion of Sandy Ave into Multi-Use Trail	< \$100,000
Conversion of One Lane of Sandy Ave Into Multi-Use Trail	\$900,000

2.3.2 Safety

The safety of users on the street is rated as 1 in the no build alternative. In the street’s current configuration, the pedestrians are restricted to a sidewalk on one side of the street. Bicyclists lack a dedicated bike lane, forcing them to share the road with motor vehicles. In addition, there is a risk of deteriorating slope stability causing a landslide, endangering users and property in some sections of the street.

The alternatives that redesign the street to separate bike and pedestrian users from motor vehicles and move vehicles further away from the edge of the slope scored higher. Because of the enhanced safety of these road designs, the conversion of Sandy Ave into a one-way with multi-use trail and a conversion into all multi-use trail scored 2 and 3 respectively. A geotechnical stabilization of the slopes next to Sandy Ave addresses many of the safety concerns associated with the slope instability and earned a score of 4.

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2.3.3 Public Approval

Because of assumed public concern with the removal of Sandy Ave as a neighborhood collector street, alternatives that eliminate the street as a route for motor vehicles score lower in public approval. Redesign of the entirety of Sandy Ave into a multi-use trail scored a value of 1. Maintaining one lane of vehicular traffic for a one-way street also reduces motor vehicle capacity, but to a lesser extent and therefore has been scored 2. A geotechnical stabilization of the street, as well as a no-build alternative maintained full vehicular capacity and got a score of 3.

2.3.4 Long Term Maintenance Cost

According to the Troutdale Transportation System Plan prepared by Kittleson & Associates (2014), the 42 mile road system administered by the City of Troutdale's costs \$1.075 million annually to maintain. Assuming this is evenly distributed, the annual cost of maintaining one traffic lane per foot is \$2.42. In a survey of yearly maintenance costs administered by Rails-to-Trails (2015), the cost of an asphalt trail that is 10 feet wide and 1 mile long costs \$1,971 annually. Using these estimations, the predicted cost of long term maintenance for each alternative can be calculated. No-build requires the maintenance of a similar amount of roadway as a geotechnical stabilization, however the slope stability is not addressed. This will likely require even more extensive roadway maintenance than other alternatives.

The lowest score of 1 goes to no-build, which requires the same annual maintenance of the current Sandy Ave configuration, but with additional long term costs associated with the deteriorating roadway near potential landslides. A geotechnical stabilization of the road attains a score of 2 because it requires the same base amount of future road maintenance investment, however the roadway is likely to retain its condition longer after treatment. Because of the lower maintenance requirements of a multi-use trail than roadway pavement, alternatives that incorporate multi-use trail elements have lower associated maintenance costs. The alternatives therefore get a score of 3 and 4 for the one-way with multi-use trail and all multi-use trail respectively.

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Table 8: Ranking of Estimated Yearly Maintenance Cost.

Alternative	Estimated Yearly Maintenance Cost
No Build	> \$8,726
Geotechnical Stabilization of Sandy Ave	\$8,726
Conversion of Sandy Ave into Multi-Use Trail	\$1,343
Conversion of One Lane of Sandy Ave Into Multi-Use Trail	\$5,035

2.3.5 Cyclist and Pedestrian Usage

Proper selection of a bicycle road type is dependent on many factors, including the ability of the users, specific corridor conditions, and facility cost. In a shared roadway with no bikeway designation, many bicycles travel mostly on streets and highways. A signed shared roadway with bike lane signaling provides safe and accessible routes through high demand corridors.

Bike lanes are established with appropriate pavement markings and signs along streets in corridors where there is significant bicycle demand and where there are distinct needs that can serve them. The purpose should be to improve conditions for bicyclists and pedestrians on the streets. Bike lanes are intended to delineate the right of way assigned to bicyclists and motorists and to provide more predictable movements for each. Bike lanes also help increase the capacity of highways or roadways carrying mixed bicycle and motor vehicle use.

SE Sandy Ave is owned and operated by the City of Troutdale. The Average Daily Traffic (ADT) count shown in Table 9 below proposed by Metro (2017) determined an ADT of 130 for SE Sandy Ave. 2.6% of these vehicles were determined to be bicycles while the remaining 87.4% were small trucks, or buses. This indicates that an average of 3.3 cyclists travel on the road per day. Additionally, the average traffic count along the road is very low indicating it could be repurposed for a shared use path with very little impact to the surrounding street system.

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Table 9: The average traffic volumes for the vicinity of SE Sandy Ave (Metro, 2017)

	ADT	AM 2hr Peak	NB - AM	SB - AM	PM 2hr Peak	NB - PM	SB - PM
Buxton Rd	6,439	825	168	657	1,092	705	387
SE Sandy Ave	130	-	-	-	33	-	-
S Troutdale Rd	8,176	1,139	454	685	1,515	584	931
SE Evans Ave	490	34	-	25	49	36	-

According to AASHTO Guide for the Development of Bicycle Facilities (2012) the recommended criteria for a shaved corridor use path is 10 to 12 feet with 2 foot shoulder widths. The minimum paved width for a two way shared directional path is 10 feet or wider, typically not more than 14 feet wide in areas with higher volumes or a high variety of travelers. A reduced 8 feet width is acceptable for short distances due to physical constraints. Therefore, a shared path can be included in a designated right of way and or may be included with an existing street right of way.

In some locations along the corridor, the trail may be split to include a natural surface hiking section with a parallel on street bicycle facility. In these locations, it is recommended that hiking trails be at least 6 feet wide and a tread surface of 18 to 36 inches. Additionally, street bicycle facilities should be consistent with the Metro Active Transportation Plan for regional bikeway and pedestrian facilities. Lastly, on streets with freight traffic or high vehicle speeds or volumes, the facility should, at a minimum, be a buffered bike lane with a 3 foot buffer between the 5 foot bike lane and vehicle travel lanes.

The low score of 1.33 was assigned to the geotechnical stabilization and no-build alternatives. These options do not improve cyclist usage as no extra space is included. A score of 2.66 was assigned to the one lane conversion design because moderate space would be created for cyclists. Possible barriers will increase cyclist and pedestrian safety. The highest score of 4 was assigned to the full multi-use trail conversion alternative because the roadway would be entirely dedicated to cyclists and pedestrians. No vehicles would be on Sandy Ave, therefore ensuring the safety for cyclists and pedestrians.

2.3.6 Seasonal Versatility

The area of Troutdale is affected by harsh winter weather conditions. This makes shallower slopes more desirable to be able to access while travelling. Therefore, closing all lanes of

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vehicular traffic would impede travel along Sandy Ave. Conversion of Sandy Ave into an exclusive cyclist and pedestrian design was given the lowest score of 1.33. The conversion of one lane into a multi-use trail allows for traffic to flow. This alternative was given a score of 2.66. The no-build and the geotechnical stabilization alternatives were given the highest score of 4 because both directions of traffic would still be available.

2.4 PREFERRED ALTERNATIVE

Utilizing the scoring criteria outlined above, each alternative was graded and organized into a Pugh matrix shown in table 10. As each criteria was discussed in-depth with the client, the Pugh matrix score is the primary rationale for choosing an alternative. The highest scoring alternative is the conversion of Sandy Ave into a multi-use trail that excludes non-emergency motor vehicle access, obtaining a score of 3.0 out of a maximum score of 4.

Although the Pugh matrix shown in table 10 calculated the best option was to fully convert Sandy Ave into a multi-use trail, the option to convert the roadway to a one-way multi-use trail was chosen to be designed. This decision was in response to Troutdale City Council’s concerns of wanting to maintain vehicular accessibility along Sandy Ave. The City Council also wanted to maintain access to the roadway for emergency access.

Table 10: Alternative Analysis Matrix

ALTERNATIVE	CRITERIA						TOTALS MULTIPLIED BY WEIGHT
	COST	SAFETY	PUBLIC APPROVAL	LONG TERM MAINTENANCE	PEDESTRIAN AND CYCLIST USAGE	SEASONAL VERSATILITY	
Weight	25%	25%	15%	20%	10%	5%	Max = 4
Conversion of one lane into multi-use trail	2	2	2	2	4	2.66	2.2
Full conversion into multi-use trail	4	3	1	4	2.66	1.33	3.0
Geotechnical Stabilization	3	4	3	1	1.33	4	2.7
NO BUILD	4	1	3	2	1.33	4	2.4

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3.0 FACILITY DESIGN

The chosen design for Sandy Ave is a multi-use road featuring a sidewalk, cycle track, and roadway. A multi-use road will serve the community by allowing pedestrian and bicycle traffic in both directions, and allow a one-way northbound lane for motor vehicles. This section details the design elements chosen.

3.1 OVERALL SITE DESIGN

Multi-use roads have many design considerations and possible configurations. Client input identified the priorities of the Sandy Ave project to be a balance of safety, cost, emergency vehicle access, transportation equity, and homeowner accessibility. Leading design guides for bikeways and shared roads were referenced for contemporary design configurations.

3.1.1 Flexible Bollards and Striping

Delineating the cycle track and vehicle travel lane is critical for cyclist safety. To separate the roadway, flexible bollards were chosen; they have a substantial profile for drivers to notice, are less expensive than other traffic separating methods, and are simple to install. A bollard and striping typical section is shown in Figure 7. The bollards will be spaced 10 feet apart (MUTCD 6F.63.08) for the majority of the cycle track. Within 20 feet of intersections, the bollards will be spaced 5 feet apart to provide greater visibility of the cycle track to turning drivers.

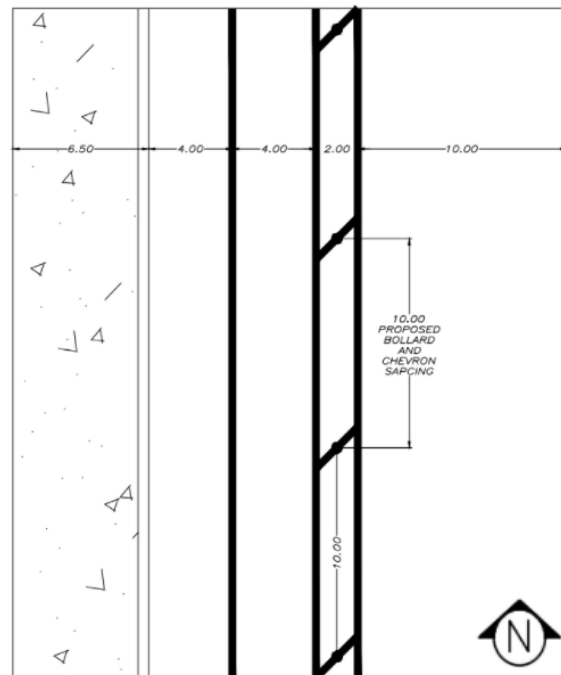


Figure 7: Typical section for bollard and chevron spacing

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Bollard spacing was chosen in accordance with ODOT Standards TM800. Around the bollards will be angled white chevron striping and straight white lines parallel with the roadway (MUTCD 3B.24.05). The chevrons will be spaced 10 feet beneath each bollard. The white line striping will be 4 inches on each side. Calculations warranting the number of bollards required along the length of Sandy Ave can be found in Appendix D-1. Figure 8 shows a 3D example for the bollard placement and striping.



Figure 8: Flexible bollards delineating bike lanes and vehicle lanes (Bike Coalition Philadelphia, 2017)

3.1.2 Cycle Track

The west road lane is to be reconfigured into a two-way cycle track. The width of the cycle track will be 8 feet with each lane 4 feet wide. The center of the bike lane will be a 4 inch solid yellow line (MUTCD 9C.03, Figure 9C-2). To provide clarity of the entrance and exits to the cycle track, striping will be installed. A bike lane stencil will be added to cycle track entrances at the 8th St intersection, 4th St intersection, and 3rd St intersection (MUTCD 9C.04; pg. 69). An example of the cycle track entrance is shown in Figure 9.



Figure 9: An example two-way cycle track entrance (Guensler, Randall, et al.)

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Where the bike lane passes through the intersection at 4th St, the bike lane will be 2 feet white dotted lines spaced 2 feet apart (MUTCD 3B.08). The intersection bike lane will be the same width (MUTCD 3B.08). A schematic diagram of a typical section is attached in Appendix C-2.5 and C-2.6 for reference. Figure 10 below provides a visualization of the proposed bike track.



Figure 10: 3D rendering of an example cycle track (NACTO, 2014)

3.1.3 Signs

All existing stop signs along Sandy Ave will be maintained. To inform motorists of the one-way traffic pattern, left turn only warning signs will be placed 100 feet before an intersection, shown in Figure 11. This distance is based on the speed limit along Sandy Ave (MUTCD Table 6C-1). Warning signs including “DEAD END” and “DEAD END AHEAD” will be placed along SE 3rd St at SE Harlow Ave and SE Dora Ave, respectively, to warn drivers of the southbound vehicular lane closure at Sandy Ave. All signs to be installed can be found in the sign glossary in Appendix C-2.7.



Figure 11: A left turn only sign (MUTCD, 2009)

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3.1.4 Motor Vehicle Travel Lane

When determining the one-way vehicle travel direction and lane placement, emergency vehicle pathing was the main consideration. Gresham Fire Department Station 75 and Legacy Mount Hood Medical Center are both located south of Sandy Ave. Fire engines and ambulances responding to an emergency in the northern area of their jurisdiction may need to travel on Sandy Ave. The decision to keep the northbound motor vehicle lane open is to allow emergency vehicle accessibility. The existing northbound vehicle travel lane striping will be modified by removing the double center yellow line, to be replaced with the white chevron markings denoted in section 3.1.1. The white shoulder lines will remain unchanged. The southbound travel lane will be closed to motor vehicles and will be converted to a two-way cycle track as mentioned in 3.1.2. Further details can be found in Appendix C-2.5 and C-2.6.

3.1.5 3rd St and Sandy Ave Exchange

SE 3rd St into Sandy Ave will be a two way motor vehicle road until the Kibling St right of way. Figure 12 shows the proposed design with numbered elements referenced throughout this section. At Kibling St, there will be a 4 feet by 2 feet reflective barrier (element 6) to ensure that vehicles will not enter Sandy Ave on 3rd St travelling eastbound (MUTCD 6F.63). A “NO MOTOR VEHICLES” sign, as seen in Appendix C-2.7, will be mounted on this barrier in addition to other warning signs along SE 3rd St. At the end of the northbound cycle track there will be an angled bike lane to allow cyclists to reenter the shared vehicle travel lane (element 2). The angled bike lane will be 40 feet long, the same width at 4 feet, and the striping will be 2 foot dotted white lines at 2 feet spacing (MUTCD 6C.08; 3B.08). Calculations for the tapered angle bike lane are shown in Appendix D-2. At the end of the transition bike lane, there will be a bike stencil with chevrons (element 5) to inform cyclists about re-entering shared travel lanes (ODOT TM500). The drawing schematic in Appendix C-2.1 shows the intersection in further detail.

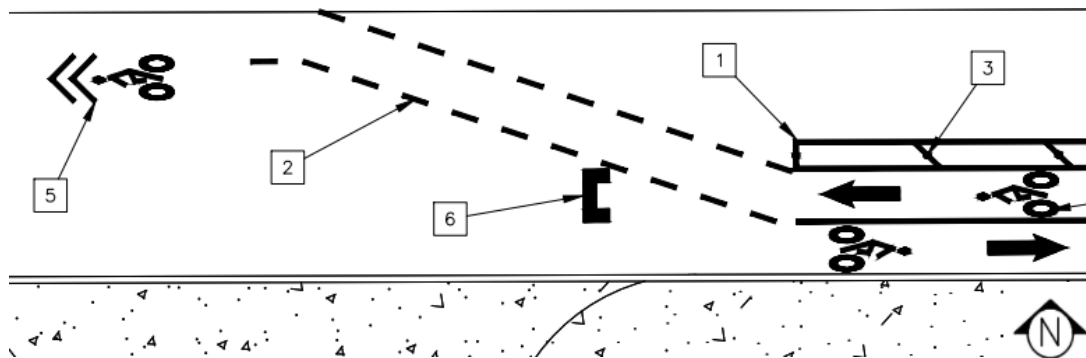


Figure 12: The 3rd Ave cycle-track transition

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3.1.6 4th St and Sandy Ave Intersection

The 4th St intersection will become a left-turn only intersection. A supplemental sign reading “NO RIGHT TURN” is to be placed on the existing stop sign. In advance of the existing stop sign, a sign reading “LEFT TURN ONLY” will be installed 100 ft. before the intersection. A “One Way” arrow sign will be mounted on the existing barrier along the northbound vehicle travel lane. These signs, shown in Appendix C-2.7, will notify drivers of the new one-way travel pattern and to be aware of bicycle traffic. The drawing schematic in Appendix C-2.2 shows the intersection of SE 4th St and Sandy Ave in further detail. Figure 13 shows a cut out of the design in Appendix C-2.2.

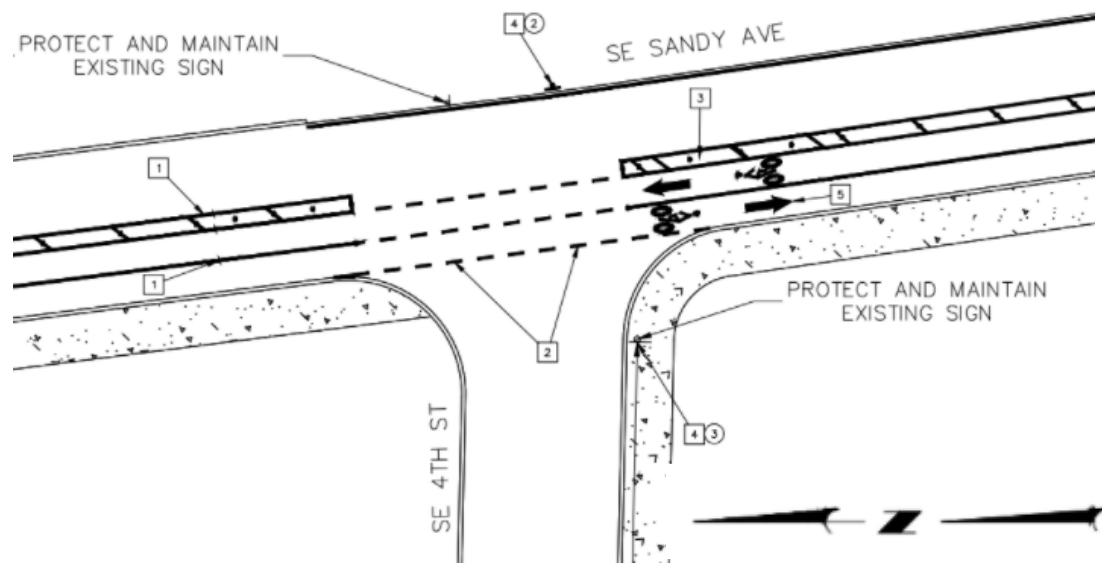


Figure 13: The 4th St intersection design

3.1.7 8th St and Sandy Ave Intersection

The existing crosswalk, stop sign, and side striping will be maintained. The new cycle track striping and bike lane stencils detailed in section 3.1.2 will begin where Sandy Ave meets with the crosswalk from the north and south sides of 8th St. The drawing schematic in Appendix C-2.3 shows the intersection in further detail. The existing signs, shown in Appendix C-2.7, will warn drivers of the curves ahead will be maintained, while the sign group warning drivers of cyclists on the roadway will be removed and reinstalled.

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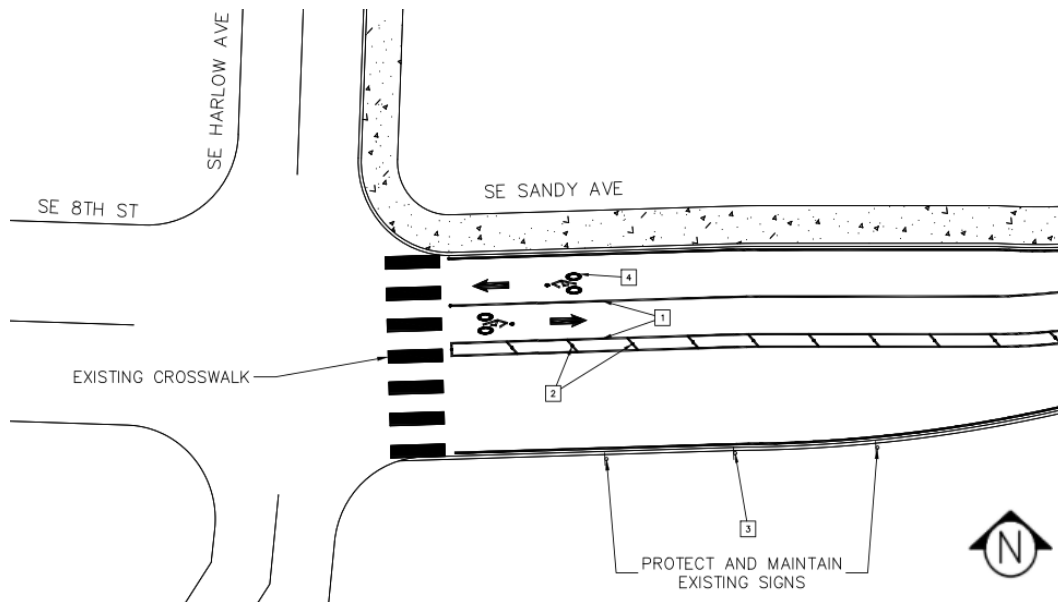


Figure 14: The 8th St intersection design

3.2 DESIGN REFERENCES

This section will discuss the references used to design the proposed road.

