FROM THE PACIFIC NORTHWEST TO THE SOUTHEAST: INTERPRETATIONS OF AN URBAN STORMWATER RETROFIT

by

KALLE ELYSIA BUTLER

(Under the Direction of BRUCE K. FERGUSON)

ABSTRACT

Stormwater management in the context of urban streets is on the cusp of major change. Innovative multidisciplinary designs pioneered in the Pacific Northwest are paving the way for more environmentally and socially responsive stormwater design. This thesis examines the practicality of incorporating the principles guiding such designs into the environmental and urban fabrics of the Southeast, determining limiting factors as well as possible design modifications.

INDEX WORDS: SEA Street, Skinny Street, Urban Stormwater Management Retrofit

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DEDICATION

This thesis is dedicated to my family, Ronda, Keefe, and Carson, and to Michael—thank you all for your love and support, none of this would have been possible without you.

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I would like to thank Professor Bruce K. Ferguson for his enthusiasm, for his boundless wisdom, and for keeping me focused. I would also like to acknowledge my committee, Alfie Vick, Wayde Brown, and Lauren Justice—thank you for taking the time out of your full schedules to lend your specialized knowledge.

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Introduction

For many landscape architects, architects, traffic engineers, and other thoughtful professionals, issues of street design, stormwater management, and environmental degradation have become increasingly important. Modern Movement designers “recognized the need to think holistically, conceiving a total environment in which physical design strove to preserve, enhance, and render visible the vitality of natural systems, as well as the individual and social lives of residents” (Howett 87). Innovative multidisciplinary designers in Seattle, WA and Portland, OR are working toward just such a holistic approach in terms of stormwater management, paving the way for a new line of thinking when it comes to street design. The Street Edge Alternatives (SEA) project in Seattle and the Skinny Streets projects in Portland are prototypes that shed new light on the opportunities for more thoughtful, dynamic, environmentally sound urban stormwater management.

Though modern streets have traditionally been designed as channels for moving vehicles, the SEA and Skinny Streets projects demonstrate that streets in the urban context can be designed to incorporate a wide variety of socially and environmentally beneficial design forms through the introduction of alternative stormwater design. The question in another region, the Southeast, then becomes how do designers successfully borrow the prototypes of the Pacific Northwest and put them into practice in the Southeast? Designers must also examine the effect that urban density would have on the appearance and function of the stormwater management systems that the SEA and Skinny Streets prototypes advocate. What design criteria can be identified in the Seattle and Portland prototypes, as well as in a Southeastern model, and what could retrofitted urban streets in the Piedmont region look like?

In this thesis, the purpose is to determine whether or not any modifications of design criterion become necessary when the application is moved into the Southeast. Throughout the thesis, a close look will be taken at the scope involved in the redesign of urban streets. In Seattle, the SEA Street project was an entire right-of-way redesign, including elements such as clustered mailboxes, clustered parking, street and sidewalk realignment, and traffic calming, as well as stormwater treatment. Thus, this prototype was limited by the decisions regarding where in the street to construct the stormwater system and the context in which it would be included. In Portland, the Skinny Streets projects were limited by what could be done in the streets according to standard safety codes. In an urban area such as Atlanta, GA, what would the limiting factors be?

In Portland and Seattle, homeowners have played a vital role in the installation and maintenance of their newly redesigned streetscapes. Psychological ownership of the stormwater systems in front of their houses has encouraged homeowners to take on active roles in the upkeep, and thus functionality, of these systems.

Many urban centers across the nation are experiencing growth, renewal, and change. With the influx of people comes a wave of measures implemented in order to attract business, create usable urban spaces, and to alleviate some of the strain placed on infrastructure and the surrounding natural environments. Often, these measures are shortsighted due to a lack of information regarding available innovative technologies. In some cases, there is simply not enough information surrounding these innovative designs as they may apply to a site's particular needs for municipalities and citizens' groups to advocate their usage.

When considering the variety of urban street characteristics, it becomes obvious that creating interesting, functional streets is one of the most difficult tasks that face urban designers. The complexity of economic, social, and environmental interactions, opportunities, and experiences taking place in our urban streets is often misunderstood or overlooked.

Current street design standards are alienating pedestrians and adding to the degradation of local watersheds. Part of the future of urban growth and, specifically, of urban streets' success lies in the way that designers respond to the relationship between stormwater management and street design.

In order to provide background and context, Chapter Two of this thesis will introduce a brief historical overview of the theories informing a potential urban stormwater retrofit. Among the theories and bodies of information covered are the history and evolution of low-impact development, the natural drainage systems approach, and restorative redevelopment.

Next, Chapter Three will examine the history, goals, and benefits of both Seattle's SEA Street and Portland's Skinny Streets projects. This chapter will discuss the defining characteristics of each of these prototypes and will look at the environmental and social impacts that the designs have on their respective neighborhoods.

In Chapter Four, the site for a hypothetical design in the Southeast will be introduced. This chapter includes the rationale for the selection of Lake Avenue, located in the Inman Park neighborhood in Atlanta, GA, and will give a brief history of the neighborhood. Additionally, there will be a description of current design restrictions that dictate the street's appearance, pedestrian use, and stormwater infrastructure requirements.

Following the introduction to the design application site, Chapter Five will examine applicable principles that have an influence on the form and function of the proposed retrofit. This chapter shall include a comparison of the physical conditions and considerations of the Northwestern and Southeastern sites, such as infiltration capabilities of the soil and typical rainfall frequencies, as well as theoretical design principles.

Next, a series of drawings will examine the hypothetical design of an urban stormwater retrofit inspired by the Seattle and Portland prototypes. Details will demonstrate any modifications that must be made in order to create a prototype, specific to the region's and the site's soils, rainfall, and urban density.

Lastly, the thesis shall conclude with a summary and evaluation of the design application and underlying factors that led to the design's relative success or failure will be discussed. This section shall also identify any aspects of the design that may need further research and exploration.

Chapter Two
Environmental Design History

With studies demonstrating that impervious surfaces in urban areas have increased by 20% over the past two decades, at a cost in excess of $100 billion nationally, local governments are increasingly embracing alternative stormwater management strategies in efforts to reduce the costs of constructing traditional stormwater control infrastructure (American Forests 2007). Armed with the strategies and principles outlined by low-impact development, restorative redevelopment, and the natural drainage system approach, municipalities are finding more environmentally, socially, and economically sustainable methods of addressing the criteria mandated by the U.S. Environmental Protection Agency’s non-point source pollution guidelines (USEPA 2007).

A. Low-impact Development

In the mid-1980s, the principles of low-impact development emerged from Prince George's County, Maryland with the introduction of bioretention technology. These technologies were aimed at designing the built environment as a functioning part of an ecosystem, rather than existing apart from it, in response to environmental degradation of the Chesapeake Bay area. This approach is not meant to be a land-use control strategy. Instead, low-impact development relies heavily on thoughtful, advanced technologies rather than simply relying on conservation and growth management (Low-Impact Development Center, Inc. 2007).

Low-impact development (LID) practices seek to reduce the footprint that development leaves on the environment. This is accomplished through the use of infrastructure that allows rainfall to maintain contact with the soil, such as porous pavements, vegetated swales, infiltration basins, and even detention basins when necessary; through groundwater recharge; through evaporation and evapotranspiration; and by finding creative beneficial and educational uses for rainwater (Coffman 2007). Low-impact development seeks to utilize land in an ecologically and socially functional and beneficial manner, while allowing development to remain economically viable.

In an article for the *Journal of Green Building*, R. Alfred Vick synthesizes the guidelines for Low-impact Land Development:

- Identify and understand the ecological and cultural context of the site.
- Preserve functioning natural processes.
- Minimize the size and severity of the development footprint.
- Utilize built surfaces to contribute to the health of the site.
- Mitigate the remaining impact of development.
- Restore and integrate natural processes into the everyday experience of the built environment.