3.2.1 Manual on Uniform Traffic Control Devices (MUTCD)

The MUTCD gives guidance and specifications on traffic control devices. Specific chapters used heavily in the design of Sandy Ave are *Chapter 3: Markings*, *Chapter 6: Temporary Traffic Control*, and *Chapter 9: Traffic Control for Bike Facilities*.

3.2.2 Oregon Bicycle and Pedestrian Design Guide Appendix L

This design guide will be used for placement of signs, restriping of roads, and bike design standards of shared use paths. An example of using this design guide would be, “AASHTO recommends a maximum grade of 5% for bicyclists, with steeper grades allowable for up to 500 feet, provided there is good horizontal alignment and sight distance; extra width is also recommended. Engineering judgment and analysis of controlling factors can help determine what distance is acceptable for steep grades” (Oregon Bicycle and Pedestrian Design Guide, pg.7-7).

3.2.3 NACTO Urban Bikeway Design Guide

The NACTO guide provides up-to-date bikeway design information from around the world. All the bicycle related treatments posted in this guide have been approved by the MUTCD and Federal Highway Administration.

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3.2.4 Portland Traffic Design Manual Vol. 1

Portland's status as a leading municipality in bikeway design gives this guide credibility to be referenced. Being published in 2020, this guide is the most contemporary referenced. Additionally, Troutdale's proximity to Portland brings continuity to cyclists who travel in the area.

3.3 COST ESTIMATE

An initial construction cost estimate for the one-way street with a cycle track is provided in Appendix A-1. The Oregon DOT Weighted Average Item Price - Calendar Year 2019 was used for cost estimating of materials. The item price listing is an average item price report, and was referenced when determining the cost of striping, signage, and other traffic control devices. The four primary material items to form the cost estimate are: striping, signs, bollards, and barricades. Some assumptions of the design were made, as follows:

- 3600 feet of striping removal
- 6000 feet of striping installation
- 7 number of bike symbols. Number of bike symbols is discretionary per MUTCD
- 250 flexible bollards

This construction cost data should include the price of installation and placement; however, it does not include some costs that are difficult to estimate, such as mobilization, clean-up, temporary traffic control, etc. To account for this, a 30% contingency has been added to the estimate.

3.4 CONSTRUCTION SCHEDULE

The preliminary construction schedule is estimated to be 77 days. The construction schedule is divided into six phases. Each phase requires the previous phase to be completed. The first phase of construction includes permitting, the closure of Sandy Ave, and the mobilization of equipment for the start of the project. The second phase of construction is the preparation of SE 3rd St, SE 4th St, as well as SE 8th St. The third phase of construction includes sign placement, bollard placement, barrier installation, and striping of each street. The fourth phase of construction includes an inspection of the three streets and a punch list of the problems encountered. The fifth phase of construction is scheduled for the final mobilization of equipment as well as a final site clean up. The final phase of construction is scheduled to close the permits and a final project close out. The construction schedule can be found in Appendix B for reference.

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3.5 TEMPORARY TRAFFIC CONTROL PLAN

The temporary traffic control plan for the one-way design can be referenced in Appendix I. Due to the driveway at the north end of SE Sandy Ave, this temporary traffic control plan has two stages in order to maintain driveway access at all times during construction. Traffic control devices used in this plan include temporary type III barricades, temporary sign supports, temporary sign posts and signs, and traffic cones.

As shown in Appendix I-1.0 and I-1.1, Stage 1 involves a road closure from SE Kibling St to the east entrance of the driveway, blocking through traffic from SE Harlow Ave to SE Kibling St. Through traffic is also blocked from SE 4th St to the east driveway as shown in Figure 15 below.

Stage 2 of the temporary traffic control plan involves a full road closure from the north end of Sandy Ave, extending to the SE 8th St. intersection. This stage includes full closure of SE Sandy at SE 4th St, as shown in Appendix I-1.2.

The associated temporary warning and detour signs are referenced in Appendix I-1.4, and should be placed according to I-1.1 and I-1.3.

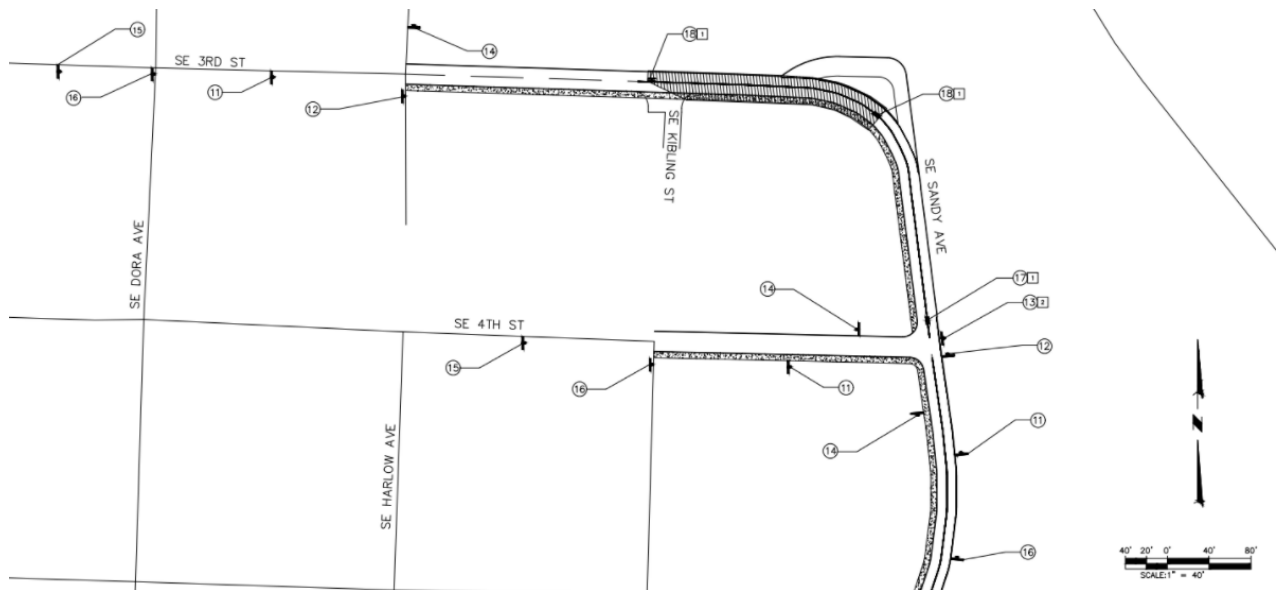


Figure 15: Temporary traffic control plan, Stage 1

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4.0 REGULATORY COMPLIANCE AND PERMITTING

This section includes the regulatory agencies, documents, and legislation that were referenced in the construction of this report. Each subsection lists the regulatory body and what information was utilized.

4.1 OREGON DEPARTMENT OF TRANSPORTATION BLUEPRINT FOR URBAN DESIGN (2019)

This is a provisional guide to the Highway Design Manual that outlines the possibility of flexible design of state owned urban roadways based on the context of land use.

4.2 CITY OF TROUTDALE CONSTRUCTION STANDARDS - STREETS

This document lists requirements and standards for street design and pavement overlay, as well as construction details for the city of Troutdale. These standards were used in the design of the bike path widths.

4.3 “BICYCLE AND PEDESTRIAN BILL” (ORS 366.514)

This bill, passed in 1971, requires that pedestrian and cyclist facilities be included where any public road, street, or highway is being built or reconstructed. It also requires a minimum of 1% of state highway funding to be put toward walkways and bikeways on such roadways.

4.4 OREGON TRANSPORTATION PLAN (2015)

This plan is a comprehensive set of policies and guidelines for including all transportation modes in the same system. Key elements of the plan include creating sustainable transportation and optimizing safety using information technology and other methods.

4.5 REGIONAL TRANSPORTATION FUNCTIONAL PLAN (2012)

This plan connects the policies of regional transportation to local communities. This follows closely with the 2040 Growth Concept put in place by Oregon Metro. The plan shares the same goals of balancing transportation systems, creating safe and sustainable neighborhoods, protection of natural areas, and efficiently using land and money for new developments.

4.6 CITY OF TROUTDALE PUBLIC WORKS

The City of Troutdale Public Works Administrative Rules 001 establishes an application form, procedures, terms and conditions, and approval or denial guidance for a Public Works Permit. Section 12.12.040 of the Troutdale Municipal Code contains the Public Works Director’s authority to adopt these administrative rules.

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A permit is required for any of the following activities unless it falls under an exception.

- To occupy or encroach on City right-of-way for more than 72 consecutive hours.
- To store materials in, or perform work in, City right-of-way.
- To connect to a public water main, sanitary sewer main, or storm sewer main.

Exceptions:

- Work performed by City forces or under a contract with the City.
- Maintenance of above ground equipment that is placed in or adjacent to public right-of-way in accordance with a Permit issued by the City or a franchise agreement with the City.
- Landscaping performed by a property owner or tenant on the frontage of his/her residence and not involving excavation deeper than 8 inches.

Under these circumstances, the act of construction does not warrant any permits, however, any equipment or supplies needing storage or staging space would require a permit from Public Works.

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5.0 GEOTECHNICAL ROADMAP

In addition to the improved transportation facilities on Sandy Ave, the potential landslide issues between SE 3rd St and SE 4th St may need to be addressed. This section will provide an outline for future geotechnical work in this area, culminating in a proposed geotechnical solution, traffic control plan, cost estimate, and construction schedule.

5.1 BACKGROUND

This area shows concerns of potential landslides according to the Oregon Department of Geology and Mineral Industries (DOGAMI) as shown in Figure 16. Shannon & Wilson completed a study in 2018 to quantify and monitor the landslide hazard. Excerpts from that study can be found in Appendix G-2 and G-3 This segment of Sandy Ave is constructed on loose material such as fill and flood deposits. Additionally, the area shows signs of distress in the pavement as shown in Figure 17. Acute tension cracks are visible at the intersection of Sandy Ave and SE 4th St, contributing to shoulder instability. Given these slope conditions, a geotechnical treatment may be necessary to prolong the longevity of the roadway. (Shannon & Wilson, 2018).

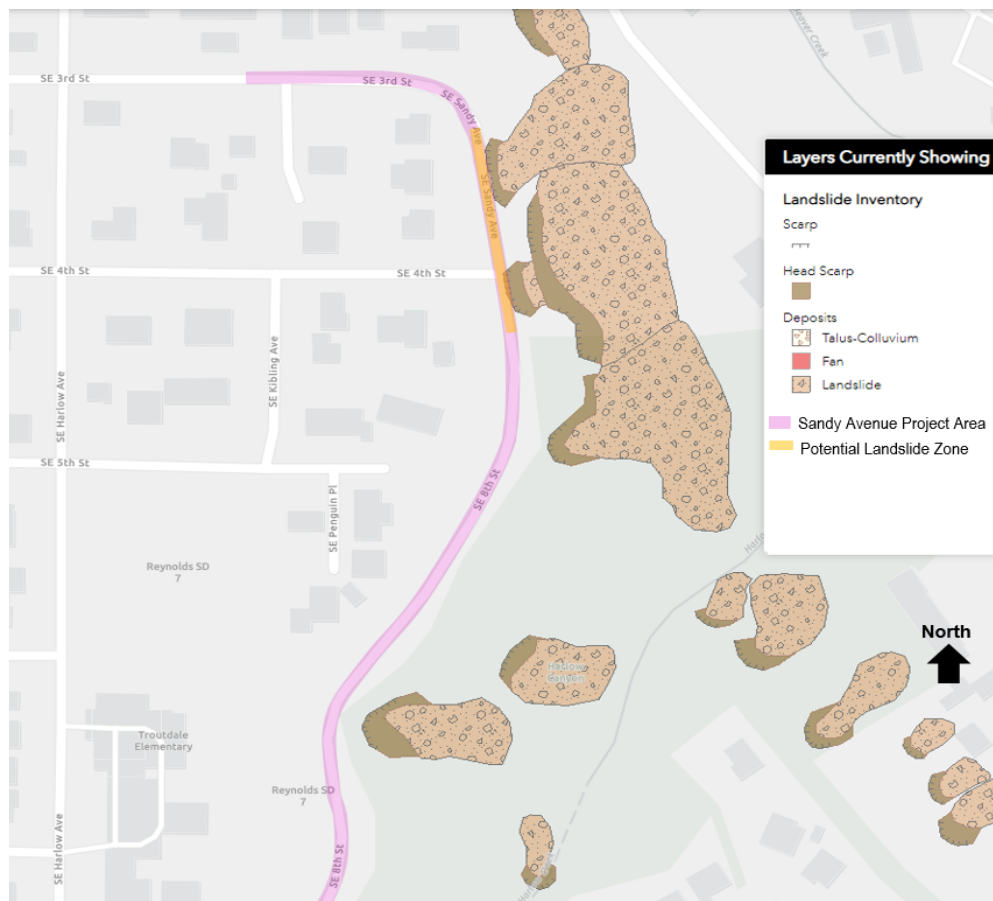


Figure 16: Landslide hazards along SE Sandy Ave (DOGAMI, 2018)

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Figure 17: Area of Pavement distress along Sandy Ave near 4th St - Looking South (Shannon & Wilson, 2018).

5.2 POTENTIAL LANDSLIDE MITIGATION MEASURES

The landslide hazard in this segment of Sandy Ave could be addressed multiple ways, including a tie-back soldier pile wall, a mechanically stabilized earth (MSE) retaining wall, or with a modified geogrid for slope erosion control. geosynthetic mesh. The following sections will describe each potential solution.

5.2.1 Tie-Back Soldier Pile Wall

Soldier pile walls are used for both temporary and permanent applications. The walls use wide flange steel members. Given the current conditions of the hillside, the wall would likely need to be set at a depth of approximately 20 feet from the road surface to ensure it is addressing the failure plane as shown in Appendix G-3. A tie-back soldier pile wall exceeding over 15 feet in height typically requires lateral resistance from tie-back rods to be driven or drilled into the earth as shown in Figure 18. The tie-backs provide a tensile force that provides extra reinforcement to the wall (ODOT, 2019).

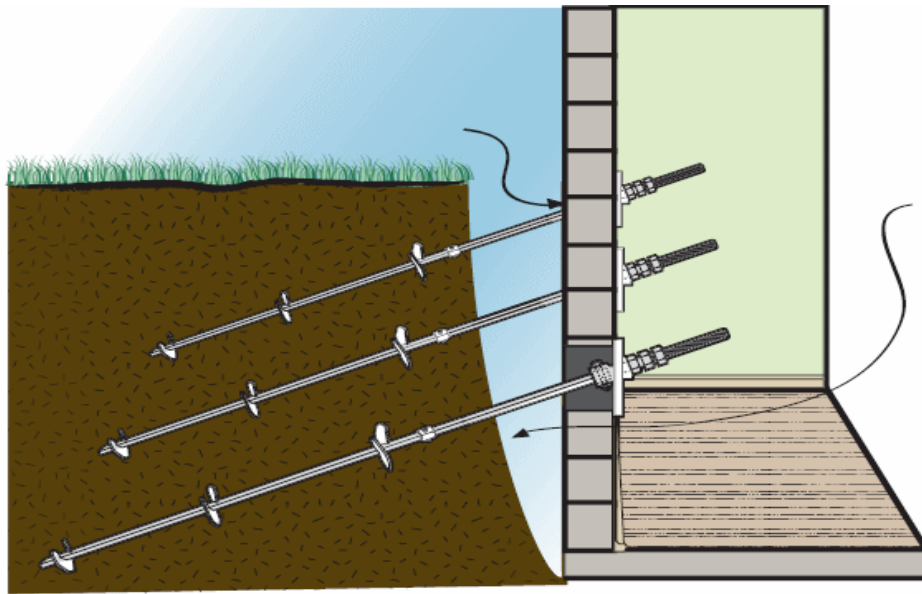


Figure 18: Tie-back soldier pile wall schematic (MacLean Dixie HFS)

5.2.2 MSE Wall

MSE walls are internally stabilized by the frictional resistance of layers of steel or geosynthetic reinforcement layers embedded within a well-compacted, gravel backfill. MSE walls rely on self-weight to resist overturning and sliding forces (ODOT, 2019).

In order to build an MSE wall, proper site planning and topographic surveying must be done. A geotechnical investigation involving properties of foundation, materials and retained materials, settlements, bearing capacity, global stability, and compound stability should be conducted. An MSE wall must be designed to support lateral earth pressure, any vertical loads, seismic loads, and meet appropriate factors of safety requirements. Generally, the wall designs must also follow AASHTO and other approved standards (FHWA, 2009).

MSE walls require a significant amount of room, a minimum of 0.7 times the designated height. Depending on the situation, sometimes more embedment depth is required. Checking geotechnical conditions before and after site excavation is recommended. Additionally, proper compaction is critical in order to maintain wall performance strength of the backfill and interaction of the reinforcements.

Compaction can be problematic and should be addressed separately. Compaction within 3 feet of the face should be done using a small hand operated compactor to prevent damage or bulging at the face. The required compactions must be achieved at the face for long term performance of the wall and maintaining wall alignment.

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Furthermore, wall drainage should be in place in order to prevent hydrostatic pressure acting on the backfill. Surface water draining additional water should be addressed to prevent wall erosion. The approximate groundwater depth is 19.1 feet according to Shannon & Wilson (2018). A potential concern of proximity to the groundwater table is seepage that can lead to hydrostatic pressure concerns.

Similarly to the tie-back soldier pile wall, an MSE wall is not recommended for this project site. Shannon & Wilson (2018) estimated that a wall of 25 feet high by 100 feet long would approximately cost \$400,000. The overall construction and design process will most likely add more expenses due to the additional site investigations, pavement reconstruction, and construction budget.

5.2.3 Reinforce Road with Geosynthetic Products

Geosynthetics are classified by their primary function: filtration, drainage, separation, reinforcement, fluid barrier, and protection (FHWA, 1998). The pavement at Sandy Ave and SE 4th St show signs of cracking. Geogrids--geosynthetics with a primary reinforcement function--can be used to add tensile strength to a soil matrix or a pavement structure, reducing movement and cracking. Applications are typically constructed over soft foundations, similar to the situation of this project site. Additionally, geogrids can facilitate drainage. They allow water to drain from or through soils with lower permeability. Applications would include dissipation of pore water pressures at the base of the roadway embankments (FHWA, 1998).

This is critical in very soft and wet subgrades, where compaction is nearly impossible to achieve with the use of normal compaction equipment.

Geosynthetics used in roadways for soft subgrade applications provide several cost and performance advantages. With the installation, the geosynthetic material acts as a separation and prevents the base aggregate from penetrating into the subgrade.¹ The separation also prevents the subgrade fine soils from migrating up into the base. Possible reinforcement includes lateral restraint, bearing capacity increase and membrane tension support. Geosynthetics reduce the thickness of the aggregate required to stabilize the subgrade. The geosynthetic material can act as a filtration median, the subgrade is allowed to increase strength over time. Additionally, it helps reduce differential settlement of the roadway, which helps maintain pavement integrity and uniformity (FHWA, 1998).

¹ A “pavement overlay geotextile” is an alternative method where the geotextile is placed on top of the existing pavement, and then covered by an overlay of new pavement. This method, while less expensive, is expected to have a shorter lifespan and cannot resist the same amount of lateral soil movement as a subgrade reinforcement geotextile (the alternative proposed here).

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Geotextile material is commonly considered because of cost, ease of installation, and compatibility. Geogrids are a specific type of geosynthetic that enhances the pavement system performance through four reinforcement effects: (1) prevention of lateral spreading and aggregate; (2) confinement of aggregate resulting in increased strength/stiffness of aggregate in the area of the geogrid; (3) reduction of vertical stresses on top of the subgrade; and (4) reduction of shear stress on subgrade (Christopher, 2010). Lateral restraint is developed between the base and subgrade through friction interlocks between the aggregate soil and geogrid, as seen below in Figure 19 and 20.

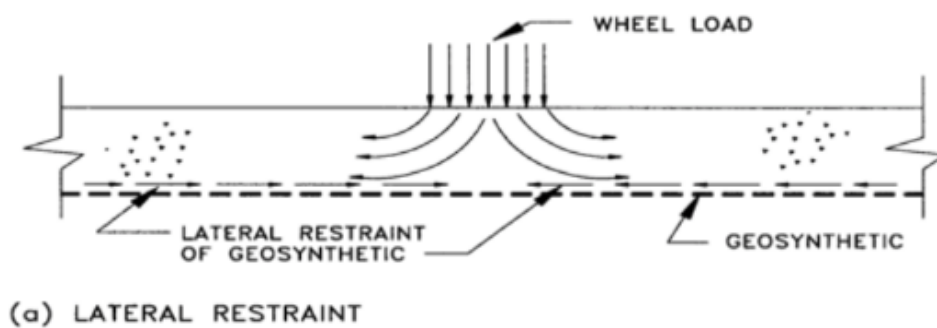


Figure 19: Lateral Restraint w/ Geosynthetic (Christopher, 2010)

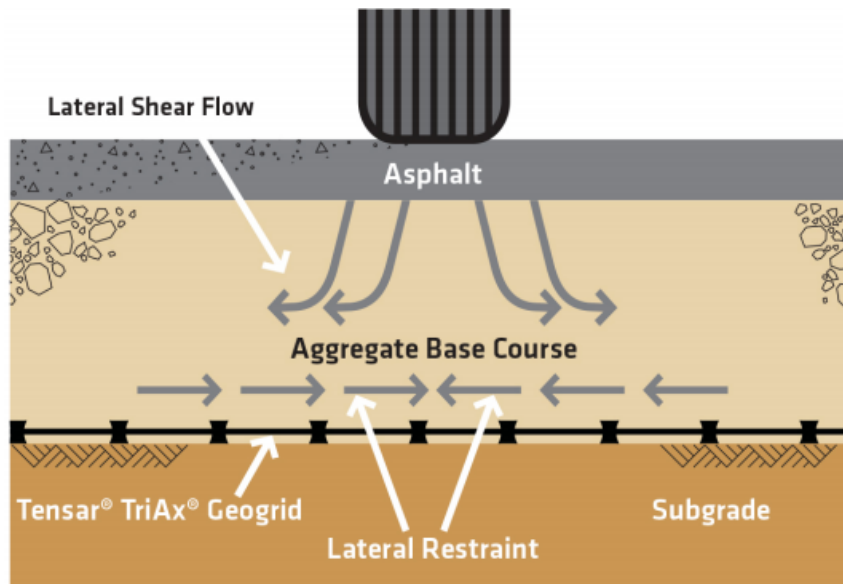


Figure 20: Subgrade Reinforcement Geogrid (TriAx, 2018)

The lateral restraint provided by geogrids will help address the tension cracking in the pavement of Sandy Ave observed in Figure 16. However, without more long-term data on the amount and rate of the local landslide zone, the performance of the geogrid cannot be

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accurately estimated. It is likely that the geogrid reinforcement would prevent cracking for some years, but will likely not prevent the underlying movement of the landslide zone.

Geogrids will also provide separation of the base and subgrade materials, as shown in Figure 21 below. Separation is critical to maintain the design thickness and stability, load carrying capacity of the base course (Christopher, 2010).

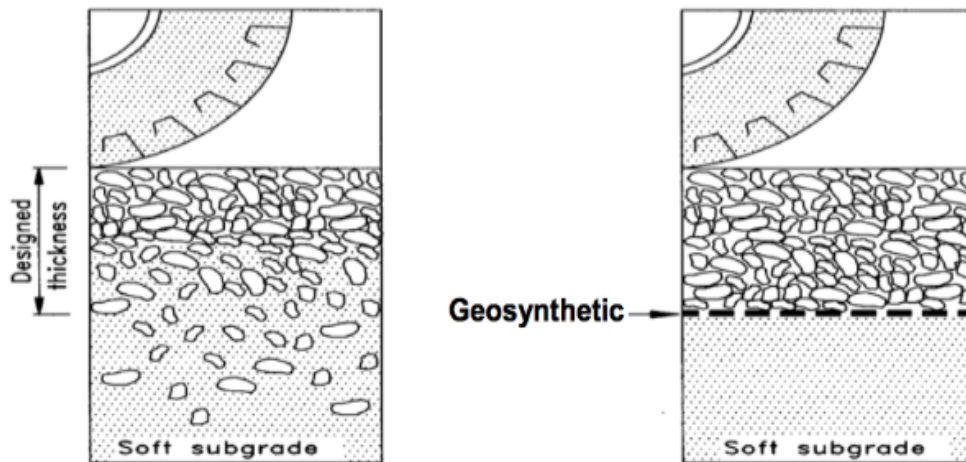


Figure 21: Subgrade Geogrid Reinforcement / Separation (Christopher, 2010)

Within stabilization design an improvement of roadbed is established. The base course thickness required to carry the design traffic loads for the design life of the pavement may be reduced due to improved roadbed condition (Christopher, 2010).

The most commonly utilized subgrade reinforcement geosynthetics are manufactured by Tensar; however, the ODOT Qualified Product List lists approved products from eight different manufacturers (ODOT- Qualified Product List, 2021). Tensar alone has four different approved products for this type of application. The specific type of geotextile will need to be determined as part of the engineering design process.

The geogrid subgrade reinforcement option is significantly cheaper and less complex compared to the MSE wall and soldier-pile wall alternatives. Specifically, the geogrid subgrade reinforcement option only requires rebuilding the roadway structure (pavement and base material) with the geogrid reinforcement, whereas the wall alternatives require significant excavation and drilling, and vertical concrete work.

In return for the lower cost, the geogrid subgrade reinforcement will likely have a shorter lifespan than the retaining wall alternatives. The lifespan and maintenance cannot be accurately estimated without long-term movement data from the site. Once additional data has been collected, the expected movement can be compared to the allowable movement for the selected geogrid and a lifespan could be estimated.

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5.2.4 Recommendation

The recommended landslide mitigation measure for this segment of Sandy Ave is a subgrade reinforcement geogrid. The primary reason for this recommendation is cost. The subgrade reinforcement geogrid only requires rebuilding the existing roadway structure with a subgrade geotextile, whereas the other measures such as the soldier pile wall and MSE wall require significant additional construction, including excavation, drilling, or vertical concrete work. The lower cost geogrid option, however, may have a significantly shorter design life, so continued monitoring and maintenance will be important.

5.3 GENERAL CONSTRUCTION SEQUENCE

The general construction sequence for reinforcement of the subgrade with a geotextile is essentially the same as rebuilding the roadway structure, with the exception that the geogrid is added after excavation. The following steps outline the general construction sequence:

1. Site Survey: In the beginning stage, a survey may be conducted for inspection on the area of work and gather information on design specifications and measurements.
2. Temporary Traffic Control: Traffic Control will need to be established to help travelers and residents along the 3rd and 4th St of SE Sandy Ave move freely.
3. Erosion Control Measures: Must be followed according to the Oregon Department of Transportation (ODOT) Erosion Control Manual.
4. Mobilization: The work consists of the mobilization and demobilization of the contractor's forces and equipment necessary for performing the work required under the contract (Construction Specification 408)
5. Removal of existing pavement surface: Existing pavement must be removed to begin the reconstruction process.
6. Excavation/grading of existing base and/or subgrade material: May need preliminary site survey to determine for excavation plan grading of existing base or subgrade material.
7. Place Geotextile Reinforcement: Follow installation procedures set by ODOT and the manufacturer of the geotextile product.
8. Place & compact base material: According to Shannon & Wilson site observation vibratory compaction should not be used within 100 feet of landslide zone. Therefore, rolling compaction is considered.
9. Place & compact pavement: Follow installation procedures set by ODOT and the manufacturer of the geotextile product.
10. Signage & striping: (if necessary)
11. Site cleanup / Monitoring: Clean and ensure project area is ready for use and no hazards are present to disrupt public safety, post term and long term monitoring plan must be set accordingly. Site observations and visits must be conducted.

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5.6 TEMPORARY TRAFFIC CONTROL PLAN

A temporary traffic control plan is necessary to organize traffic flowing as construction begins. Road closure signs will be used to indicate SE Sandy Ave is under construction along parallel roads SW Harlow Ave and intersecting roads of SE 3rd and 4th St. Vehicles will be detoured to alternative routes such as SE Harlow Ave, SE Dora Ave, or SE Buxton Road during construction. The site located along the intersection SE Sandy Ave intersecting SE 4th St will need to be closed off from public pedestrian and bike use with temporary road closure barricades during construction and digging of the road. A schematic of the proposed temporary traffic control plan is shown in Figure 22.

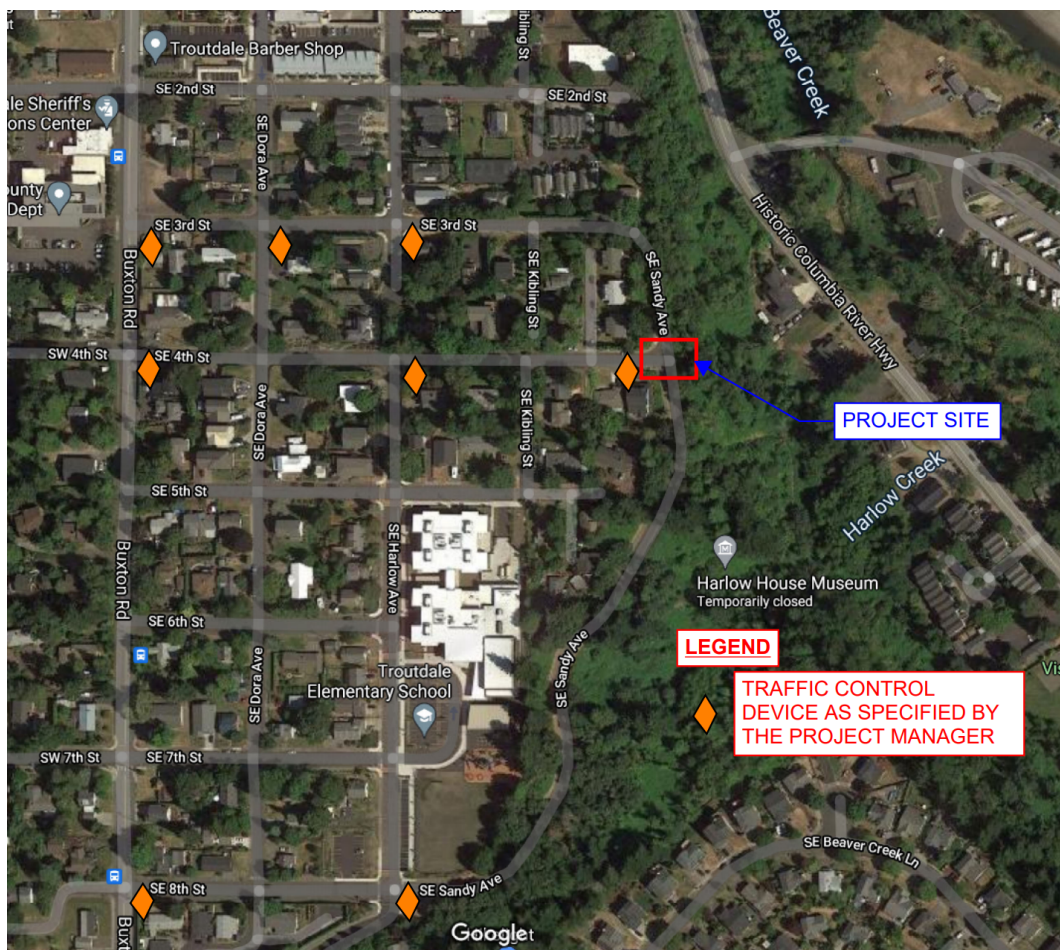


Figure 22: Temporary traffic control plan schematic for future geotechnical work

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The temporary traffic control plan for geotechnical work is similar to the control plan discussed in section 3.5 for the one-way design. Road closure barricades will be used during the time of closure and focus on blocking traffic at the 4th St intersection and SE Sandy Ave specifically during geotechnical work.

The traffic control plan is split into two stages. Stage 1 of the traffic control plan will have the construction zone extend along 3rd St up to the inflection point of Sandy Ave as shown in Figure 15 indicated by the hatched area. This will allow residents living at the corner lot to have access by driving northbound on Sandy Ave. Road closure barricades will be placed on 3rd St and at the Kibling right-of-way to prevent drivers from entering the construction zone. In addition to the barricades, the road will consist of “road closure warning signs” on 3rd St prior to SE Dora Ave. Additional signs will be positioned along 3rd St until SE Kibling St is reached, where road closure barricades will be placed. This segment of roadway will be closed during the pavement excavations and geotechnical changes completed at the site further down SE Sandy Ave.

The second stage of the temporary traffic control plan will close off the segment of Sandy Ave from 8th St up to 4th St as shown in Figure 23. Road closure signs will be used to indicate a road closure on the 4th St and Sandy Ave intersection. The signs will be placed on 4th St prior to SE Kibling street, and at the intersection of 4th St and Kibling St to indicate the upcoming road closure ahead. Barricades will be placed at the intersection of SE Harlow and SE Sandy avenue to prevent traffic from entering. Road closure barricades will serve to protect motorists and bicyclists from entering the road from either direction. The temporary traffic control plan can be referenced in Appendix I.

During the time of geotechnical remodeling, safety concerns pertaining to excavated site work and roadwork should impose additional barricades around the work zone at the SE 4th St SE Sandy intersection. The additional barricades serve to protect construction workers, provide an additional safety barrier on site, and reduce motorists speeds if a road closure sign is disregarded.

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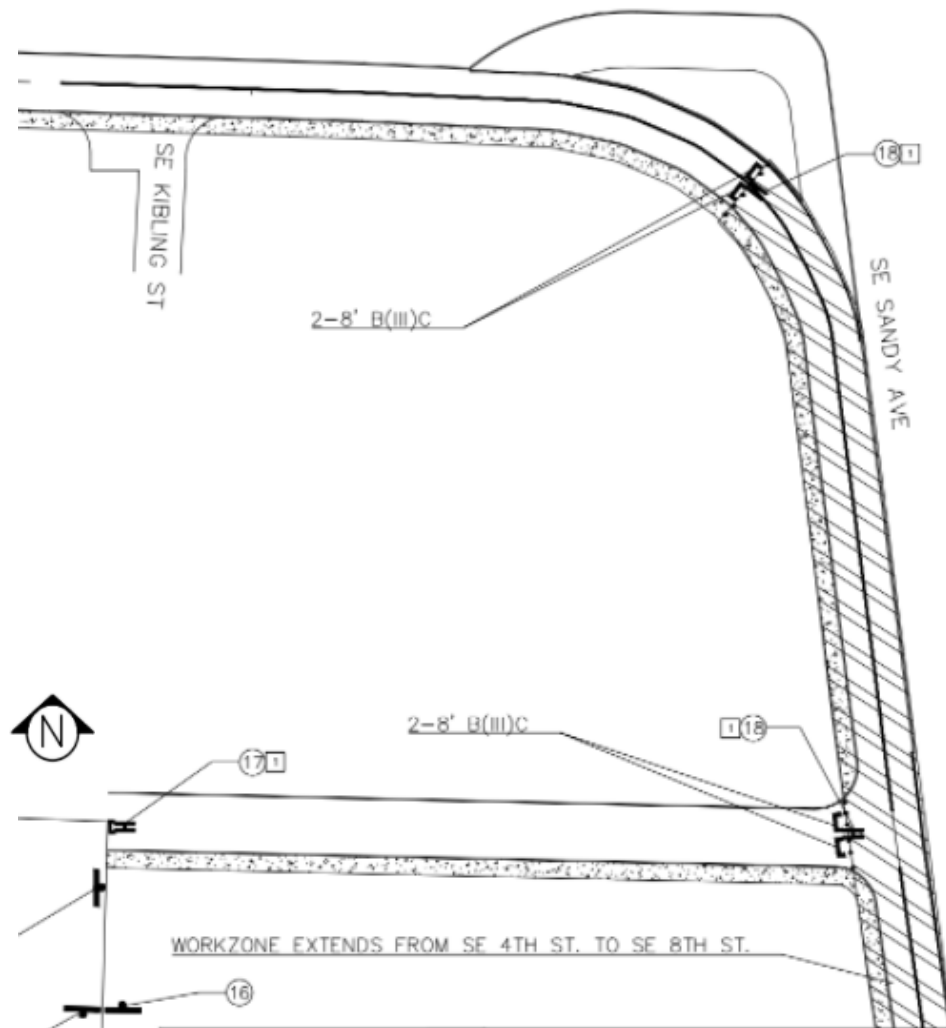


Figure 23: Temporary traffic control plan, Stage 2 excerpt

5.7 CONTRACTING COMPANIES

In general, construction contractors with experience in roadway construction should be familiar with the installation of geogrid subgrade reinforcement. Some of these local contractors include: Oregon Mainline LLC, LaDuke Construction LLC, Knife River, and K&E Excavation.

The geogrid reinforcement could be supplied by multiple manufacturers according to the ODOT Qualified Products List, but the most utilized subgrade reinforcement is made by Tensar. They provide design and cost estimate services for this type of project.

This type of subgrade reinforcement project may require additional design services from a pavement and/or geotechnical engineering consultant. Consulting firms with these required specialities include: Shannon & Wilson, WSP, HDR.

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5.8 COST ESTIMATE

A preliminary construction cost estimate for the subgrade reinforcement and roadway structure rebuild is provided below in Table 11. This cost estimate is based on the ODOT Weighted Average Item cost data (“average of low 3 bidders”) from 2019. The five primary bid items that form the basis for this cost estimate are: pavement removal, excavation, geotextile placement, base course, and new pavement. Some assumptions on roadway structure depths/levels were made, as follows:

- 100 ft length of geotextile to match the length of the MSE retaining wall proposed by Shannon & Wilson
- 30 ft roadway width
- Only 3 in of excavation, due to the subsidence of the existing roadway
- 8 in of base course
- 4 in of HMAC pavement

This construction cost data should include the price of installation/placement; however, it does not include some costs that are difficult to estimate, such as mobilization, clean-up, temporary traffic control, etc. Quantities of each item have been calculated and can be found in Appendix D-3. To account for this, a 30% contingency has been added to the estimate.

Table 11: Construction Cost Estimate for Pavement Rebuild with Subgrade Geotextile

Roadwork Description	Quantity	Unit Price	Amount
Pavement Removal 0310-0103000J	333 yd ²	\$8.95	\$2,983
Excavation of Existing Base/Subgrade 0330-0105000K	28 yd ³	\$10.59	\$296.52
Subgrade Reinforcement Geogrid 0350-0105000J	333 yd ²	\$1.27	\$423
Base course - 1” or ¾”	135 tons	\$41.00	\$8,282
Level 2, ½” Dense HMAC 0744-0202000M	67.5 tons	\$124.43	\$12,567.43
Subtotal			\$24551.95
30% Contingency			\$7365.59
TOTAL ESTIMATED COST			\$32,000

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6.0 CONCLUSION

This section will summarize the proposed design and outline recommendations for future work to finalize the design. It includes possible future recommendations found in section 6.4 below, which can be referred to further ideas to improve this project site.

6.1 SUMMARY

The current 30% proposed design solution for the Sandy Ave project includes facility design changes including, flexible bollards, closing one lane of vehicle traffic, adding a two way bike lane facility, a small barrier, new signs, new striping, and a bicycle transition. In addition to the 30% proposed design reconfiguration, a geotechnical roadmap is included within this report to help guide the client for possible geotechnical work for Sandy Ave. The design evolved by addressing client guidance. Additionally, the project team refocused efforts to address the concerns brought up by the local representatives.

6.2 BENEFITS

One of the goals of reconfiguring Sandy Ave was to reduce the loading on the hillside roadway. By closing one lane of traffic and transforming it into a bike facility, the theoretical volume of traffic would be reduced by half. Vehicles would still maintain access along the roadway. With the flexible bollards installed, emergency vehicles will still be able to access the roadway in both directions if necessary. Additionally, by adding a bike facility the team hopes this will add comfort and safety to cyclists who choose to utilize Sandy Ave.

6.3 LIMITATIONS

The selected alternative is relatively low cost and should be easy to install. However, due to drastic traffic flow changes, locals who did not get a chance to express their opinion may be unhappy with the changes or may find the changes inconvenient. Furthermore, the project area is located on a large hill, and many of the main roads have an average grade of 8 to 9 percent. If severe weather conditions such as snow or ice impact the roads, people may not be able to travel safely to their destination since Sandy Ave will be one-way travel. The treatments proposed by this design may have less impact than the existing roadway or other potential solutions.

6.4 NEXT STEPS AND RECOMMENDATIONS

Due to the large change in traffic pattern, it is recommended that this 30% design be proposed before the Troutdale Citizen's Advisory Committee, City Council, and local homeowners be directly reached for comment. If consensus cannot be reached on the conversion of Sandy after community feedback and any required design plan revisions, it is recommended that the City of Troutdale move forward with the geotechnical solution.

Design Report (Final Draft)

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APPENDICES

The following appendices are attached.

A. Construction Cost Estimate

An initial cost estimate for the construction of the SAC project proposed design solution is included in this appendix.