(Vick 30)

Under these guidelines, urban stormwater is addressed in the context of site conditions, including existing surface and subsurface drainage patterns; in terms of regulations such as those set out under the National Pollution Discharge Elimination System (NPDES), which is a permit program that regulates the amount of pollution entering waterbodies and local ordinances; and in terms of the needs of human inhabitants and wildlife.

As it allows for the integration of treatment and management measures into urban site features, LID practices enable municipalities and developers to reduce costs ordinarily incurred with complex and centralized conveyance and treatment infrastructure (Low-Impact Development Center, Inc. 2007). Utilizing built surfaces such as parking lots constructed with porous pavements, roof surfaces that act as catchment areas, and structural soils that prevent compaction of vegetative root zones are some of the methods of LID that contribute to the overall long-term health of a site. Low-impact development also seeks to manage the preservation of natural areas by working to reduce habitat fragmentation, the interruption of natural systems, and pollution (Vick 28-38).

In the study "Comparison of Stormwater Lag Times for Low Impact and Traditional Residential Development," researchers observed that low-impact development practices resulted in lowered peak discharge depth, lowered runoff coefficient, and lowered discharge volume as compared with traditional development practices. Also observed were increased lag times and increased runoff thresholds (Hood, Clausen, Warner 1036). Such findings support the hypothesis that adhering to the principles of low-impact development indeed aids in the reduction of environmental damage caused by the quantity and velocity of stormwater runoff in urban areas.

B. Restorative Redevelopment

Restorative redevelopment is an approach in which stormwater runoff is no longer moved, as quickly as possible, into traditional sewer systems but is rerouted into the soil and into vegetated areas. In contrast with LID methods, which typically involve bottom-up approaches that are implemented from the beginning of a project, restorative redevelopment incorporates LID technologies into existing development. By utilizing empty spaces between buildings, along roads, and in parking areas, complex systems of swales and infiltration basins not only serve to reintegrate natural processes into a site and return urban areas closer to their pre-development stormwater functions, but also create more harmonious and rejuvenating environments for human inhabitants and wildlife (Ferguson 9).

According to hydrometeorologist Matt Kelsch, of The University Corporation for Atmospheric Research, Boulder, CO, nearly 50% of rainfall in heavily urbanized areas runs directly into nearby streams during storm events. Comparatively, only about 5% of the rainfall occurring in subsaturated woodlands runs off into associated streams (Frazer 459). Excessive stormwater runoff within a watershed, resulting from rainfall onto pavements and other impervious surfaces, results in abnormally high base flows in streams and often results in raw sewage spills due to overstressed systems (Ferguson 10). Through the features utilized in restorative redevelopment, plants and microbes in the soil break down pollutants, stormwater runoff volumes and velocities are reduced, and groundwater supplies are recharged.

C. <u>Natural Drainage Systems Approach</u>

Natural drainage systems, which emphasize decentralized, natural infrastructure, are designed to more closely replicate the natural hydrologic process of a forested watershed in its 'pre-developed' state, as well as more natural levels of runoff flowing into associated creeks. Unlike traditional pipe and vault storm sewer systems, which are designed to quickly convey large amounts of polluted stormwater off-site and have a limited lifespan, natural drainage system approaches are actually able to increase in functional value over time (Seattle Public Utilities 2007).

An evolution of both low-impact development and restorative redevelopment, natural drainage systems take stormwater systems a step further by working to incorporate community education and involvement in projects. This approach works under the assumption that "stewardship by design" is an invaluable component in mitigating the effects of development on urban watersheds (Seattle Public Utilities 2007).

Designed to mimic natural processes, natural drainage system approaches utilize such LID features as swales, which capture and filter rainwater using the natural processes of soils and plants, and open, landscaped ponds or small wetland ponds, which store overflow. These designs aim to reduce stormwater velocities, allow for the infiltration of stormwater, filter and reduce pollution, reduce impervious surfaces, and provide much needed greenspace in urban areas (Seattle Public Utilities 2007).

Chapter 3
Case Studies

Prior to WWII, the traditional neighborhood vehicular area was designed at 28- to 30-feet wide with a corner radius of 5 to 10 feet. As time progressed, the typical local street grew to a width of 36 feet with a corner radius of 25 feet. While the wider street has upheld the mission to move traffic more quickly and efficiently and to assure safe emergency vehicle access, higher speed traffic and increased amounts of asphalt have diminished the quality and character of neighborhoods and have increasingly degraded associated watersheds (Cohen 1997). Today, a typical medium-sized city in the United States has more than 500 miles of residential streets. With just a five-foot reduction in street width, over 300-acres of asphalt can be reduced (Ewing, et al 123).

A. Street Edge Alternatives Streets Project   Seattle, WA

As the city of Seattle's population grows, so increases the amount of impervious cover, which, in turn, increases the volume of stormwater that flows into area creeks. In the winter, this results in flooding and scoured creek beds and in summer, drastically reduced creek flows.

With this in mind, in the spring of 2001, Seattle Public Utilities completed the prototype for the Street Edge Alternatives (SEA) Streets Project. The 650-foot continuous block along Second Avenue, NW, between N. 117th and 120th Streets, was chosen as the pilot block due to its lack of an existing drainage system and its need for general street improvements (Bennett 2000). This block is characterized by its designation as a single-family residential street with homes placed on small lots. The design of the project reconfigures the original paved street taking it from a grid-style straight road built for efficiency to a curved, more narrow roadway that addresses not only stormwater issues, but also takes the wellbeing of residents and users into account through the use of traffic calming devices (see Figure 1).

Figure 1 :: 2nd Avenue Before & After SEA **Source :: Seattle Public Utilities 2007**

With the Natural Drainage Systems approach in mind, the design goals of decreasing the volumes and peak flows of runoff resulted in a reduction of the impervious areas to 11% less than those found in traditional streets in this area (Seattle Public Utilities 2007). This was achieved by reducing the paved street width from 20 feet to 14 feet, with a width of 18 feet at intersections, and by providing sidewalks on only the west side of the street. While this width is sufficient for the passage of two slow-moving standard size vehicles, larger vehicles and emergency vehicles are able to utilize the areas provided for parking and driveways in order to pass oncoming traffic. In cases where these areas are not free, oversized vehicles are provided with a two-foot-wide "flat curb," or white strip, and an additional two feet of structural grass shoulder on each side of the roadway (Bennett 2000; Seattle Public Utilities 2007).

In addition, six vegetated swales with subsurface drains were designed into each side of the road and connected to an existing ditch and culvert system located on 117th Street (Bennett 2000; Seattle Public Utilities 2007). These swales vary in width, length and soil depth. Typically, soil depth is either 1-foot minimum in swales without trees, or a 4-foot minimum depth in areas with trees. All of the swales contain 8-inch PVC overflow pipes that connect each swale to the next and, eventually, to the existing drainage system on 117th Street (Refer to Appendix A for further details) (Seattle Public Utilities 2007).

In the fall of 2002, Seattle Public Utilities began work on the Cascade Prototype, a spin-off of the original SEA Streets Project designed for use on steeply sloped residential streets. This prototype enlisted cascading swales, intensive vegetation, and sediment traps to slow stormwater runoff velocity and to improve the water quality (Seattle Public Utilities 2007).

After reviewing the results of two seasons of measurement, one during the dry months and one during the wet months, University of Washington researchers concluded that the SEA Streets prototype reduced the volume of stormwater leaving the site by 98% (Taus 2002; Seattle Public Utilities 2007). In Seattle, the primary drainage system is a series of swales and infiltration basins designed to accommodate the 2-year storm, allowing for a 24-hour limit for ponding time.

B. Skinny Streets Portland, OR

Most streets in residential neighborhoods in the city of Portland, Oregon are 28 feet wide, which permits two travel lanes and parking on one side; 32 feet wide, which permits parking on both sides and two travel lanes; and occasionally 20 feet wide, which allows for two travel lanes, but no parking. These streets typically include curbs, sidewalks, and storm drainage systems (Bray & Rhodes 32-36). One of the main factors behind these widths was concern for the ability of emergency vehicles to access the neighborhoods. However, communities within Portland were unhappy with such wide roadways, viewing them as encouraging to high traffic speeds and expensive to build and maintain (Bray & Rhodes 32).