B. Construction Schedule

An estimated construction schedule Gantt chart has yet to be completed. Information will be gathered for the addition of this document in subsequent Design Report Drafts

C. Drawings

A plan set that communicates the SAC project of the proposed design solution is included in this appendix.

D. Calculations

Calculations addressing traffic control treatments specific to the SAC project site are included in this appendix.

G. Existing Conditions**H. Proposed Alternative Designs****I. Temporary Traffic Control Plan****J. QC Checklist****K. Group Poster****L. Final Presentation**

Appendix A
Construction Cost Estimate



Sandy Ave. Construction Cost Estimate				
Section	Item	Quantity/ft2/ft	Cost per Each	Total Cost
Temporary Traffic Control Plan (TTCP)	Temporary Signs (size varies, sheet aluminum)	245 ft2	\$ 18.00	\$ 4,320.00
	Temporary Barricades (8ft)	6	\$ 115.00	\$ 690.00
	Temporary Barricades (4ft)	1	\$ 115.00	\$ 115.00
Traffic Control Plan (TCP)	Striping Removal	3600 ft	\$ 0.45	\$ 1,620.00
	Install 4" Solid White Striping	6000 ft	\$ 0.50	\$ 3,000.00
	Bike Symbol	7	\$ 65.00	\$ 455.00
	Permanent Signs	70 ft2	\$ 18.00	\$ 1,260.00
	Wood Sign Posts	6	\$ 9.00	\$ 54.00
	Barricade (4ft)	1	\$ 115.00	\$ 115.00
	Tubular Markers/Bollards	250	\$ 52.00	\$ 13,000.00
	Pavement Bars (Crosswalks/Stop Bars)	50	\$ 5.00	\$ 250.00
Subtotal				\$ 24,879.00
30% Contingency				\$ 7,463.70
Total Estimated Cost				\$ 32,342.70

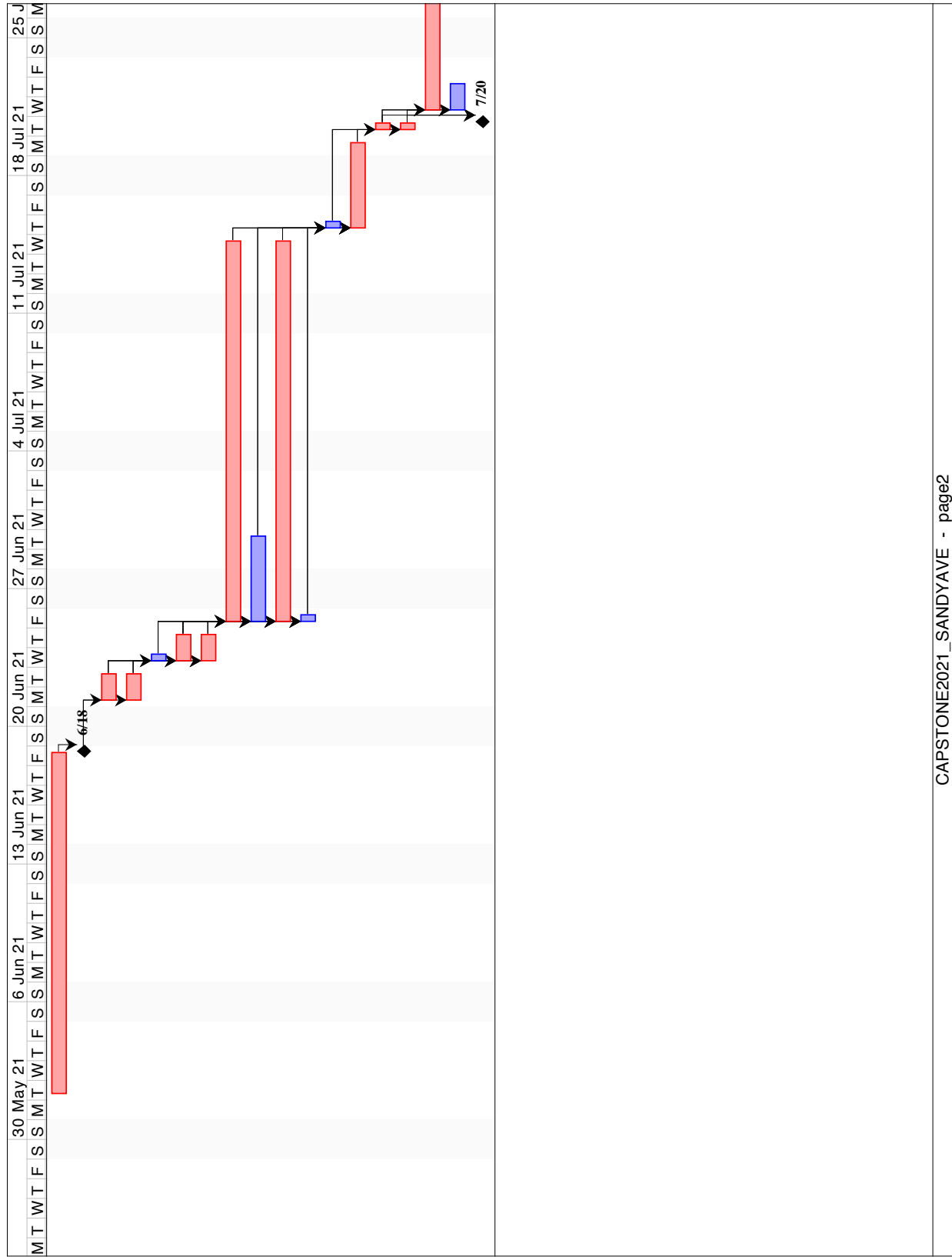
Note: Construction costs are taken into account within the cost estimate.
 Flaggers were not incorporated within this estimate.

References

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Appendix B
Construction Schedule

		Name	Duration	Start	Finish	Total Slack	Predecessors
1		PERMIT	14 days	6/1/21 8:00 AM	6/18/21 5:00 PM	0 days	
2		START	0 days	6/18/21 5:00 PM	6/18/21 5:00 PM	0 days	1
3		ROAD CLOSURE	2 days	6/21/21 8:00 AM	6/22/21 5:00 PM	0 days	2
4		MOBILIZATION 1	2 days	6/21/21 8:00 AM	6/22/21 5:00 PM	0 days	2
5		8TH CONSTRUCTION PREP	1 day	6/23/21 8:00 AM	6/23/21 5:00 PM	1 day	3;4
6		4TH CONSTRUCTION PREP	2 days	6/23/21 8:00 AM	6/24/21 5:00 PM	0 days	3;4
7		3RD CONSTRUCTION PREP	2 days	6/23/21 8:00 AM	6/24/21 5:00 PM	0 days	3;4
8		STRIPING	14 days	6/25/21 8:00 AM	7/14/21 5:00 PM	0 days	5;6;7
9		SIGNS PLACEMENT	3 days	6/25/21 8:00 AM	6/29/21 5:00 PM	11 days	5;6;7
10		BOLLARDS PLACEMENT	14 days	6/25/21 8:00 AM	7/14/21 5:00 PM	0 days	5;6;7
11		BARRIERS	1 day	6/25/21 8:00 AM	6/25/21 5:00 PM	13 days	5;6;7
12		INSPECTION	1 day	7/15/21 8:00 AM	7/15/21 5:00 PM	2 days	8;9;10;11
13		PUNCHLIST	3 days	7/15/21 8:00 AM	7/19/21 5:00 PM	0 days	8;9;10;11
14		MOBILIZATION 2	1 day	7/20/21 8:00 AM	7/20/21 5:00 PM	0 days	12;13
15		SITE CLEAN UP	1 day	7/20/21 8:00 AM	7/20/21 5:00 PM	0 days	12;13
16		CLOSE PERMIT	14 days	7/21/21 8:00 AM	8/9/21 5:00 PM	0 days	14;15
17		FINAL CLOSE OUT	2 days	7/21/21 8:00 AM	7/22/21 5:00 PM	12 days	14;15
18		END	0 days	7/20/21 5:00 PM	7/20/21 5:00 PM	14 days	14;15



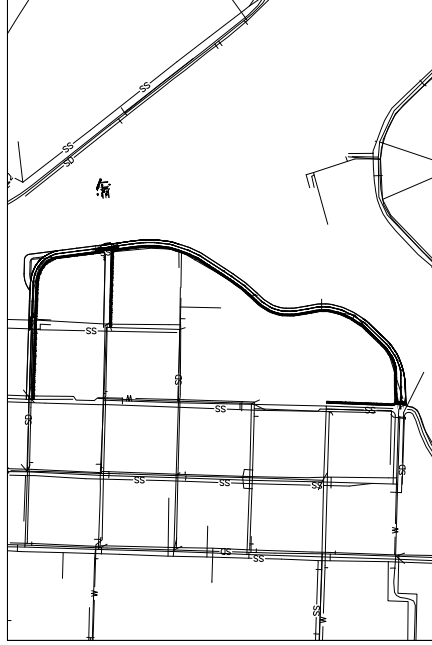
Jul 21	1 Aug 21	8 Aug 21	15 Aug 21	22 Aug 21	29 Aug 21	5 Sep 21
T	F	S	S	M	T	F
F	S	M	T	W	T	F
S	M	T	W	T	F	S
M	T	W	T	F	S	M
T	W	T	F	S	M	T
W	T	F	S	M	T	W

Appendix C

Drawings

SE SANDY CONVERSION

30% SUBMITTAL



PROJECT AREA
NOT TO SCALE

SHEET INDEX	
NUMBER	SHEET TITLE
C0.0	COVER SHEET
C2.0	OVERALL SITE PLAN
C2.1	3RD AND SE SANDY
C2.2	4TH AND SE SANDY
C2.3	8TH AND SE SANDY
C2.4	SE SANDY AVE TYPICAL SECTION ELEVATION VIEW
C2.5	SE SANDY AVE TYPICAL SECTION PLAN VIEW
C2.7	SIGN GLOSSARY

CLIENTS		CONTACT INFO	
NAME	TITLE	NAME	CONTACT INFO
CHRIS DAMGEN	COMMUNITY DEVELOPMENT DIRECTOR	CHRIS.DAMGEN@TROUTDALE.OREGON.GOV	
AMBER SHACKELFORD	ASSISTANT PLANNER	AMBER.SHACKELFORD@TROUTDALE.OREGON.GOV	

DATE	REVISION	BY

DO NOT SCALE THIS DRAWING
FOR MEASUREMENTS. ALL
SCALES CORRECT ONLY FOR
FULL SIZE SHEET (22"X34")

GROUP MEMBERS	
NAME	TITLE
SHIORI BABA	PM
PAUL BRAVERMAN	APM
KODY PAK	UTILITIES MANAGER
MARIE BURKOFF	DESIGN AND CODE MANAGER
AHMED ALI	CIVIL/CONSTRUCTION DESIGNER
ARVIND DATA	SITE/CIVIL DESIGNER
NATHAN RIDDLE	QUALITY CONTROL ENGINEER
RYAN RUSSELL	CAD LEAD



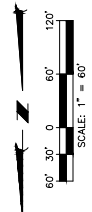
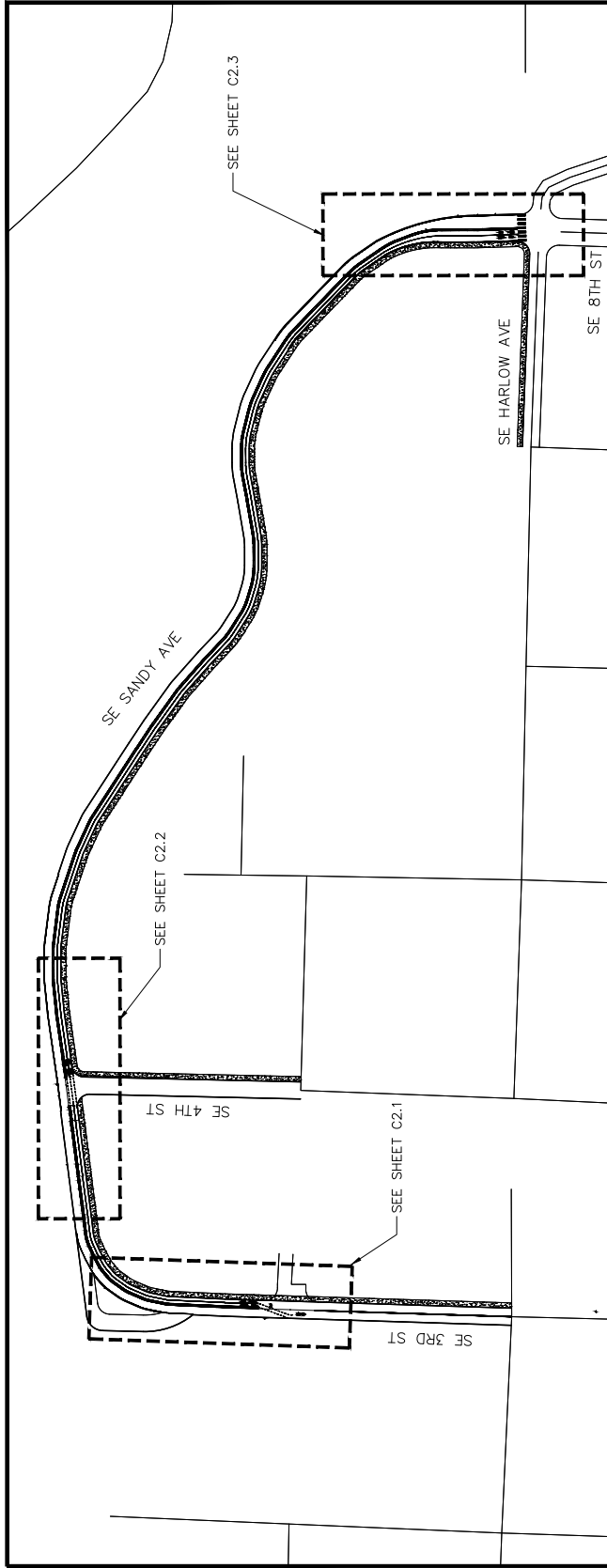
Portland State
941441117
Civil & Environmental Engineering Capstone

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DESIGNER: RAR REVIEWER: SB

SE SANDY AVE CONVERSION
2021.TROUT.04

SHEET NO. C0.0

COVER SHEET

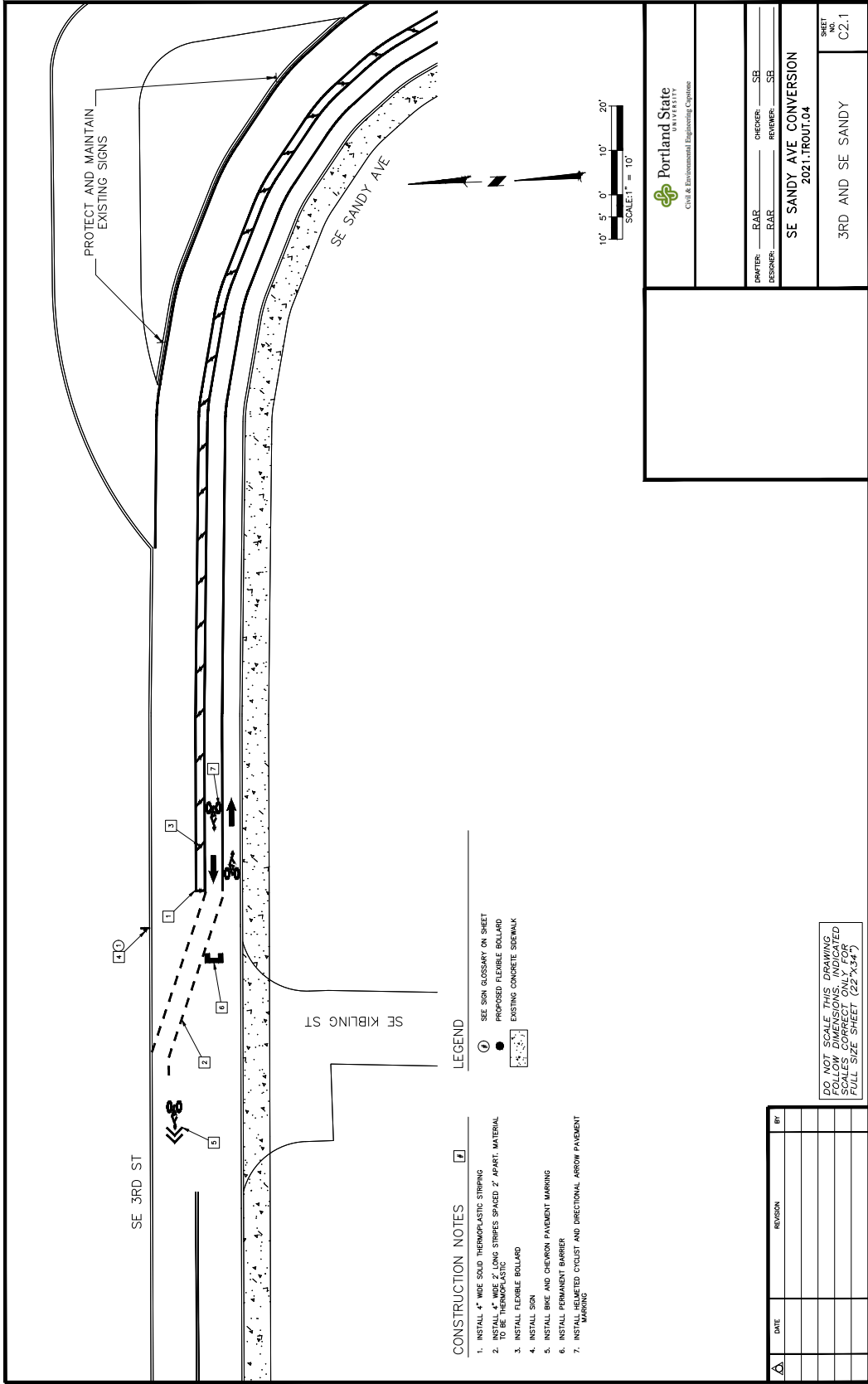


 Portland State University Civil & Environmental Engineering Offices	
WRITER: <u>BAR</u> CHECKER: <u>SR</u>	DRAWN: <u>BAR</u> REVIEWER: <u>SB</u>
SE SANDY AVE CONVERSION 2021.TROUT.04	
OVERALL SITE PLAN	
SHEET No. C2.0	

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DATE	REVISION	BY

PLOT DATE: 6/9/2021 PLOT TIME: 11:25 PM USER: Rjyn



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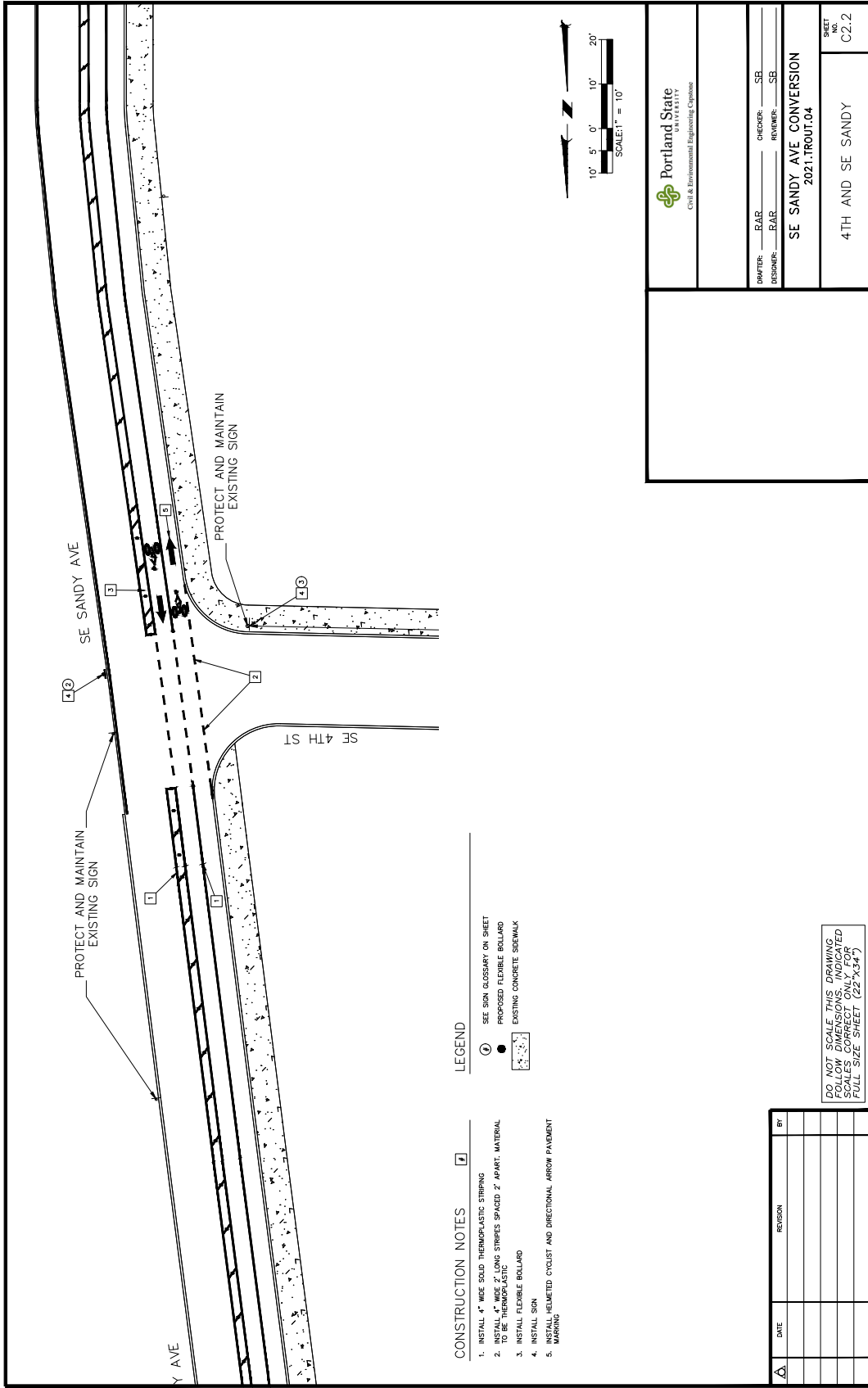
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SE SANDY AVE CONVERSION
 2021.TROUT.04

3RD AND SE SANDY

SHEET NO. C2.1



- CONSTRUCTION NOTES**
1. INSTALL 4" WIDE SOLID THERMOPLASTIC STRIPING
 2. INSTALL 4" WIDE 2" LONG STRIPES SPACED 2' APART. MATERIAL TO BE THERMOPLASTIC
 3. INSTALL FLEXIBLE BOLLARD
 4. INSTALL SIGN
 5. INSTALL HELMETED CYCLIST AND DIRECTIONAL ARROW PAVEMENT MARKING

- LEGEND**
- ④ SEE SIGN GLOSSARY ON SHEET
 - PROPOSED FLEXIBLE BOLLARD
 - ▨ EXISTING CONCRETE SIDEWALK

DATE	REVISION	BY

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FOLLOWS CONTACT WITH FULL
SCALE SHEET (24" X 36")

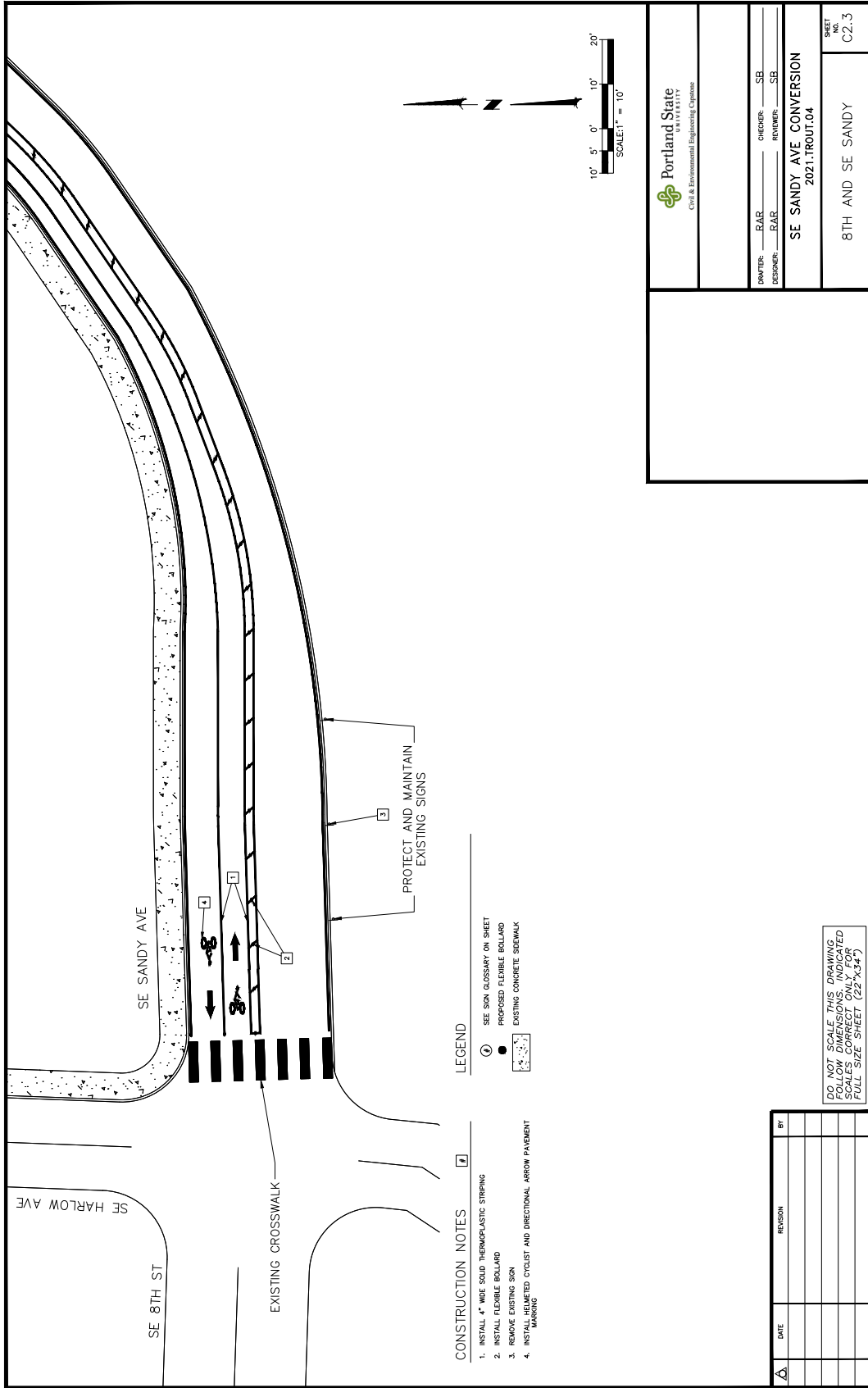
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Civil & Environmental Engineering Expenses

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4TH AND SE SANDY

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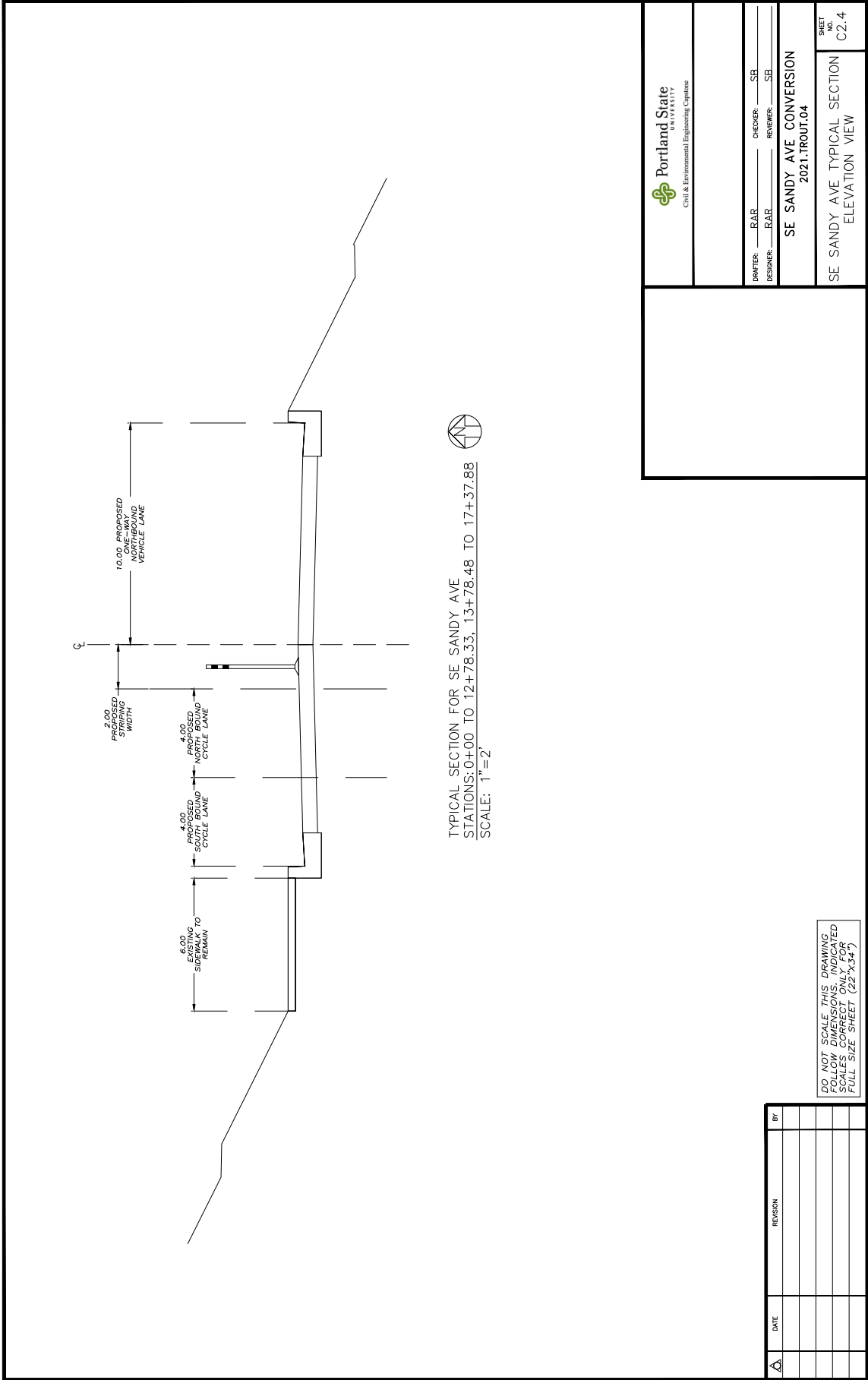
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Civil & Environmental Engineering Capstone

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SE SANDY AVE CONVERSION
2021.TROUT.04

8TH AND SE SANDY


SHEET NO. C2.3



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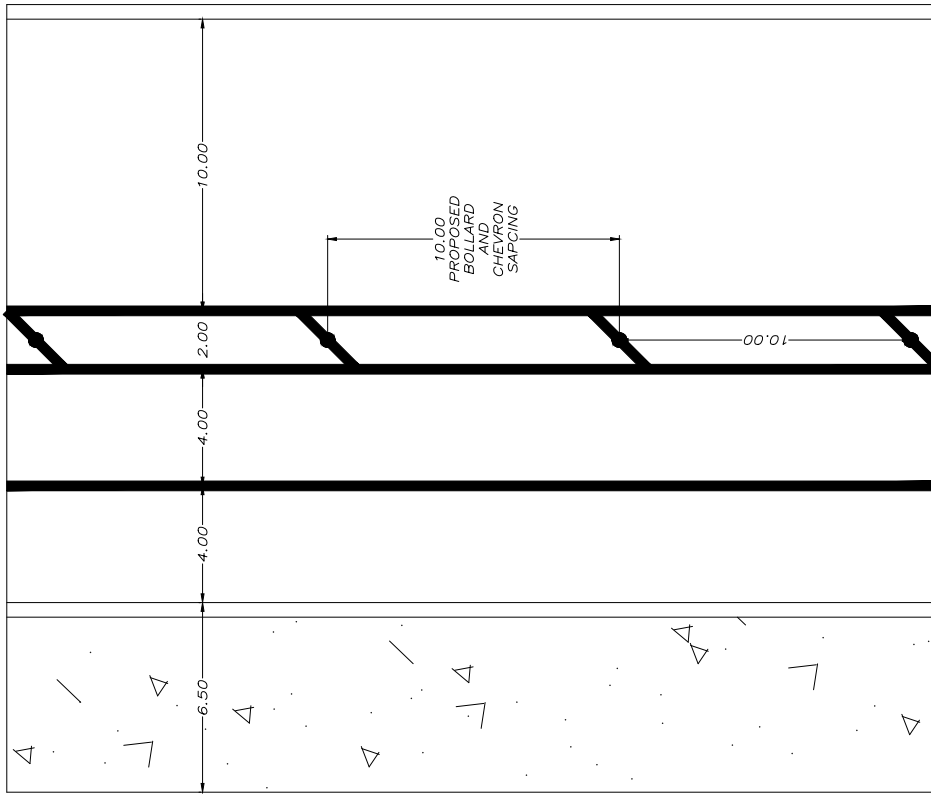
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 DESIGNER: E.A.R. REVIEWER: S.E.I.

SE SANDY AVE CONVERSION
 2021.TROUT.04

SHEET
 SE SANDY AVE TYPICAL SECTION
 ELEVATION VIEW C2.4



TYPICAL SECTION FOR SE SANDY AVE
 STATIONS: 0+00 TO 12+78.33, 13+78.48 TO 17+37.88
 SCALE: 1"=2'



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 SCALE: 1"=2'
 FULL SIZE SHEET (24" X 36")

DATE	REVISION	BY

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 UNIVERSITY
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 DESIGNED: RAR REVIEWER: SB

SE SANDY AVE CONVERSION
 2021.TROUT.04

SE SANDY AVE TYPICAL SECTION
 PLAN VIEW

SHEET
 OF
 C2.5

PLOT DATE: 6/9/2021 PLOT TIME: 11:59 AM USER: Rym

Appendix D

Calculations

1
R6-1L
36" x 12"

2
OBW1-9R
30" x 30"

3
R1-2
18"

4
R3-5L
30" x 36"

5
W14-1
30" x 30"

6
W1-6L
24" x 12"

7
W1-6R
24" x 12"

8
W11-1
24" x 24"

OW11-1a
24" x 18"

9
W1-5L
30" x 30"

W13-1p
18" x 18"

10
R5-3
24" x 24"

LEGEND

EXISTING SIGN

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

NO.	DATE	BY	REVISION

Portland State UNIVERSITY
Civil & Environmental Engineering Capstone

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DESIGNED BY: RAR REVIEWED BY: SB

SE SANDY AVE CONVERSION
TROUTDALE, OR

SIGN GLOSSARY C2.7

Table of Calculations

This sheet lists the calculations for this project

#	Calculation Title
D-1	Bollard Quantity
D-2	Determining Taper Length
D-3	Geotechnical Cost Quantities

D.1: Determining the Number of Bollards to Install

For calculating the number of bollards to install along the centerline of Sandy Ave as a function of roadway length.

x	--	bollards	<i>number of bollards to install</i>
N	3	intersections	<i>number of intersections along roadway</i>
L	1800	ft	<i>Length of roadway segment</i>
s	10	ft	<i>Desired spacing of bollards</i>
f	1.05		<i>factor to account for locations where bollard spacing is reduced for safety</i>

$$x = 1.05 \left(15 \times N + \frac{L}{s} \right)$$

$$x = 1.05 \left(15 \times 3 \text{ intersections} + \frac{1800 \text{ ft}}{10 \text{ ft}} \right) = \underline{\underline{227 \text{ bollards}}}$$

** Cost estimate reflects additional bollards to use as replacements

D.2: Determining Taper Length

This equation, taken directly from Section 6C.08 of the MUTCD, is used for determining the ideal length for cyclists to shift from the dedicated bike lane on Sandy Ave. to the shared vehicle lane on 3rd St.

l	--	ft	<i>Length of taper</i>
w	10.5	ft	<i>Width of shift from bike lane to shared roadway</i>
s	15	mph	<i>Cyclists speed</i>

$$l = \frac{ws^2}{60}$$

$$l = \frac{(10.5 \text{ ft})(15 \text{ mph})^2}{60} = \underline{\underline{39.4 \text{ ft}}}$$

References:

U.S. Department of Transportation Federal Highway Administration. (2009). *Manual on Uniform Traffic Control Devices*. <https://mutcd.fhwa.dot.gov>, United States of America, 862.

D.3: Geotechnical Cost Quantities

Roadwork Description

The following will calculate quantity items for the cost estimate for subgrade reinforcement and roadway structure rebuild

Assumptions

- 100 ft length of geotextile to match the length of the MSE retaining wall proposed by Shannon & Wilson
- 30 ft roadway width
- Only 3” of excavation, due to the subsidence of the existing roadway
- 8” of base course
- 4” of HMAC pavement
- Material density is 3650 lbs/yd³

Pavement Removal

l	100	ft	<i>Length of geotextile, taken from Shannon & Wilson as reference</i>
w	30	ft	<i>Roadway width</i>

$$l \times w = \text{area of Pavement removal}$$

$$100 \text{ ft} \times 30 \text{ ft} = 3000 \text{ ft}^2$$

$$3000 \text{ ft}^2 \times \left(\frac{1 \text{ yd}}{3 \text{ ft}}\right)^2 = 333 \text{ yd}^2$$

Excavation of Existing Base and Subgrade

l	100	ft	<i>Length of geotextile, taken from Shannon & Wilson as reference</i>
w	30	ft	<i>Roadway width</i>
d	3	in	<i>Depth of excavation</i>

$$l \times w \times d = \text{Excavation volume}$$

$$100 \text{ ft} \times 30 \text{ ft} \times \frac{3 \text{ in}}{12 \text{ in/ft}} = 750 \text{ ft}^3$$

$$750 \text{ ft}^3 \times \left(\frac{1 \text{ yd}}{3 \text{ ft}}\right)^3 = 27.78 \text{ yd}^3$$

Subgrade Reinforcement Geogrid

l	100	ft	<i>Length of geotextle, taken from Shannon & Wilson as reference</i>
w	30	ft	<i>Roadway width</i>

$$l \times w = \text{area of geogrid needed}$$

$$100 \text{ ft} \times 30 \text{ ft} = 3000 \text{ ft}^2$$

$$3000 \text{ ft}^2 \times \left(\frac{1 \text{ yd}}{3 \text{ ft}}\right)^2 = 333 \text{ yd}^2$$

Base Course 1" minus

l	100	ft	<i>Length of geotextle, taken from Shannon & Wilson as reference</i>
w	30	ft	<i>Roadway width</i>
d	8	in	<i>Depth to fill</i>
ρ	3650	lb/yd ³	<i>Density of rock</i>

$$l \times w \times d = \text{Excavation volume}$$

$$\text{Volume} \times \rho = \text{tonnage of rock}$$

$$100 \text{ ft} \times 30 \text{ ft} \times \frac{8 \text{ in}}{12 \text{ in/ft}} = 2000 \text{ ft}^3$$

$$74.07 \text{ yd}^3 \times 3650 \frac{\text{lb}}{\text{yd}^3} \times \frac{1 \text{ ton}}{2000 \text{ lb}} = 135.19 \text{ tons}$$

Level 2, 1/2" Dense HMAC

l	100	ft	<i>Length of geotextle, taken from Shannon & Wilson as reference</i>
w	30	ft	<i>Roadway width</i>
d	4	in	<i>Depth to fill</i>
ρ	3650	lb/yd ³	<i>Density of rock</i>

$$l \times w \times d = \text{Excavation volume}$$

$$\text{Volume} \times \rho = \text{tonnage of rock}$$

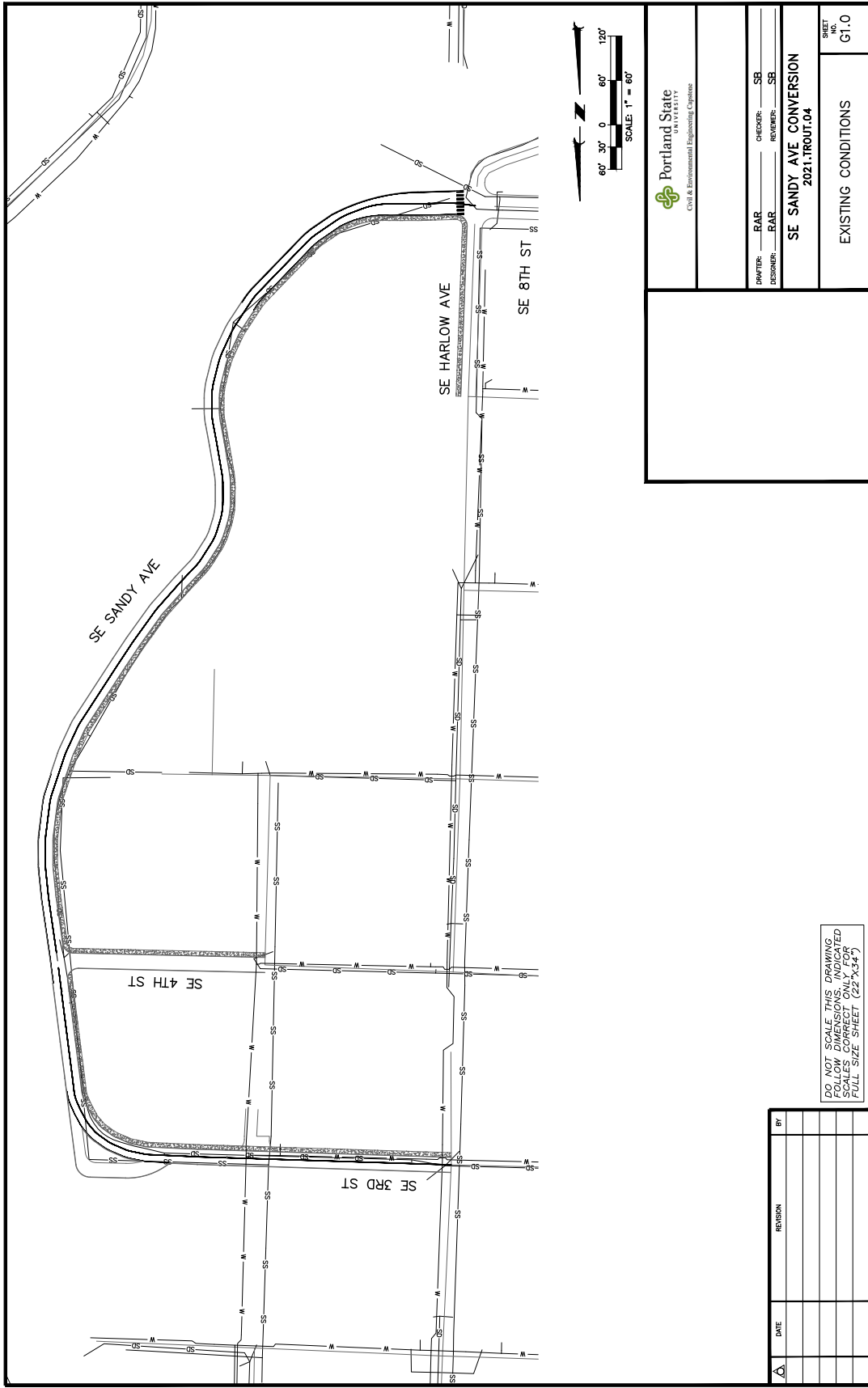
$$100 \text{ ft} \times 30 \text{ ft} \times \frac{4 \text{ in}}{12 \text{ in/ft}} = 1000 \text{ ft}^3$$

$$37.04 \text{ yd}^3 \times 3650 \frac{\text{lb}}{\text{yd}^3} \times \frac{1 \text{ ton}}{2000 \text{ lb}} = 67.5 \text{ tons}$$

References:

Oregon Department of Transportation. (2020). *Oregon DOT Weighted Average Item Prices - Calendar Year 2019*. Oregon Department of Transportation.