In 1991, the Portland city council authorized the implementation of Skinny Streets. By definition, a “skinny street” is a queuing street in which the roadway is designed to have only one travel lane, requiring the oncoming vehicle to pull over into the designated parking lane while the other vehicle passes. Depending on neighborhood parking needs, Skinny Street standards for residential streets are either 26 feet wide with two parking lanes and one travel lane or 20 feet wide, permitting one parking lane and one traveling lane (Bray & Rhodes 35-38).

Studies conducted in Portland indicate that Skinny Streets maintain neighborhood character, reduce overall road construction costs, save and/or increase vegetation, reduce stormwater runoff, and use land more efficiently. Another important benefit is that these street forms encourage more cautious driver behavior, thus lowering traffic speeds and increasing safety (West Coast Environmental Law 2007; Bray & Rhodes 36). An example of this can be seen in the Northeast Siskiyou Green Street Project (see Figure 2), an example of an evolution of the Skinny Street project that incorporates planted intersection bulbouts as stormwater retention and infiltration devices (LAM 58-59).

According to the design guidelines for Skinny Street projects, two different stormwater infiltration methods are approved for use. The first option, the curb extension swale, has a minimum length of 35 feet and a minimum width of 6 feet. These swales are designed with a curb cut at the higher elevation end in order to receive runoff and a 12-inch-wide by 3-inch-deep notch in the top of the curb at the lower elevation end to allow for overflow. The second option is a planter swale with a minimum length of 12 feet, a maximum length of 18 feet, and a minimum width of 3 feet. These design features utilize curb cuts covered by trench drains at the higher elevations to allow for the inflow of stormwater runoff and an identical method for overflow, which then flows down-slope to the next planter. In both options, clay check dams slow the flow velocity of the runoff and force infiltration. Additionally, a soil mix of 67% sandy loam topsoil and 33% compost material is incorporated with a typical soil depth of 1'-6," with the exception of the areas with trees, which have a depth of 3 feet minimum, and a minimum and maximum ponding depth of 6 inches and 12 inches, respectively (Refer to Appendix B for further details) (City of Portland 2007).

Lastly, one of the largest obstacles to overcome in obtaining approval for the implementation of Skinny Streets was the perception that emergency vehicles would not be able to perform their duties adequately in streets where the historically required 20-foot wide unobstructed fire lane did not exist. After many versions of testing using actual emergency vehicles, the Bray and Rhodes team discovered that even with cars parked on each side of the street, fire trucks were still able to safely pass through 24-foot wide streets (Bray & Rhodes 34).

Figure 2 :: NE Siskiyou Stormwater Curb Extensions **Source :: ASLA 2006**

C. <u>Design Benefits</u>

Creating a sense of place

Both of the above mentioned improvement projects provide social benefits for the communities in which they were developed. The visual continuity created in the natural, soft-edged roadways contrasts with the hard edges of traditionally designed streets. These prototypes increase the opportunities for vegetation, including the urban tree canopy, thus increasing shade-cover and space-defining qualities, such as spatial order and sequence. This use of a “garden-street” appeal is intended to encourage interactions amongst community members and facilitate a sense of ownership and pride in the community.

Community involvement in landscape design, maintenance, and installation follows a prescription of stewardship by design. According to the Seattle Public Utilities Department, one of the key factors in the success of SEA Street plant survival is the fact that local residents have agreed to take responsibility for maintaining the plants within the right-of-way by weeding, mulching, and mowing when necessary (Seattle Public Utilities 2007). Through the use of educational community design and development meetings in the initial phases of the SEA and Skinny Street projects, as well as informational signage incorporated into several of the final designs, these stormwater systems work to create an awareness of citizens’ role in the larger context of the local watershed (Seattle Public Utilities 2007).

Lastly, these designs provide the benefits of traffic calming, ensuring safe access for pedestrians, bicyclists, and emergency vehicles. The clear distinction between parking lanes and traveling lanes, created by curb extensions and “flat curb” strips, visually narrows the roadways, encouraging drivers to slow their speeds and pay closer attention to their place on the road. In the SEA Streets design, the curving of the roadway is reminiscent of chicanes (see

Figure 8, Chapter Five), which have been successfully utilized across the United States as a traffic calming measure.

Environmental benefits

Both of the Northwestern prototypes are designed to capture all of the runoff from the 2-year 24-hour storm. Due to the reduction in stormwater runoff, SEA Streets and skinny streets enable a reduction in sediment and pollution loads entering associated creeks and waterbodies. Simultaneously, the plantings incorporated into such designs have multiple benefits. In addition to absorbing rainfall, thus decreasing the amount of runoff that leaves a site during a storm by as much as 2 to 7% (McIntyre 91), and reducing summer heat indexes, researchers with the USDA Forestry Service have concluded that trees are capable of reducing the amount of pollutant particulates in the air, an important health benefit, especially in urban areas. An example of the calculated benefits of such removal is evident in findings that in the metro-Atlanta area, trees have been shown to remove 19,000,000 lbs of pollutants annually, resulting in a savings of $47 million (American Forests 2007).

Budgetary concerns

To begin with, these street improvement projects reduce costs by following the rule of “right plant, right place.” More appropriate plantings, such as specifying trees with naturally small root systems that more easily fit into the right-of-way and the placement of plants that thrive in wetlands into the lower lying areas of stormwater swales and ponds, results in lowered replacement frequency and lowered maintenance fees. Additionally, increased walkability and the “garden-street” appearance have resulted in increased property values (Seattle Public Utilities 2007).

Also worth noting is the City of Seattle’s estimate that a typical installation cost for a SEA Streets project is $710,000, as opposed to $840,000 for an equivalent traditional stormwater drainage and street improvement project (Seattle Public Utilities 2007).

Educational benefits

In addition to the afore mentioned educational benefits for the immediate community, the SEA Streets and Skinny Streets projects can serve as learning tools for the world at large. Analysis of these projects provides statistical information regarding environmental and social benefits that can be utilized in the implementation of similar projects worldwide.

Chapter Four
Site Introduction

In order to determine the design constraints and opportunities posed by the implementation of a SEA Street- and Skinny street-inspired stormwater retrofit in the Southeast, several factors had to be weighed. As previously stated, the design considerations involved in such a retrofit include infiltration rates, rainfall, and percentages of impervious cover reflective of urban density. This chapter discusses the motivations behind the selection of the Inman Park neighborhood in Atlanta, Lake Avenue specifically, as the application site.