Appendix G
Existing Conditions



<p>Portland State University Civil & Environmental Engineering, Capstone</p>	
DRAWN BY: RAR	CHECKED BY: SER
DESIGNED BY: RAR	REVIEWED BY: SER
<p>SE SANDY AVE CONVERSION 2021.TROUT.04</p>	
<p>EXISTING CONDITIONS</p>	
<p>SHEET G1.0</p>	

DO NOT SCALE THIS DRAWING
FOLLOW DIMENSIONS INDICATED
ON FULL SIZE SHEET (22" X 34")

DATE	REVISION	BY

PLOT DATE: 6/9/2021 PLOT TIME: 12:02 PM USER: Ryan

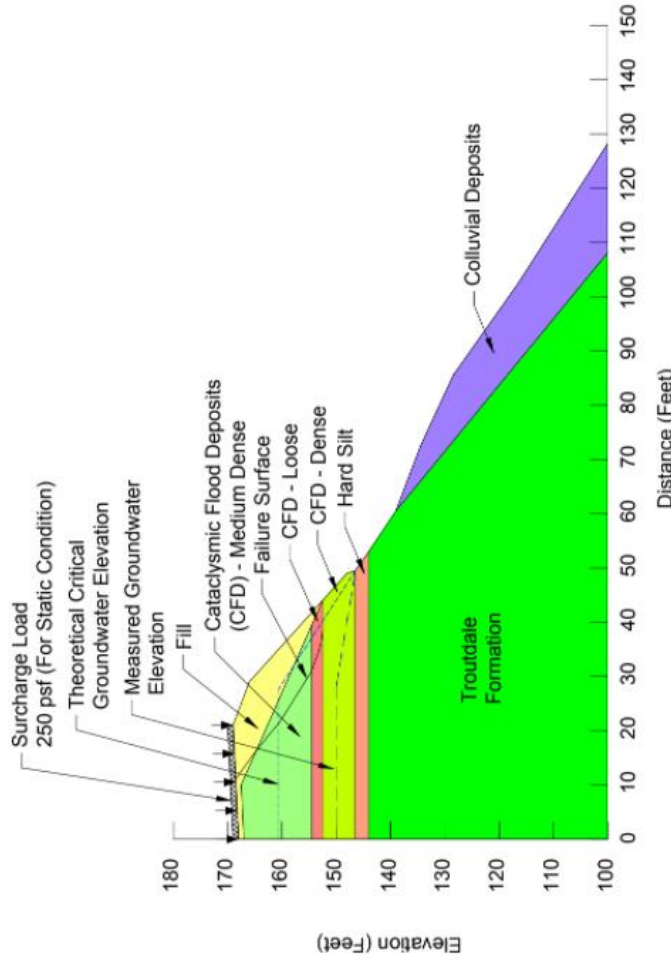
EXISTING CONDITIONS.DWG

Appendix G.2 Sandy Avenue Geological Site Plan

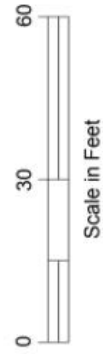


Appendix G.3 Sandy Avenue Geological Cross Section

File: I:\EF24-1_PDX\04200s\04218 SE 2nd St and S/DRAFTING\Slope Stability Figures\StabilityFigure.dwg Date: 03-16-2018 Author: kjw



Fill: Unit Weight=115 pcf Cohesion=50 psf Friction Angle=30°
 Catastrophic Flood Deposit (CFD) - Medium Dense: Unit Weight=115 pcf Cohesion=50 psf Friction Angle=28°
 CFD - Loose: Unit Weight=115 pcf Cohesion=0 psf Friction Angle=25°
 CFD - Dense: Unit Weight=115 pcf Cohesion=50 psf Friction Angle=36°
 Troutdale Formation: Unit Weight=135 pcf Cohesion=100 psf Friction Angle=40°
 Colluvial Deposit: Unit Weight=115 pcf Cohesion=0 psf Friction Angle=28°



NOTES

1. Critical failure surface estimated using the entry and exit search criteria and the Morgenstern and Price analysis method.
2. Horizontal seismic coefficient used for seismic analysis is 0.18.

SE 2nd Street / SE Sandy Avenue
Stability Assessment
Troutdale, Oregon

**SECTION C-C'
GLOBAL STABILITY**

March 2018 24-1-04218-001

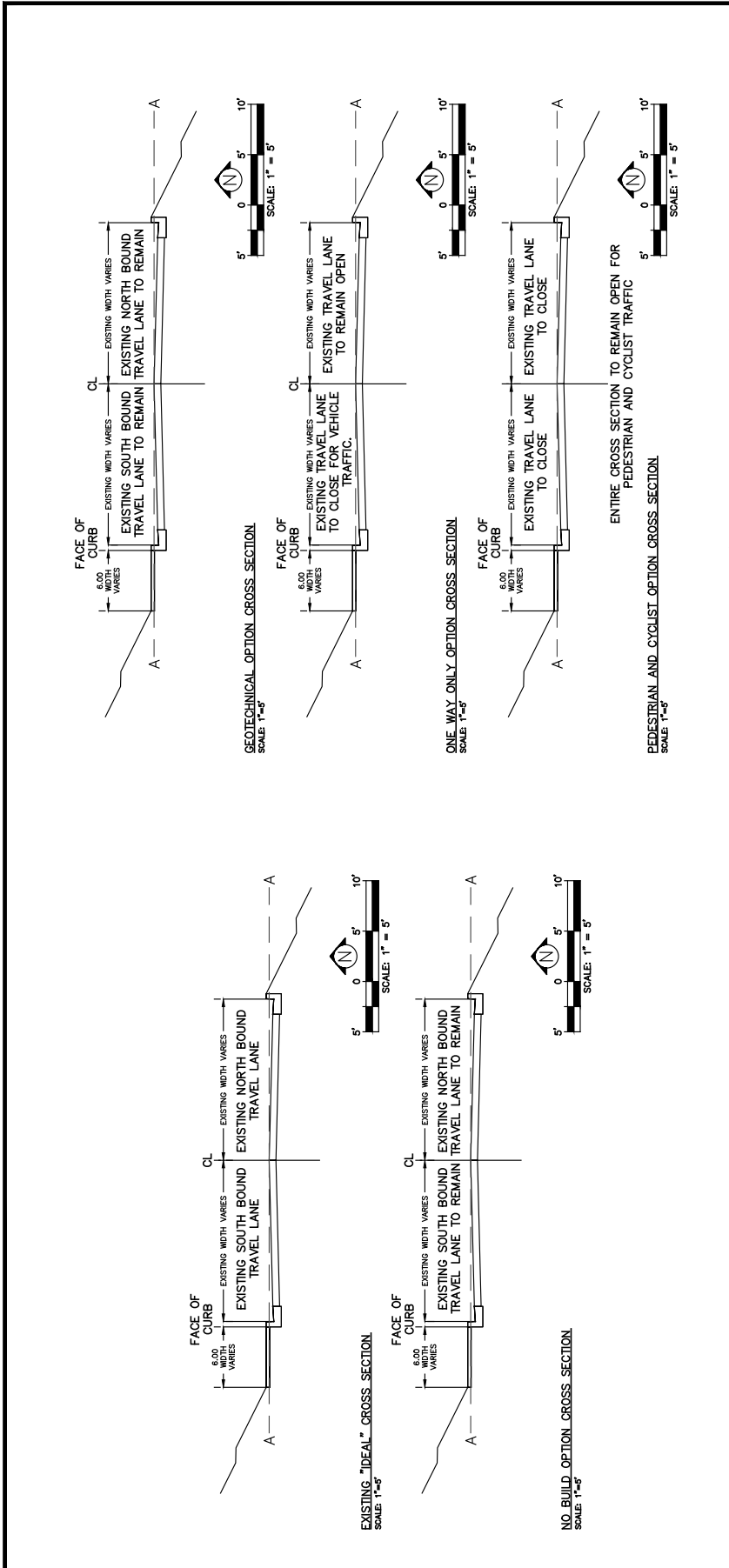
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 9

FIG. 9

Appendix H
Proposed Alternative Designs

Appendix I
Temporary Traffic Control Plan



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

NO.	DATE	REVISION	BY

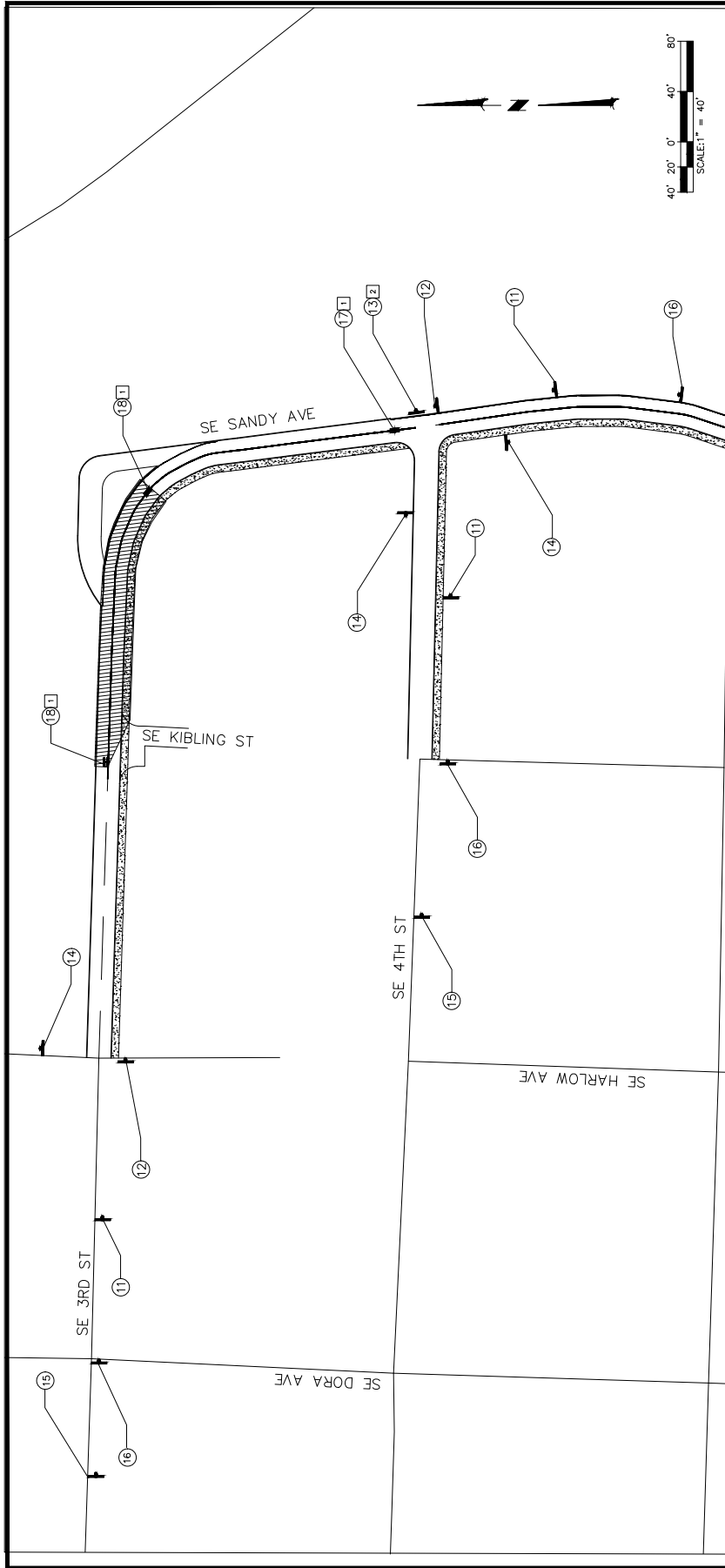
PLOT DATE: 6/9/2021 PLOT TIME: 12:05 PM USER: Ryan


Portland State
UNIVERSITY
Civil & Environmental Engineering Capstone

DRFTER: RAR CHECKER: SB
DESIGNER: RAR REVIEWER: SB

SE SANDY AVE CONVERSION
2021.TROUT.04

SHEET NO. H1.0
ALTERNATIVES ANALYSIS
TYPICAL SECTIONS




Portland State University
 Civil & Environmental Engineering Campus

DRAFTER: BAR CHECKER: SE
 DESIGNER: BAR REVIEWER: SE





SE SANDY AVE CONVERSION
 2021.TROUT.04

SHEET NO. **11.0**
 TEMPORARY TRAFFIC CONTROL
 SIGN PLAN, STAGE 1

CONSTRUCTION NOTES

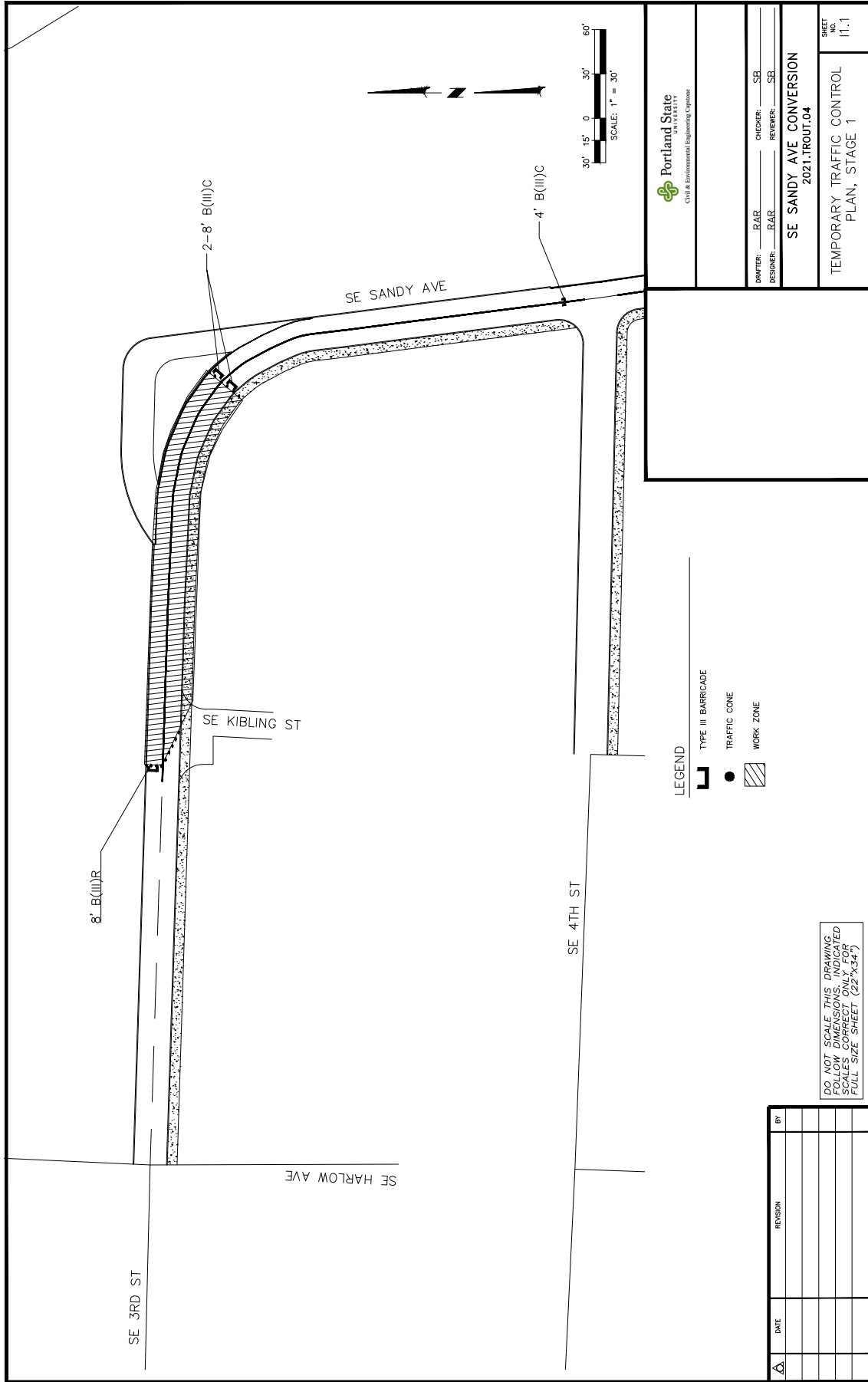
- INSTALL ON TEMPORARY SIGN SUPPORT
- INSTALL ON EXISTING BARRIER


LEGEND

-  WORK ZONE
-  TEMPORARY SIGN SUPPORT
-  TEMPORARY SIGN POST
-  INSTALL SIGN NO. # SEE SHEET 11.4

DO NOT SCALE THIS DRAWING
 FOLLOW DIMENSIONS, INDICATED
 SCALES CORRECT ONLY FOR
 FULL SIZE SHEET (24" X 36")

DATE	REVISION	BY







Portland State University
 Civil & Environmental Engineering Campus

DRAFTER: BAR CHECKER: SE
 DESIGNER: BAR REVIEWER: SE

SE SANDY AVE CONVERSION
 2021.TROUT.04

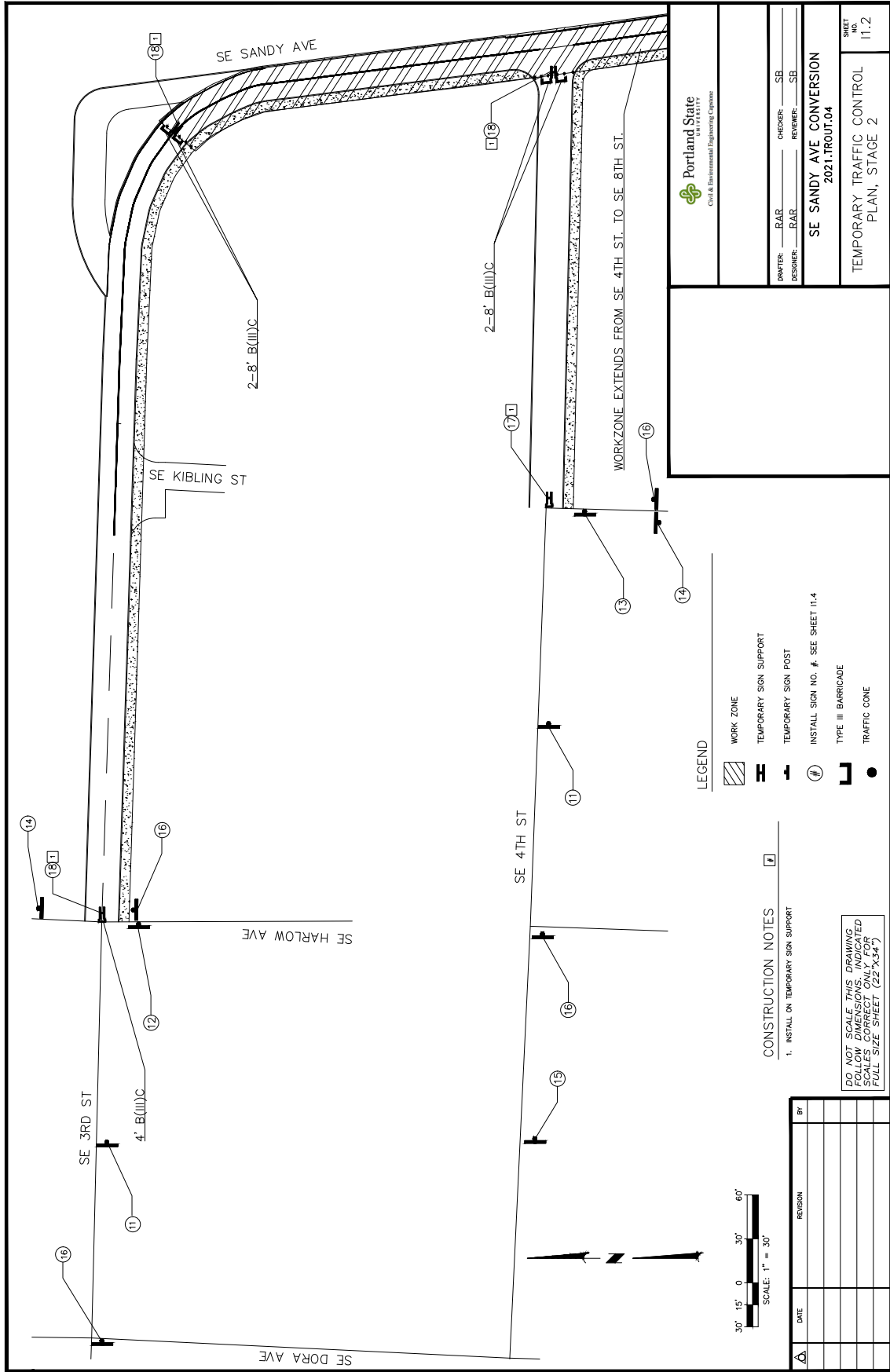
SHEET NO. 11.1
 TEMPORARY TRAFFIC CONTROL PLAN, STAGE 1

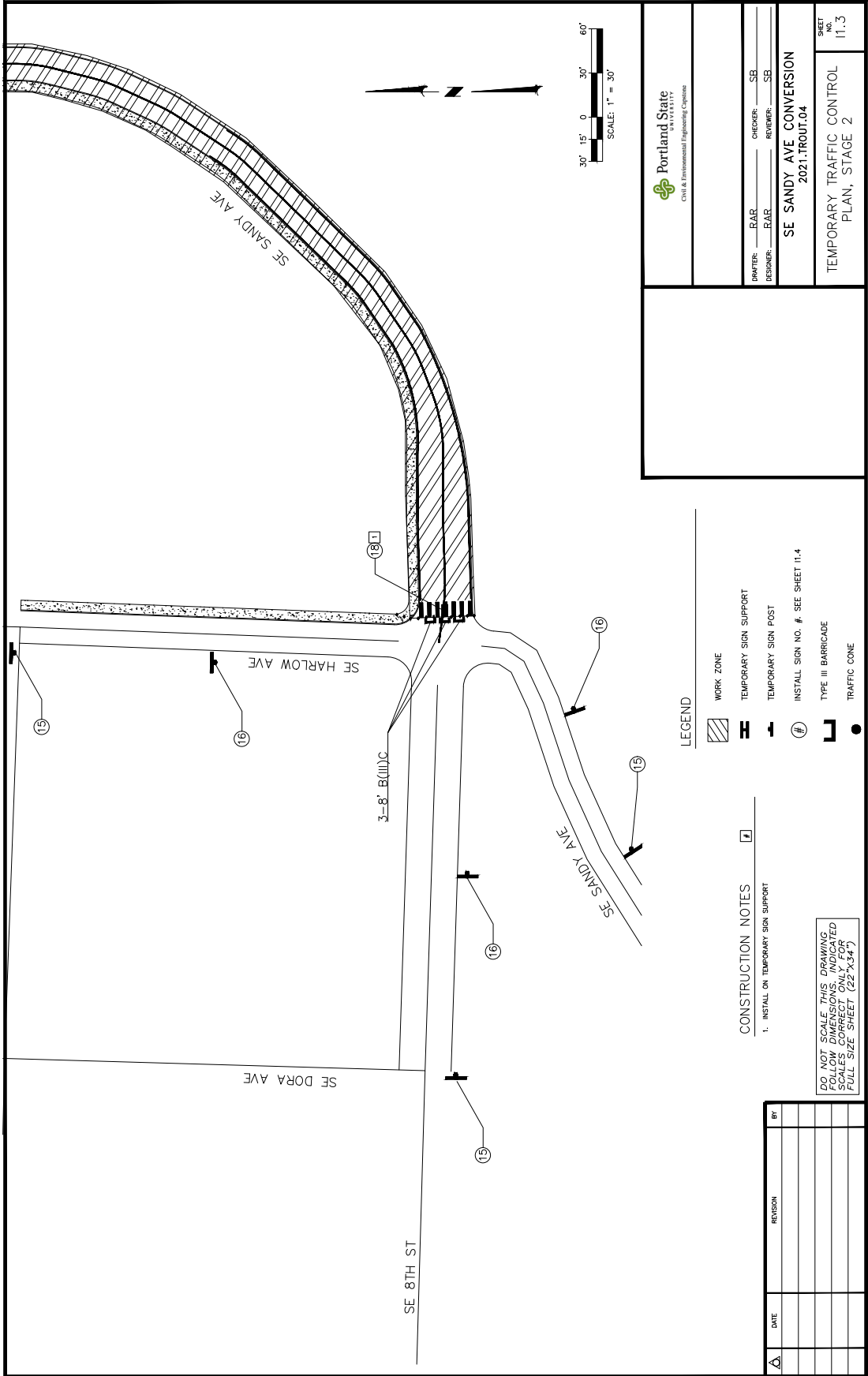
LEGEND

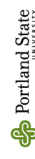
-  TYPE III BARRICADE
-  TRAFFIC CONE
-  WORK ZONE

DO NOT SCALE THIS DRAWING
 FOLLOW DIMENSIONS. INDICATED
 SCALES CORRECT ONLY FOR
 FULL SIZE SHEET (24" X 36")

DATE	REVISION	BY












Portland State
Civil & Environmental Engineering College

DESIGNER: E.A.R. CHECKER: S.B.
 REVIEWER: S.B.

SE SANDY AVE CONVERSION
 2021.TROUT.04

SHEET NO. 11.3
 TEMPORARY TRAFFIC CONTROL PLAN, STAGE 2

LEGEND

-  WORK ZONE
-  TEMPORARY SIGN SUPPORT
-  TEMPORARY SIGN POST
-  INSTALL SIGN NO. #. SEE SHEET 11.4
-  TYPE III BARRICADE
-  TRAFFIC CONE

CONSTRUCTION NOTES

- INSTALL ON TEMPORARY SIGN SUPPORT

DO NOT SCALE THIS DRAWING FOLLOW DIMENSIONS, INDICATED SCALES CORRECT ONLY, FOR FULL SIZE SHEET (22 X 34)

DATE	REVISION	BY

PLOT DATE: 6/9/2021 PLOT TIME: 10:06 PM USER: burko

Appendix J
Quality Control Checklist

11 W20-2 30" x 30" DETOUR AHEAD

12 M4-9L 30" x 24" DETOUR [down arrow]

13 M4-9R 30" x 24" DETOUR [up arrow]

14 M4-8a 24" x 18" END DETOUR

15 W20-1 30" x 30" ROAD WORK AHEAD

16 W20-3 30" x 30" ROAD CLOSED AHEAD

17 R11-4 60" x 30" ROAD CLOSED TO THRU TRAFFIC

18 R11-2 48" x 30" ROAD CLOSED

DATE	REVISION	BY

DO NOT SCALE THIS DRAWING
FOLLOW DIMENSIONS. INDICATED
SCALES CORRECT ONLY FOR
FULL SIZE SHEET (22 X 34)

Portland State
UNIVERSITY
Civil & Environmental Engineering Course

DRAWN BY: RAR CHECKED BY: SR
DESIGNED BY: RAR REVIEWED BY: SR

SE SANDY AVE CONVERSION
TROUTDALE, OR

SHEET NO. 11.4
TEMPORARY SIGN GLOSSARY

Quality Control Checklist

Project: Sandy Avenue Conversion

2021.TROUT.04



PREPARER

Name: Paul Braverman

Signature: Paul Braverman

Date: 6/10/21

CHECKER

Name: Shiori Baba

Name: Shiori Baba

Date: 6/10/21

<i>CRITERIA</i>	<i>REQUIREMENTS</i>	<i>PREPARER</i>	<i>CHECKER</i>
General Level = 100% Points = 20.0	Proper grammar, spelling, punctuation, etc.	✓	✓
	Template Followed	✓	✓
	CEE Writing Style Guide followed	✓	✓
	Technical writing style used (clear, concise, easy to understand)	✓	✓
	Single, combined PDF	✓	✓
	Consistent formatting: Times New Roman with 12 font and 1.15 spacing	✓	✓
	Descriptive File Name	✓	✓
	No orphaned headers, tables not separated from each page	✓	✓
Cover Page Level = 100% Points = 0.5	Project title and ID	✓	✓
	Relevant figure	✓	✓
	Team member names	✓	✓
	Client name	✓	✓
	PSU logo & Capstone Caption	✓	✓
Project Disclaimer Level = 100% Points = 0.5	Provided disclaimer reproduced verbatim	✓	✓
Acknowledgements Level = 100% Points = 0.5	Professional	✓	✓
	Concise	✓	✓
Table of Contents Level = 100% Points = 0.5	All sections, subsections listed, with page numbers (Do not list cover page, disclaimer, or acknowledgements)	✓	✓
	Appendices listed in order (no page numbers)	✓	✓
	Executive summary numbered with roman numerals at “	✓	✓
	Project Background begins at page “1”	✓	✓

Executive Summary Level = 100% Points = 2.5	Provide a summary of your Design Report	✓	✓
	1-2 pages long and no figures	✓	✓
	1/3 should provide background of the project	✓	✓
	2/3 should summarize proposed design	✓	✓
1.0 Project Background Level = 100% Points = 1.0	Introductory paragraph with project history, location, and need/purpose	✓	✓
	Figure showing project location	✓	✓
1.1 Existing Site Conditions Level = 100%	Details about project location	✓	✓
	Site photos with captions in text, captions should be concise	✓	✓
1.2 Stakeholders Level = 100%	Explanation of each party's interest	✓	✓
2.0 Alternative Analysis Level = 100% Points - 1.5	Detailed description of considered alternatives (note that if your alternatives involve different geometries/plans, then you must include a CAD-drafted figure for each alternative)	✓	✓
	Detailed Description of selection criteria	✓	✓
	Completed Pugh Matrix with alternatives and criteria listed	✓	✓
	Narrative describing how each alternative scored for each selection criteria	✓	✓
	Clearly indicate which alternative is the preferred alternative at the end of this section	✓	✓
3.0 Facility Design Level = 100% Points - 25	Organized into subsections	✓	✓
	Provide a detailed discussion and summary of your proposed facility design	✓	✓
	Provide references to design manuals/codes, your calculations appendix, and the plan set appendix.	✓	✓
4.0 Regulatory Compliance and Permitting Level = 100% Points - 3.0	Describe the regulatory permits and/or approvals that would be required to complete the project.	✓	✓
	Identify the regulatory agency in charge of each, and summarize the requirements for the permit/approval.	✓	✓
5.0 Geotechnical Roadmap	Describe what treatment type was selected	✓	✓

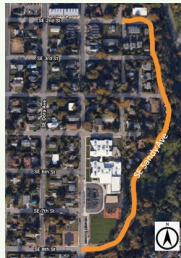
Level = 100% Points - 10	Identify and describe in detail the steps the client would	✓	✓
	Identify potential companies the client could contract with	✓	✓
	Identify any safety or miscellaneous concerns the project could have	✓	✓
	Create a traffic control plan, provide references to design manuals/codes and the plan set appendix	✓	✓
6.0 Conclusion Level = 100% Points - 2.0	Summarize your facility design recommendation to your	✓	✓
	Suggest what steps your client should take to complete the project	✓	✓
References Level = 100% Points - 3.0	Proper citation format followed	✓	✓
	Provide at least five (5) citations to relevant design codes, manuals, etc. These citations must also appear in the body of the report (w/ in-text citations).	✓	✓
Appendices	Each appendix must include a cover sheet	✓	✓
A. Construction Cost Estimate Level = 100% Points - 5.0	Provide an itemized construction cost estimate	✓	✓
	Support your cost estimate with references to cost data and/or specifications. Provide quantity calculations, where appropriate	✓	✓
	10-20 items	✓	✓
B. Construction Schedule Level = 100% Points - 3.0 Extra Credit	Provide a preliminary construction schedule Gantt chart using Excel or MS Project	✓	✓
	Show logic (predecessor/successor) links	✓	✓
	15-20 Tasks	✓	✓
C. Drawings/Plan Set Level = 100% Points - 20.0	Use Tabloid (11"x17") sheets	✓	✓
	Include a title block on each page with sheet number,	✓	✓
	The first sheet must be a title sheet and include a region/area view with the project location identified	✓	✓
	The plan set must be plotted in grayscale using a pen table to vary line thickness (see, e.g., Clackamas County example)	✓	✓
	The plan set must communicate the facility design	✓	✓
D. Calculations Level = 100% Points = 5.0	Provide a "Calculation List" at the beginning of this section that serves as a table of contents for your calculations.	✓	✓
	Provide calculations that are required to support your proposed design, in a complete/professional format	✓	✓

Appendix K

Project Poster

BACKGROUND

SE Sandy Avenue is a collector street popular with cyclists and motorists alike. However, Sandy Ave has long-term slope stability and erosion concerns. By reconfiguring Sandy Ave, the City of Troutdale hopes to provide equitable access to cyclists, motorists, and emergency vehicles, and to improve the longevity of Sandy Ave for years to come.



PURPOSE



City of Troutdale would like to consider a 30% design to reconfigure or reclassify in an attempt to fix the road located on SE Sandy Avenue between 3rd street and 8th street. The relatively low-grade slope of Sandy Avenue presents long-term erosion concerns. Geotechnical solutions may be cost-prohibitive given the hillside conditions.

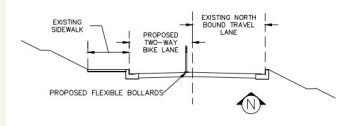
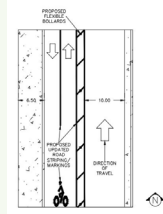
Citizens of Troutdale expressed concerns of local road accessibility and emergency safety measures for all commuters at SE Sandy Avenue. The team was tasked in finding a solution to accommodate for emergency vehicle access, adding space for bikes and pedestrians, and preserve the road for future local usage.

ALTERNATIVES

ALTERNATIVE	CRITERIA						TOTALS MULTIPLIED BY WEIGHT
	COST	SAFETY	PUBLIC APPROVAL	LONG TERM MAINTENANCE	PEDESTRIAN AND CYCLIST USAGE	SEASONAL VERSATILITY	
Weight	25%	25%	15%	20%	10%	5%	Max = 4
Conversion of one lane into multi-use trail	2	2	2	2	4	2.66	2.2
Full conversion into multi-use trail	4	3	1	4	2.66	1.33	3.0
Geotechnical Stabilization	3	4	3	1	1.33	4	2.7
NO BUILD	4	1	3	2	1.33	4	2.4

The table above shows the results of the alternative analysis. Based on several weighted factors, the option to close the road to vehicles and converting Sandy Ave into a multi-use trail scored the highest. However due to opinion obtained from the Troutdale Citizen's Advisory Committee and Troutdale Councilors, the one-lane multi-use trail was selected to be designed by the team.

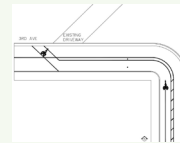
GENERAL DESIGN



Sandy Ave will be converted from a two way collector street to a one-way multi-use trail as shown in the schematics above. Vehicles will be travelling northbound on the east, outer side of the road. In the west lane, there will be a gap with flexible bollards installed and a two-lane bicycle pathway. No changes will be made to the sidewalk.

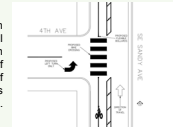
BIKEWAY DESIGN

Flexible bollards and a 1 foot striped buffer will be used as traffic delineators to separate the one-way vehicle traffic from bicyclists and pedestrians. Their flexibility will continue to allow access to emergency vehicles but give bicyclists and pedestrians some breathing room for a more safe Sandy Avenue.



Bicycle transitions will be added to SE 8th Street and SE 3rd Street in order to create a safe environment for bicycle traffic. The design is currently being consulted with PBOT. The design would allow for emergency vehicle access as well.

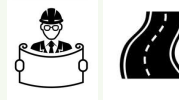
A modification of 4th Street is shown in the figure to the left. Vehicles will only be allowed to turn left off of 4th Street. Bollards will be at the ends of the bike lane with the addition of dashed bike paint to protect cyclists from oncoming traffic.



Additional signs and traffic control equipment in the area will be required to notify drivers of the change in traffic and of cyclists on the roadway ahead. Striping will be updated all along Sandy Ave will improve bicycle infrastructure and safety.

FUTURE GEOTECHNICAL WORK

Future geotechnical work will be roadmapped for this project. With a cost estimate, type of reinforcement, and construction plans



Appendix L

Final Presentation

SE Sandy Avenue Conversion

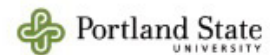
(2021.TROUT.04)

2021 CEE Capstone: Final Design Presentation



Shiori Baba
Paul Braverman
Ryan Russell
Kody Pak

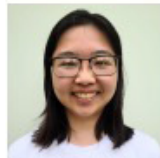
Arvind Datta
Ahmed Ali
Marie Burkoff
Nathan Riddle



Meet the Team!