Figure 3 :: Existing Conditions Hale Street at Lake Avenue Looking West

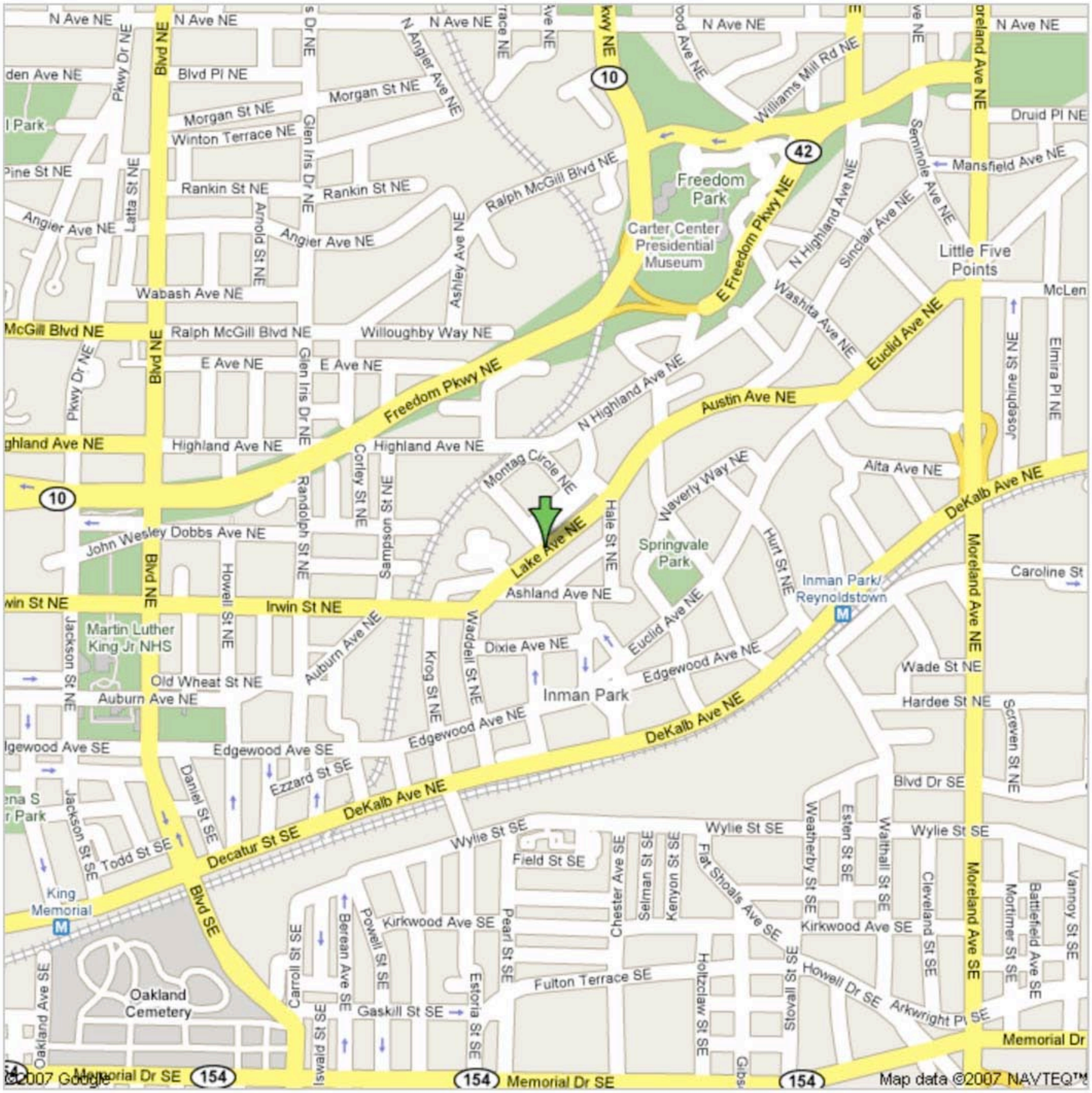


Figure 4 :: Lake Avenue Location Map **Source :: Google Maps 2007**

A. Rationale for Selection

In order for the design application to highlight similarities and differences between a Southeastern example and the Pacific Northwestern prototypes, a design area had to be chosen that would provide an adequate portrayal of design constraints typical of sites in urban areas throughout the Southeast. In general, residential streets in such areas include a range of densities, from single-family lots with low percentages of impervious cover to multi-family, medium density lots to mixed-use, commercial, high density lots with high percentages of impervious cover. Because the Northwestern prototypes are found in moderate-density residential areas, this investigation also seeks to determine whether such designs can provide beneficial effects in higher density, commercial or multi-use areas and how the design forms would have to evolve in order to effectively achieve these benefits.

Although the design application in this thesis is located on a single street, Lake Avenue is unique in the Inman Park neighborhood in that it is characterized by density transitions from historic low-density lots to new mixed-use development. Additionally, Lake Avenue, in its current form, is a 40-foot wide roadway in need of traffic calming measures, general street improvement projects to increase pedestrian and bicyclist use, and drainage improvement.

Lastly, the Inman Park neighborhood boasts an active neighborhood association and an enthusiastic garden club, both of which are important factors that indicate a strong proclivity for citizen-powered maintenance of street improvement projects, aiding in extending the functional life of the project (IPNA 2008).

B. Neighborhood History

In the late nineteenth century, businessman Joel Hurt established the East Atlanta Land Company and, along with landscape designer James Forsyth Johnson, developed Inman Park as one of the country's first planned garden communities. Influenced by Frederick Law Olmsted's Riverside community outside of Chicago, the 130-acre suburb east of Atlanta relied on several design elements to create an idyllic atmosphere located in close proximity to the central business district. Among these elements were expansive lots, softly curving roads, and ten acres of park land which became Crystal Lake and Springvale Park, landscaped by the Olmsted Brothers firm. Home styles in the neighborhood include Victorian, Folk Victorian, Arts &

Crafts, Queen Anne, Richardsonian Romanesque, Colonial Revival, and Neoclassical. Hurt also developed one of the nation's first electric streetcar systems, providing transit from downtown to Inman Park, ending only a block away from the current-day location of the neighborhood MARTA station on Edgewood Avenue (IPNA 2008; Galloway 2007; IPHPC 4-11).

C. <u>Design Restrictions</u>

In the 1950s, the neighborhood experienced significant change as Crystal Lake was infilled, Springvale Park was divided in half, and the zoning changed to allow for multi-family residential and commercial construction. However, in the 1970s, a group of individuals formed Inman Park Restoration, Inc., later becoming the Inman Park Neighborhood Association, and worked to return the area to single-family residential zoning. Thanks in part to their work, Inman Park was officially listed on the National Register of Historic Places in July of 1973. In 2002, the Inman Park Historic District was officially pulled under the auspices of the Atlanta Comprehensive Preservation Program, with oversight going to the Atlanta Urban Design Commission. Under this local designation, there is greater regulation aimed at protecting the unique cultural and aesthetic characteristics of the neighborhood than would be found under the auspices of designation on the National Register of Historic Places. The City of Atlanta designation also requires a stringent design review process for changes proposed within the outlined district, including both historic and non-historic properties (IPNA 2008; Galloway 2007; IPHPC 4-6). While these guidelines do much in the way of protecting the character of the existing properties and qualifying new additions to the neighborhood, they have little input in terms of streetscape applications, as will be discussed further in Chapter 5.

Chapter Five
Principles to Apply

While environmental design history and even urban design history have great influences on the form and function of a proposed stormwater management system, underlying design principles and site criteria must also be considered in order to create an environmentally and socially sensitive urban stormwater retrofit.

A. Stormwater Design

The infiltration of stormwater utilizes land's inherent ability to filter out urban contaminants, to reduce the volume of stormwater at the source, and to provide long-term storage. Infiltration in an urban context is a restorative practice that aides in mitigating the effects of development on hydrologic processes in part by restoring groundwater levels to provide more natural base flows in streams. According to Bruce Ferguson, infiltration, due to its ability to turn potentially hazardous storm flows into much needed base flows, "is environmentally the most complete solution to the problem of urban stormwater" (Ferguson 191).

Increases in direct stormwater runoff as a result of urban development result in flooding, stream channel erosion, and the loss of riparian habitat in associated watersheds (Ferguson 93-94). In traditional storm drainage systems, smooth, impervious gutters, channels, and pipes convey runoff at high velocities and provide little if any opportunity for water to come into contact with soils and vegetation. Conversely, by utilizing vegetated swales to convey stormwater, runoff velocities are reduced, there is an opportunity for biophysical treatment of contaminants, and there are ample opportunities for human interaction with and education regarding the natural processes of the water cycle (Ferguson 114, 191). Limitations that must be examined when designing stormwater systems with vegetated swales include the fact that it may be difficult to utilize these systems in highly urbanized areas due to their space requirements. Additionally, in areas with steep slopes, vegetated swales must be used in conjunction with other best management practices in order to avoid channelization caused by high-velocity flows (Boston Metropolitan Area Planning Council 2008).

To some extent, infiltration is possible in all vegetated swales and porous soil surfaces, but it occurs to the greatest extent in infiltration basins that are designed without primary surface outlets (Ferguson 40-44). Because every site consists of a primary drainage system, which works with all storms up to and including the design storm, and a secondary system, which works when the primary system becomes overloaded or clogged, this thesis is examining the use of two distinctly different drainage systems, which will work in conjunction with each other. As stated in Chapter Three, the primary drainage system in Seattle is a series of swales and infiltration basins designed to accommodate the 2-year 24-hour storm event. The secondary drainage system is the existing traditional storm sewer system that will accept runoff in the event of storms that exceed the amount of runoff produced during the designed storm event. The purpose of this thesis is to determine whether or not any modifications of this design criterion become necessary when the application is moved into the Southeast.

By designing for a 2-year storm event, the Seattle retrofit treats the “first flush” or the concentrated pollutants running off of impervious surfaces, especially roadways. Treating even small amounts of runoff works to reduce the amount of pollution flowing into associated streams and treating small volumes of water is still beneficial to the restoration of a site’s environmental functions within its watershed (Ferguson 191-202). Because most storm events tend to be relatively small, designing for the smaller, more frequent storms accomplishes these benefits and may be necessary in Atlanta, due to the slower infiltration rates characteristic of the soils found in the Southeast, as further explained in the following section, and the lack of space available in urban areas in which runoff can be stored.

B. Physical Considerations

Rainfall

In terms of regional hydrology, Seattle and Portland have rainfall patterns that are typical of the Pacific Northwest. In Seattle, the average annual precipitation is 37.07 inches, generally falling in the form of a fine misty rain (Western Regional Climate Center 2007). Such climate patterns result in Seattle experiencing a 2-year storm 24-hr rainfall depth of 1.68 inches on average. Portland's climate is temperate and seasonal with an annual rainfall average of 36.3 inches. With 8o percent of the total annual rainfall occurring between November and April, both Seattle and Portland are characterized by mild, wet winters, and hot, dry summers (Alo 2007).

On the other hand, Atlanta follows climate patterns commonly found in the Southeast. With precipitation fairly evenly distributed throughout the year, the heaviest concentration of rain occurs in March. The average annual precipitation is 50.77 inches (City-Data 2007) and is commonly delivered in intense bursts compared with those in the Northwest, as illustrated in the contrast of Figures 5, 6 and 7. Atlanta typically experiences a 2-year storm 24-hr rainfall depth of 3.7 inches.

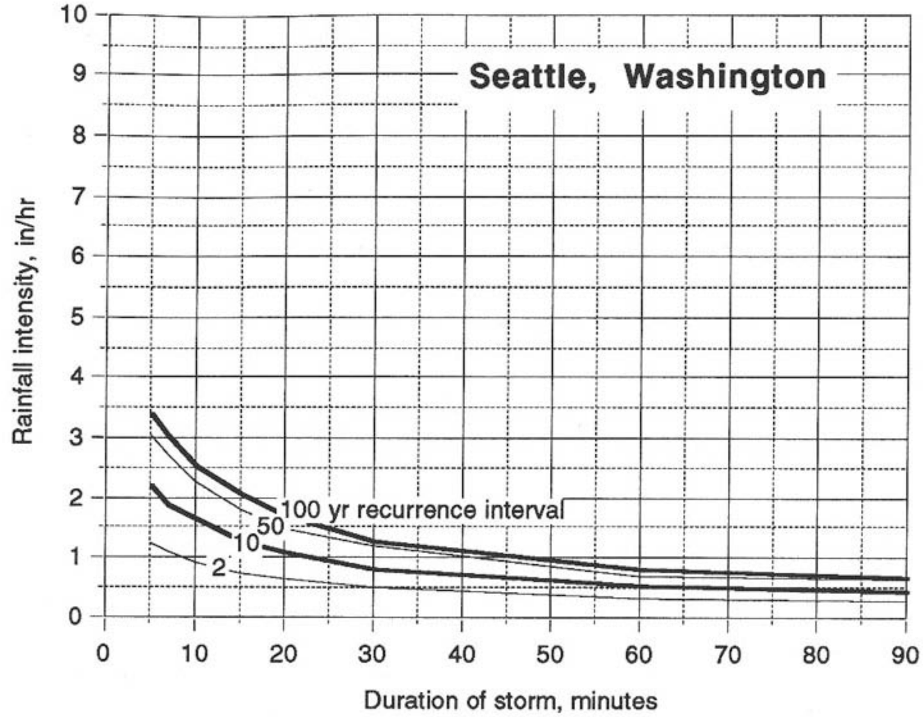


Figure 5 :: Intensity-Duration-Frequency Curves   Source :: Ferguson 47

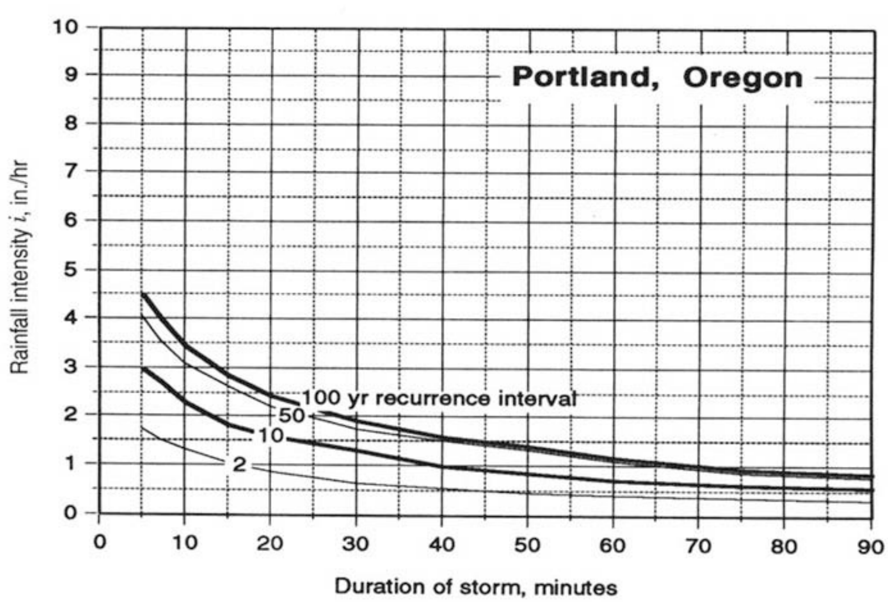


Figure 6 :: Intensity-Duration-Frequency Curves   Source :: Ferguson 251

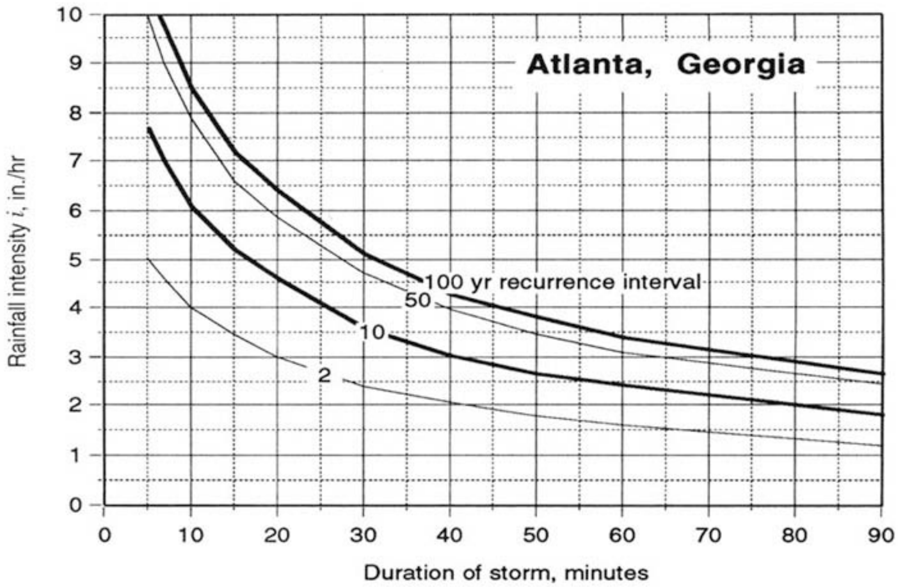


Figure 7 :: Intensity-Duration-Frequency Curves Source :: Ferguson 241

<u>Soils</u>

In the Pacific Northwest, soils are characterized by their diverse compositions, including some that are well drained and ideal for efficient stormwater infiltration. In the Southeast, Piedmont soils are characterized by their high clay content, which results in significantly slower infiltration rates.