Evan Kristof
Office Manager



Shiori Baba
Project Manager



Paul Braverman
Assistant Project
Manager



Ryan Russell
CAD Lead



Arvind Datta
Site/Civil
Designer



Ahmed Ali
Civil/Construction
Designer



Nathan Riddle
Quality Control
Engineer



Kody Pak
Utilities Manager



Marie Burkoff
Design and Code
Manager

Client - City of Troutdale



Chris Damgen
Community Development Director



Amber Shackelford
Assistant Planner

3

Roadmap

- **Project Background**
- **Alternative Analysis**
- **Facility Design**
- **Geotechnical Roadmap**
- **Conclusion**

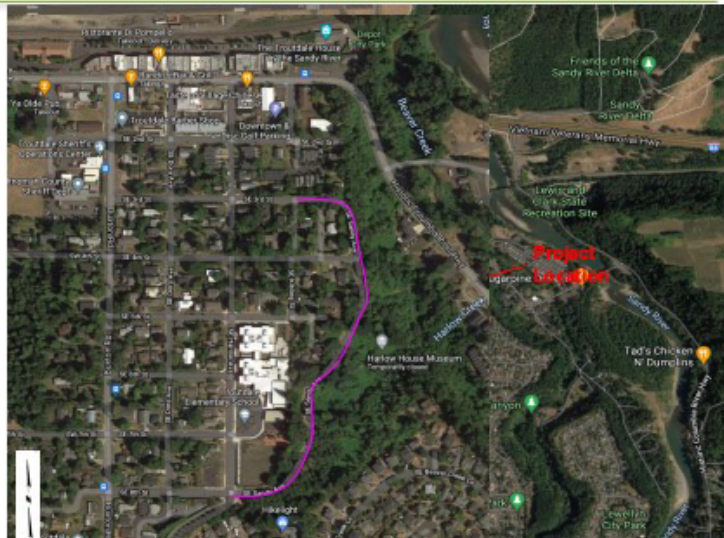


(Softwareplante, 2021)

4

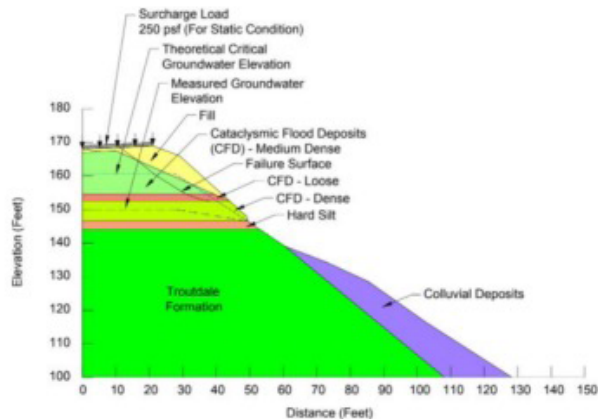
Project Location

- **South of Troutdale Town Center**
- **Suburban area**
- **Major landmarks**
 - I-84
 - Columbia Gorge Outlet Mall Center
 - Troutdale Elementary School
 - Sandy River
- **Local collector street**
- **Grade 4-5%**



Project Background

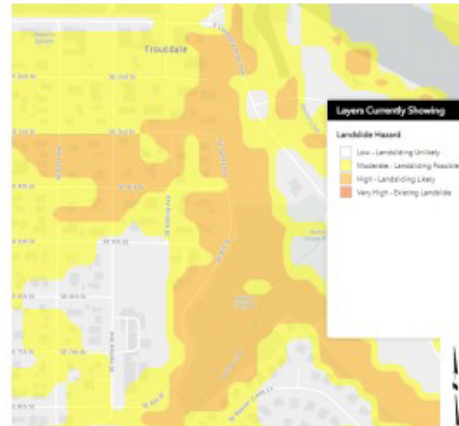
- **Geology**
 - Fill
 - Cataclysmic Flood Deposits
 - Troutdale Formation
- **Sandy Ave likely built along old headscarp of the existing slope failure plane**
 - More details in geotechnical section



Interpretive geological cross section at Sandy Ave and 4th St (Shannon and Wilson 2018)

Background

- **Roadway identified for partial or full closure**
 - General area is landslide prone
 - Slope instability
 - Geotechnical options may be expensive
- **Team Objective**
 - Explore transportation alternatives
 - Create 30% design for the reclassification

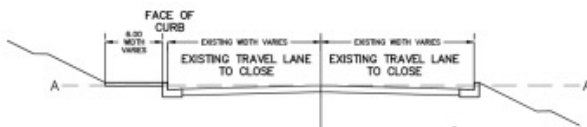


Map of landslide hazards (DOGAMI)

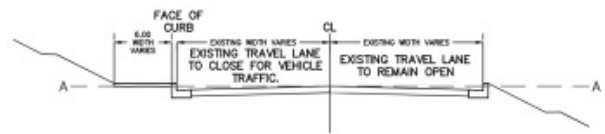
7

Alternative Analysis - Options

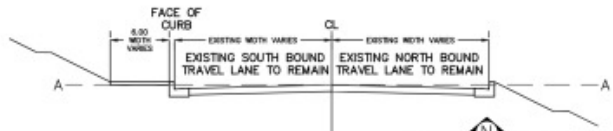
1. Replace Sandy Ave. with multi-use trail
2. Replace one lane to create a one-way street with one lane of multi-use trail
3. Geotechnical work to stabilize Sandy Ave
4. No Build



Alternative 1: Close Sandy Ave, replace with multi-use trail



Alternative 2: Close one lane, replace with a multi-use trail



Alternative 3 and 4: No configuration change to Sandy Ave

8

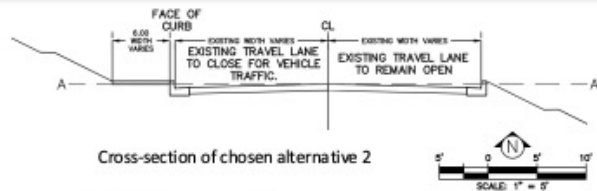
Alternative Analysis

ALTERNATIVE	CRITERIA						TOTALS MULTIPLIED BY WEIGHT
	COST	SAFETY	PUBLIC APPROVAL	LONG TERM MAINTENANCE	PEDESTRIAN AND CYCLIST USAGE	SEASONAL VERSATILITY	
Weight	25%	25%	15%	20%	10%	5%	Max = 4
Conversion of one lane into multi-use trail	2	2	2	2	4	2.66	2.2
Full conversion into multi-use trail	4	3	1	4	2.66	1.33	3.0
Geotechnical Stabilization	3	4	3	1	1.33	4	2.7
NO BUILD	4	1	3	2	1.33	4	2.4

9

Alternative Analysis - Chosen Alternative

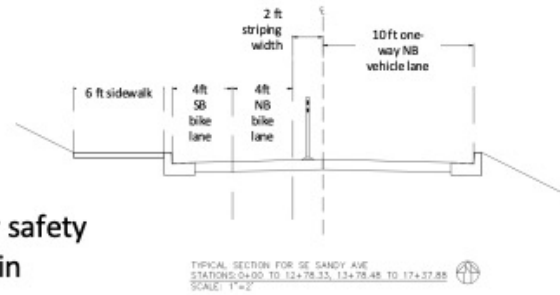
- **Replace one vehicle lane of Sandy Ave to create a one-way street with a two lane cycle track**
- **This design was chosen due to alternatives analysis feedback from the client**
- **The city council wanted to retain some vehicular and emergency vehicle access to Sandy Ave**



10

General Facility Design and Treatments

- **General Design info**
 - Vehicular travel in NB lane
 - Existing sidewalk remains
 - Bollards and additional striping
- **Flexible Bollards**
 - Delineates vehicular and bike travel lanes for safety
 - Allows for emergency vehicle access to remain throughout Sandy Ave
- **Vehicle Travel Lane**
 - NB direction based on emergency facilities located south of Sandy Ave
 - Offers greater cyclist protection



(freepik.com)

11

Traffic Control Devices

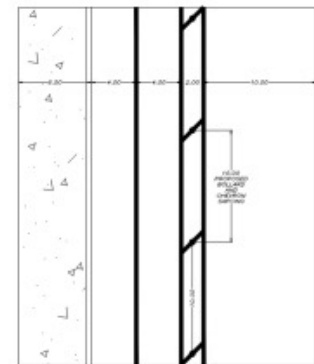
- **Signs**
 - Primarily warning signs
 - Regulatory signs
 - Most existing signs remain
- **Barricades**
 - Installed at closure of Sandy Ave at 3rd St
 - Existing to remain
- **Striping/Bollards**
 - Updated 2 ft spaced chevron striping to accommodate bollard placement at 10 ft spacing
 - New striping for cycle track



Example Warning Sign
(MUTCD, 2009)



Example Regulatory Sign
(MUTCD, 2009)



Typical Section Plan View

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Cost Estimate

- **Includes:**

- **Striping**
 - *New, Removal, Bike Symbols, Pavement Bars*
- **Signage**
 - *Temporary, New, Sign Posts*
- **Bollards**
- **Barricades**

A.1 Sandy Avenue Construction Cost Estimate

Section	Item	Quantity/ft ² /ft	Cost per Each	Total Cost
Temporary Traffic Control Plan (TTCP)	Temporary Signs (size varies, sheet aluminum)	245 ft ²	\$ 18.00	\$ 4,320.00
	Temporary Barricades (8ft)	6	\$ 115.00	\$ 690.00
	Temporary Barricades (4ft)	1	\$ 115.00	\$ 115.00
Traffic Control Plan (TCP)	Striping Removal	3600 ft	\$ 0.45	\$ 1,620.00
	Install 4" Solid White Striping	6000 ft	\$ 0.50	\$ 3,000.00
	Bike Symbol	7	\$ 65.00	\$ 455.00
	Permanent Signs	70 ft ²	\$ 18.00	\$ 1,260.00
	Wood Sign Posts	6	\$ 9.00	\$ 54.00
	Barricade (4ft)	1	\$ 115.00	\$ 115.00
	Tubular Markers/Bollards	250	\$ 52.00	\$13,000.00
Pavement Bars (Crosswalks/Stop Bars)	50	\$ 5.00	\$ 250.00	
Total Estimated Cost				\$24,879.00

Note: Construction costs are taken into account within the cost estimate.
 Flaggers were not incorporated within this estimate.

- **Estimated Cost: \$24,879.00**

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Facility Design - 4th Street Intersection

- **Signage**

- One way arrow on existing barricade
- Left turn only arrow on existing stop sign

- **Striping & Bollards**

- Two-way bike lane symbols
- 4 in wide, 2 ft dashed lines through intersection
- Flexible bollards every 10 ft

- **Alternatives**

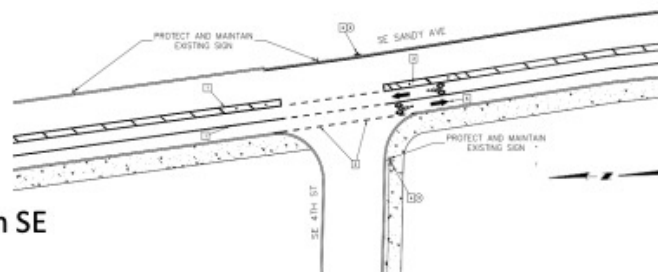
- Left turn arrow pavement marking on SE 4th
 - *No existing striping on SE 4th*



One way sign (MUTCD, 2009)



Left turn only sign (MUTCD, 2009)



CAD design of 4th St intersection

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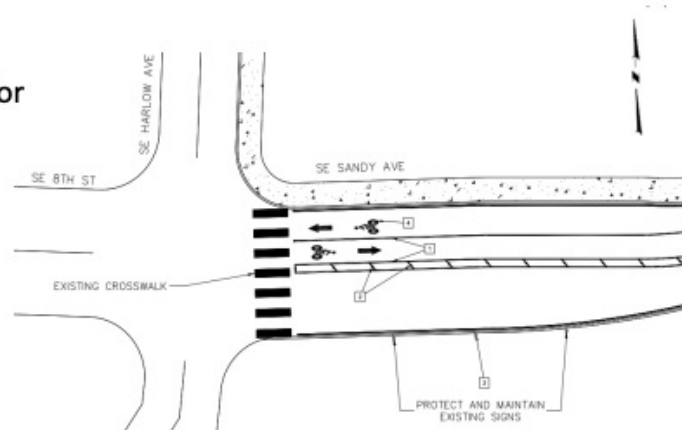
Facility Design - 8th Street Intersection

- **Signage**

- No proposed signs
- Removal of bikes on roadway sign for northbound vehicle lane

- **Striping & Bollards**

- Two-way bike lane symbols
- Flexible bollards every 10 ft



CAD design of 8th St and Sandy Ave.

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Facility Design - 3rd Street Intersection

- **Vehicle Traffic**

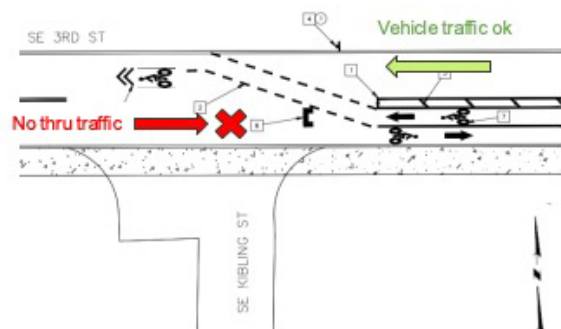
- Vehicles travelling east on 3rd street will not be allowed to enter Sandy Ave
- Vehicles exiting Sandy Ave. will be sharing a lane with cyclist

- **Bicycle Traffic**

- Cyclist travelling east on 3rd Street will have enough room between barrier and sidewalk to enter bike lane onto Sandy Ave
- Cyclist traveling west will have to use bike crossing and will share a lane with vehicle traffic

- **Pedestrian Traffic**

- Pedestrians should use the sidewalk entering and exiting Sandy Ave

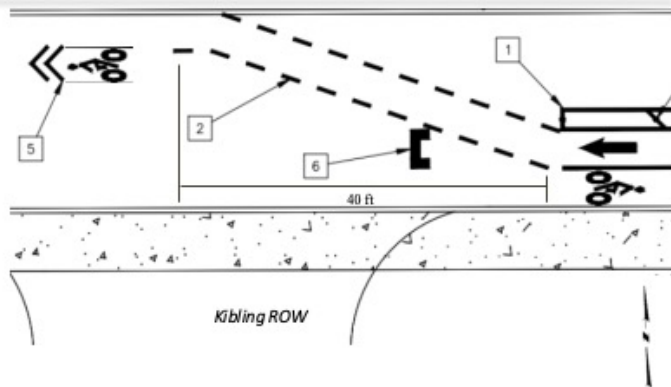


CAD design at 3rd St

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Facility Design - 3rd Street Intersection

- **Transition**
 - Angled bike lane allows cyclists to exit Sandy Ave. into the shared vehicle travel lane
 - Transition taper will be 40 ft long with a width of 4 ft
- **Striping**
 - 2 ft dotted white line with 2 ft spacing
- **Chevron Bike Paint**
 - Used to inform cyclist that 3rd Street will be a shared road .(ODOT TM500)



Design detail at 3rd St

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Facility Design - 3rd Street Intersection

- **Barricade**
 - 4 ft by 2 ft reflective barricade on Sandy Ave to prevent traffic from travelling eastbound on 3rd Street into Sandy Ave
 - The barrier will be white with red stripes to show that barrier will be permanent
- **Bollards**
 - Plastic Bollards will be placed on the centerline of the Sandy Ave ending before the bike transition



Example barricade to be installed on 3rd St (CTAM)

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Geotechnical Recommendations

- Background
- Type of Reinforcement
- Traffic Control Plan
- Recommended Alternative
- Construction Schedule
- Cost Estimate
- Potential Contracting Companies

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Future Geotechnical Considerations

- **Landslide affected areas**
 - Segment between SE 3rd St and SE 4th St
 - 100 ft drop with head scarp
 - Sandy constructed over loose material
- **4th St intersection**
 - Acute tension cracks
 - Shoulder instability
 - Cracking started prior to 2001
- **Geotechnical treatment may be necessary to prolong the longevity of the roadway**

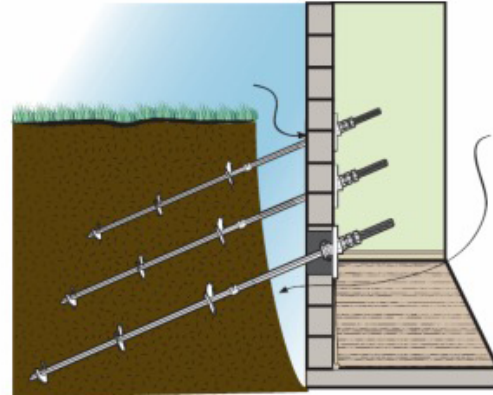


Pavement distress along Sandy Ave at 4th St
(Shannon and Wilson, 2018)
Landslide hazards along SE Sandy Ave. (DOGAMI, 2018)

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Types of Reinforcement: Tie-back Soldier Pile Wall

- **Temporary and permanent applications**
- **Wall uses wide flange steel members**
 - Provides tensile strength
- **Wall exceeding 15 feet in height requires lateral resistances**
 - Tie-back rods driven/drilled into the earth

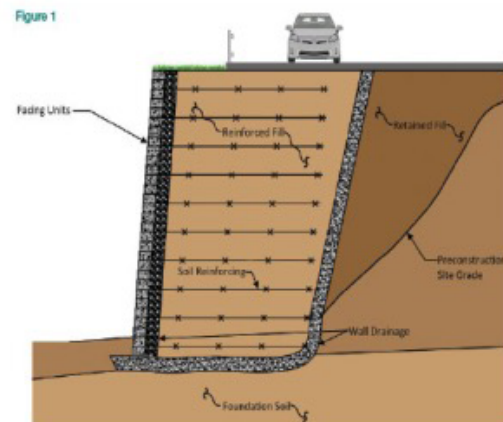


Tie-back soldier pile wall schematic (MacLean Dixie HFS)

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Types of Reinforcement: Mechanically Stabilized Earth Wall

- **A composite structure**
 - Alternating layers of compacted backfill and soil reinforcement elements
 - Rely on self-weight to resist overturning and sliding forces
 - Can support variety of heavy loads
 - Primary function of preventing erosion of the structural backfill
- **Stability of the wall system**
 - Internally stabilized by frictional steel
 - Interaction between the backfill and soil reinforcements

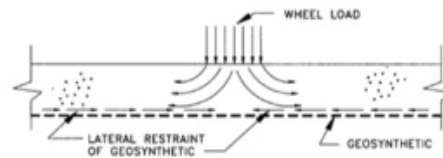


MSE wall cross section schematic (Construction Specifier, 2013)

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Types of Reinforcement: Subgrade Geogrid Reinforcement

- **Geogrid primary function**
 - Add tensile strength to soil matrix
 - Reduce movement
 - Reduces cracking
- **Applications**
 - Constructed over soft foundations
 - Can facilitate drainage
 - Provides separation of base and subgrade materials
 - Geogrids develop lateral restraint
 - *Friction interlocking mechanism between the aggregate soil and geogrid*

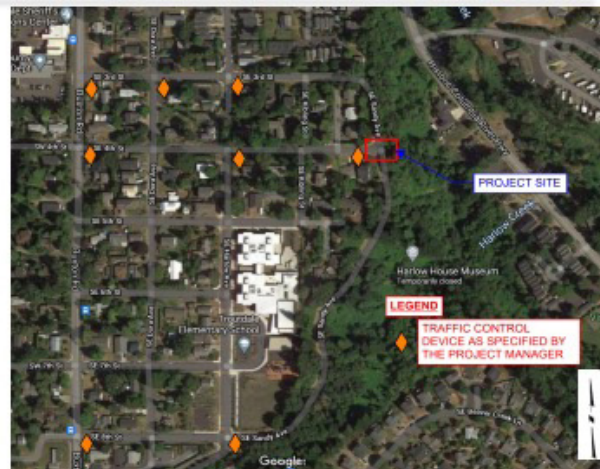


Geosynthetic lateral restraint (Christopher, 2010)

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Temporary Traffic Control Plan

- **A temporary road closure is necessary**
- **Detour plan focused on neighboring roads**
 - SE Harlow Avenue
 - SE Dora Avenue
 - Buxton Road
- **Road closure signs placed along neighboring streets**
 - Road Closed Ahead
 - Detour



Temporary traffic control plan for geotechnical work

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Subgrade Reinforcement Geogrid (Chosen Reinforcement)

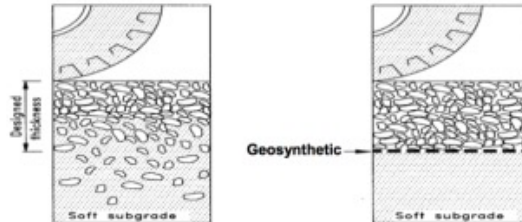
▪ Recommended Mitigation: Subgrade Reinforcement Geogrid

▫ Advantage

- *Cost Effective*
- *Ease of Installation*

▫ Disadvantage

- *Short design life*
- *Continued monitoring and maintenance*



Subgrade geogrid reinforcement and separation (Christopher, 2019)

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Construction Schedule

▪ The following steps outline the general construction sequence:

1. Site Survey
2. Temporary Traffic Control Plan
3. Erosion Control Measures
4. Mobilization
5. Removal of Existing Pavement Surface
6. Excavation / Grading of Existing Base
- 7. Placement of Geotextile Reinforcement**
8. Compaction of Base Material
9. Placement of Pavement / Compaction
10. Signage Stripping
11. Site Cleanup



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Cost Estimate

- **Properties:**

- Dimensions
 - 100 ft length of geotextile
 - 30 ft roadway width
- Roadwork Description
 - 3" of excavation
 - 8" of base course
 - 4" of HMAC Pavement

Roadwork Description	Quantity	Unit Price	Amount
Pavement Removal 0310-0103000J	333 yd ²	\$8.95	\$2,983
Excavation of Existing Base/Subgrade 0330-0105000K	333 yd ²	\$10.59	\$3,526.47
Subgrade Reinforcement Geogrid 0350-0105000J	333 yd ²	\$1.27	\$423
Base course - 1" or 1/4"	135 tons	\$41.00	\$8,282
Level 2, 1/2" Dense HMAC 0744-0202000M	67.5 tons	\$124.43	\$12,567.43
Subtotal			\$27,782
30% Contingency			\$8,334.57
TOTAL ESTIMATED COST			\$36,000

- **Estimated Cost: \$36,000**

- Cost estimate for pavement rebuild w/ subgrade geotextile.

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Contracting Companies

- **Construction Contractors**

- Oregon Mainline LLC, LaDuke Construction LLC, Knife River, and K&E Excavation



- **Manufacturers (per ODOT qualified product list)**

- The most utilized geosynthetic brand is manufactured by Tensar.
- Others Include, Alliance Geosynthetics, Hanes Geo Components, Geostar Technologies

Tensar

- **Pavement / Geotechnical Engineering Consultants**

- Shannon & Wilson, HDR and WSP



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Conclusion

- **Solution is a Balancing Act**
- **Benefits**
 - Upping equity for all modes of transportation
 - Improved cyclist safety
 - Low Cost
- **Limitations**
 - Vehicle safety during winter months
 - Snow weather plan may be necessary
- **Next Steps**
 - CAC Involvement
 - Resident Outreach



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Questions?

Thank you for your time!



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Benefits (placeholder, maybe?) - Paul

- **Low Cost**
- **Not Intrusive**
- **Keeps All Forms of Transportation**
- **Limitations**
 - **Transportation Solution is Cheap, Geotechnical is Not**
 - **One-way Road Issues with Weather**
 - **3rd Street Transition**

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