King County, Seattle, WA

About 52 percent of King County is comprised of Alderwood Association soils. This association consists of about 85 percent Alderwood soils, characterized by moderately well drained gravelly sandy loams with a substratum of consolidated glacial till, 8 percent Everett soils, which are gravely sandy loam, underlain by gravely sand, and 7 percent less extensive soils (Snyder, et al 2-4). In combination, these soils have an infiltration rate of about 3.34 feet per day (Ferguson 198).

Multnomah County, Portland, OR

The soils near Portland consist of deep, well-drained gravelly silt loams and very fine sandy loams. The soil association here is characterized by about 30 percent Sauvie soils, a silty loam, 10 percent each Pilchuck, also a silt loam, and sandy Rafton soils, and 50 percent soils of minor extent and Urban land, which are well drained loams and silt loams, characterized as good sources for sand and gravel (Green, et al 5-9). These soils have an infiltration rate of about 2.04 feet per day (Ferguson 198).

Fulton County, Atlanta, GA

Soils around the metro Atlanta area are listed as unclassified city land. Due to extensive alteration caused by urban works and structures, identifying and mapping the soils in this area is not considered feasible (Walker, et al 41). However, it is possible to make several valid generalizations regarding soil characteristics for this area. Before widespread urban development, typical soils found in the area included Cecil, Pacolet, and Madison, which are dominantly clay and clay loam. While urban development has modified the soil surrounding Atlanta by digging, filling, and mixing in debris and construction materials, the existing soils and their correspondingly low infiltration rates still apply. These soils typically have an infiltration rate of about 0.18 feet per day (Ferguson 198).

C. Historic Preservation Design Principles

As discussed in the previous chapter, while the historic preservation guidelines for the Inman Park neighborhood do provide some design guidelines for the streetscape, the scope is fairly limited due to the focus on the character of the structures.

Among the guidelines set forth, there is a mandate for a planting strip adjacent and parallel to the public street for which a compatibility rule applies to the dimensions and locations (IPHPC 16-20L.006.1.b). Currently, the infill development areas along Lake Avenue have a 3-foot wide planting strip, while the original planting strips are about 2-feet wide in most areas. In the instance of sidewalks, all replacements and new additions must match the original materials and design for the block on which it is located. In Inman Park, this is typically either hexagonal cast pavers, concrete inlaid with hexagonal imprint, brick, or square cast pavers. These sidewalks must either match the width of the abutting sidewalks or be the width required by the zoning code, whichever is greater, but they cannot be less than six feet in width (IPHPC 16-20L-005.1.b.v; 16-20L.006.1.c; 16-20L.006.1.q.vii). Lastly, while curb material in the Inman Park neighborhood has traditionally been local granite, new curbs made of concrete are in place at various points along the road.

D. <u>Elements of Urban Streetscape Design</u>

Categorizing streets according to their traffic type and fronting land use enables designs for street pavement widths that are limited only to what is needed for proper traffic flow, parking, stormwater treatment, and drainage (Ferguson 18). However, there is much more to consider in the design of a street when striving to create an environment that attracts local users and visitors alike. According to Allen Jacobs, great streets must have definition, some unique physical identity or expression that sets them apart from others and allows residents to take pride in the street (Jacobs 154).

Pedestrian experience improves with the addition of paths and goals, or intermediate destinations along the route that act as markers, which breaks up the overall route into a series of smaller sequences (Spooner 37). This is in line with Jacobs' assertion that one of the characteristics of a great street is the ability to allow the eye to move from object to object and from place to place (Jacobs 282). Paving, benches, light standards, gates, signage and fountains all contribute to the richness of urban streets. All of these elements are not required, but using enough of them helps to create a unique character. Lastly, following the idea that people attract people, it is also important to design for chance encounters. Street corners are great places for impromptu conversations and can take on the role of goals and landmarks (Spooner 58-59).

Arguably the most important detail in an urban street is the tree. The movement, texture, shadow patterns, and colors provided by the street tree introduce a wide range of visual experiences to the urban space. Additionally, trees provide a sequence to the street and aid in establishing spatial order (Spooner 54).

Traffic calming is another area of concern in the creation of great urban streets. Although the Inman Park neighborhood has all of the elements of a walkable community, including interconnected streets, public transit, parks, bicycle paths, and a relatively small size, the overall pedestrian environment remains hostile due to high vehicular speeds and poorly maintained sidewalks (Day-Wilburn Associates, Inc. 2.3).

Some of the commonly utilized methods for traffic calming across the region include round-abouts, chicanes, bulb-outs, chokers, speed tables, and speed humps. While these methods are relatively effective at slowing vehicular speeds, they are often difficult for bicyclists to navigate and do nothing to aid in the restoration of the physical environment in terms of addressing stormwater issues. The SEA Street and Skinny Street projects are both excellent examples of ways in which designers can aid in the reduction of vehicle speeds while simultaneously addressing ecosystem, pedestrian, and urban needs.

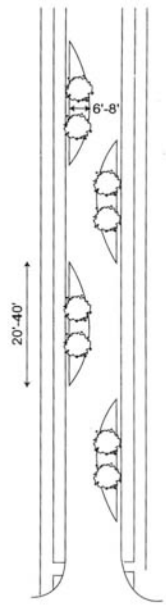


Figure 8 :: Chicanes   Source :: Watson, Plattus, Shibley 7.2-9

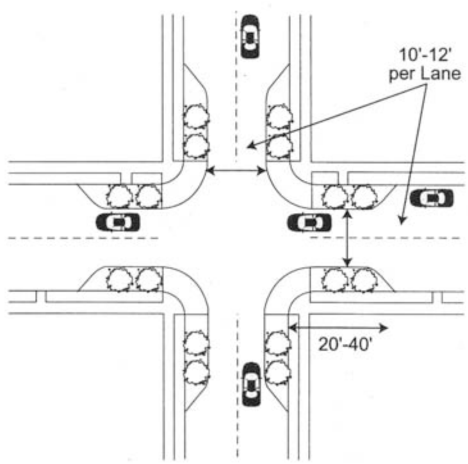


Figure 9 :: Intersection Bulbouts   Source :: Watson, Plattus, Shibley 7.2-6

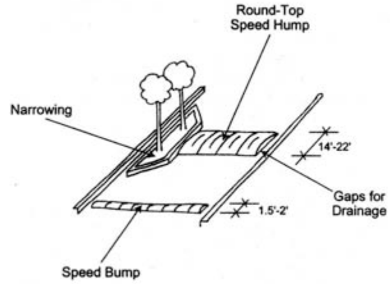


Figure 10 :: Round-top Speed Humps   Source :: Watson, Plattus, Shibley 7.2-2

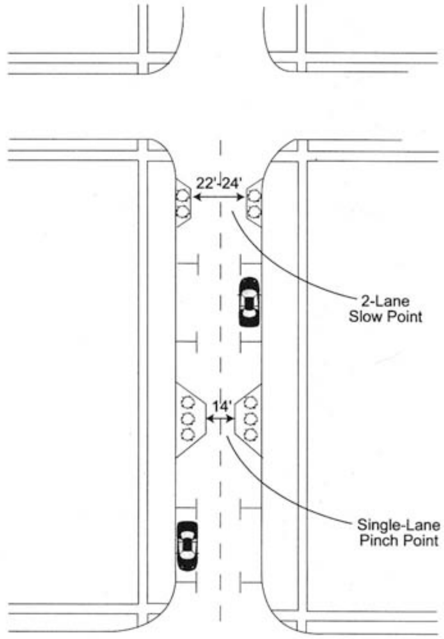


Figure 11 :: Mid-block Bulbouts   Source :: Watson, Plattus, Shibley 7.2-6

Chapter Six
Design Application

In order to more accurately compare the design application involved in this thesis with the prototypes that inspired it, the site had to be broken down into smaller segments for the resulting calculations to more closely relate to those found in the Pacific Northwest. Following the existing drainage patterns, the design application focuses on segments of Lake Avenue that have slightly differing urban densities.

A. Design Overview

In its current state, Lake Avenue is a residential through street with a 60 foot right-of-way that consists of 40 feet of paved roadway with sufficient space for on-street parking on both sides, several blocks of newly constructed sidewalks, and historic, badly degraded sidewalks on the south-east side.

Area 1 (see Figure 12) begins 200 feet into Ashland Avenue, toward the south-west side of Lake Avenue, and continues north-east ending at the centerline of Inman Village Parkway. The based upon first-hand observations noted during a moderate rain event, the drainage area for this site is bounded at the back of the lots facing Lake Avenue. It is 2.19 acres and is characterized by low-density single-family residential units and has about 50% impervious cover. Based on SCS method calculations using a curve number of 84, the runoff volume (Qvol) for this watershed during a 2-year storm 24-hour rainfall event is 0.29 acre-feet, with an associated peak rate of flow of 5.44 cubic feet per second (cfs).

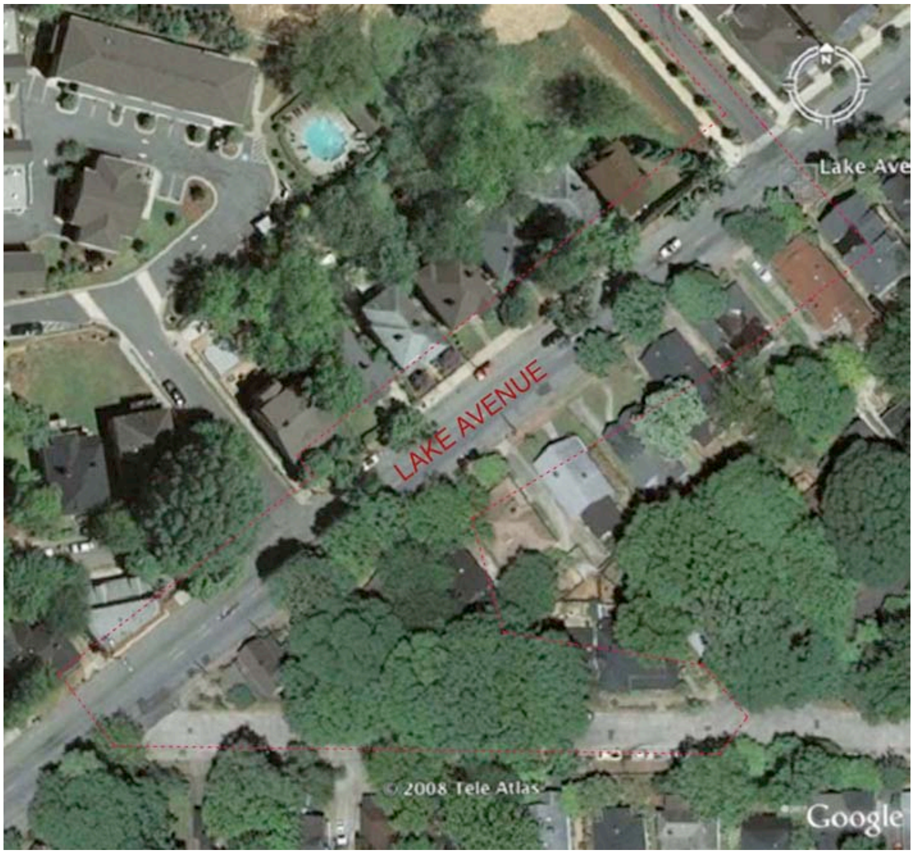


Figure 12 :: Area 1 **Source :: Google Earth 2008**

Area 2 (see Figure 13) begins at the centerline of Inman Village Parkway and continues north-east to the intersection of Lake Avenue and Hale Street, including 100 feet of Hale Street, SE. This drainage area is 3.65 acres and is characterized by higher density single-family residential units and has about 75% impervious cover. Using a curve number of 93, the Qvol for this watershed during a 2-year storm 24-hour rainfall event is 0.88 acre-feet, with an associated peak rate of flow of 16.52 cfs (Refer to Appendix C for calculation details).

Figure 13 :: Area 2 **Source :: Google Earth 2008**

As the initial starting point in the redesign of Lake Avenue, the assumption was made that the right-of-way would remain 60 feet in width. Within this right-of-way, general principles set forth by Fulton County ordinances, historic district design guidelines, and neighborhood needs influenced the overall form of the design.

Figure 14 :: Proposed Plan (nts)

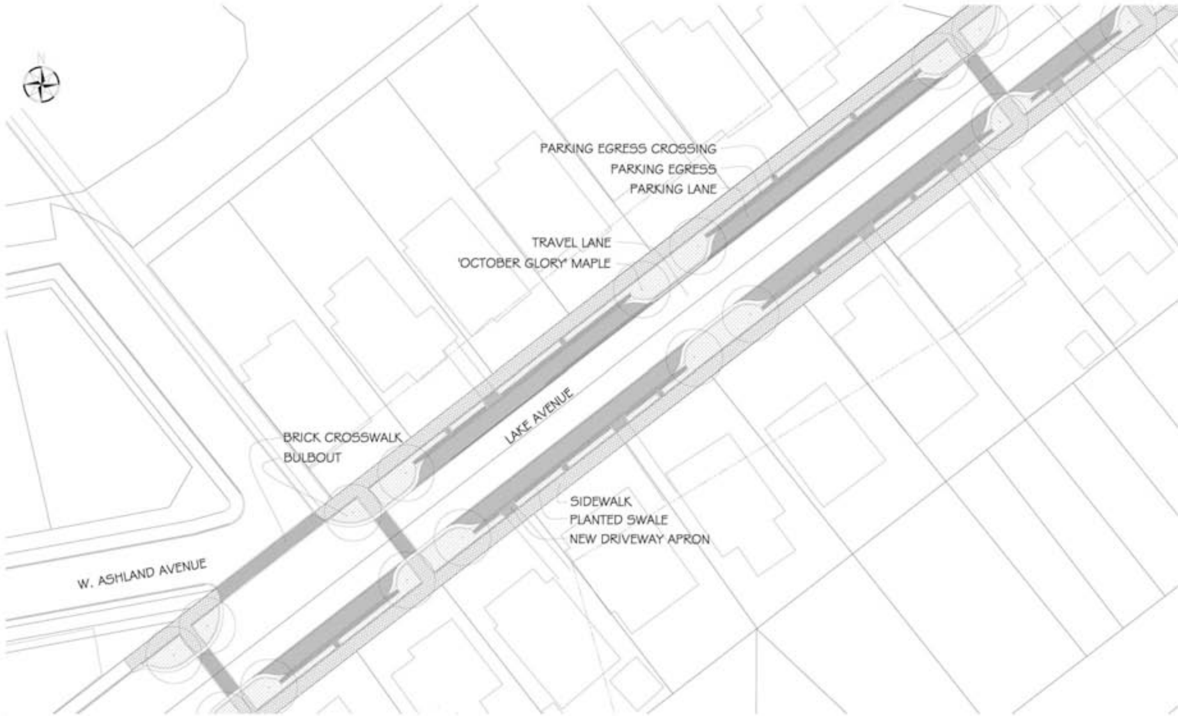


Figure 15 :: Proposed Plan Area 1 (nts)

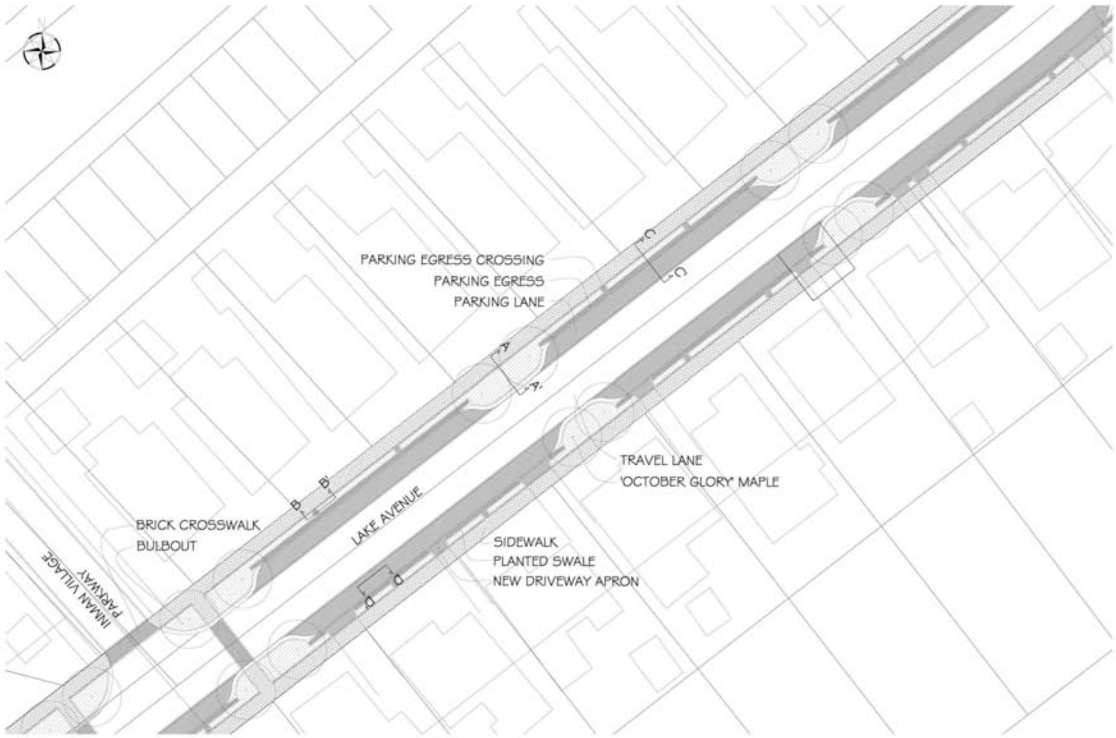


Figure 16 :: Proposed Plan Area 2a (nts)

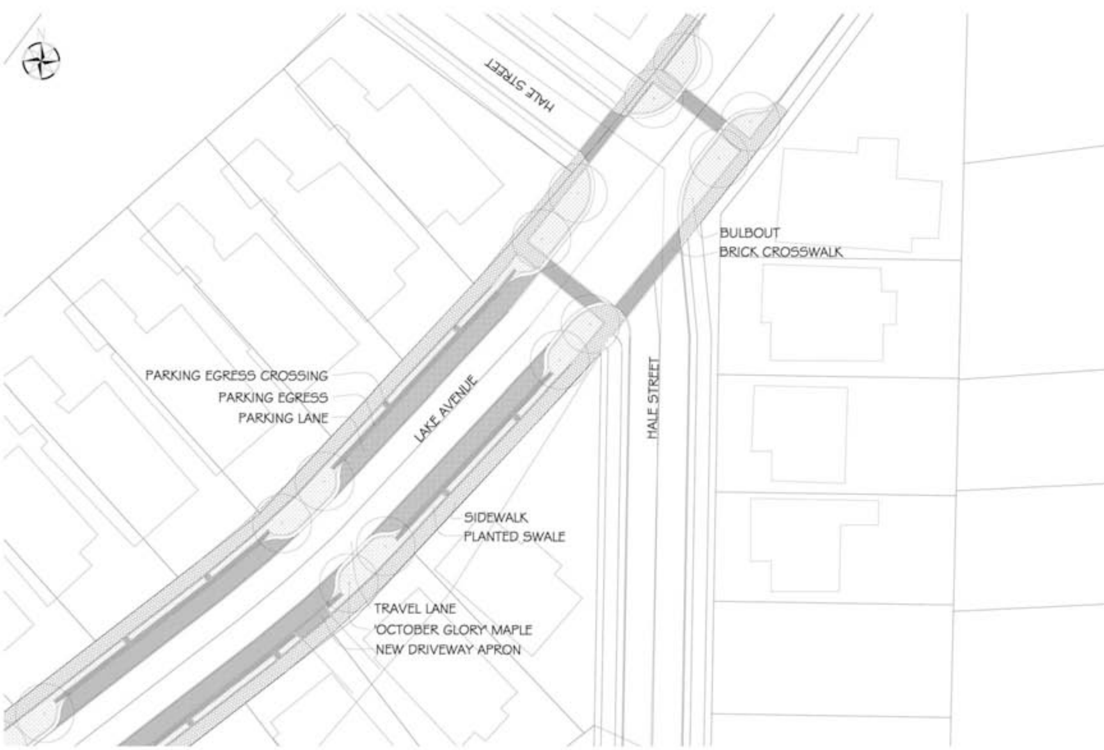


Figure 17 :: Proposed Plan Area 2b (nts)

In order to address the needs of pedestrians in both design areas, each side of the street includes a 6-foot-wide sidewalk. At every intersection, planted curb extensions push out into Lake Avenue to shorten the distance over the street that pedestrians must walk. Also included at the intersections are ADA-compliant brick crosswalks, providing visual markers for drivers that aid in slowing traffic speeds and provide clearly designated pedestrian routes.

In addition to serving as stormwater runoff, 3-foot-wide planted swales alongside the sidewalks and planted bulbouts that extend out about 8 feet into the road provide pedestrians and residents with valuable greenspace. The swales, which vary in length according to current driveway placement, serve as infiltration areas with a maximum ponding depth of 9 inches (Refer to Figures 18 & 22). The curb extensions typically include two 'October Glory' red maples, for a design total of 39 trees, providing a sense of rhythm, casting changing shadow patterns and adding year-round visual interest, and providing all of the environmental benefits typical of urban street trees. Following the lead of the Portland prototype, in all of the stormwater areas in the Lake Avenue design, runoff enters through curb cuts at the high end of the swale or extension and overflows through curb cuts at the lower elevation end, spilling back into the gutter and traveling down slope to the next inlet.

Due to the fact that on-street parking is in high demand in the Inman Park neighborhood, this design includes an 8-foot-wide parking lane. The herringbone-patterned pavers utilized in this space clearly separates the parking lanes from the travel lanes, thus visually reducing the width of the travel areas. Such a technique is a well-documented traffic calming measure that has had much success in similar neighborhoods throughout the United States. Additionally, a 2-foot-wide parking egress along the length of the planted swales provides access to the sidewalks.

In order to incorporate existing driveways into the design, each driveway is given a new apron that adjoins the parking lane, with on-street parking and curb extensions adjusted to account for the driveways' current locations. Lastly, the width of the travel lanes has each been reduced to from 20 feet to 11 feet. As previous research suggests, this width allows for the safe passage of emergency vehicles, but is effective in slowing traffic speeds to levels safer for pedestrians.

B. <u>Design Benefits</u>

In the SEA Street and Skinny Street prototypes, infiltration of stormwater runoff occurs almost entirely in planted swales adjacent to the roads and walkways. However, in the Lake Avenue site, design codes and urban density prevent the allocation of the amount of space required to create swales of the same dimensions and capacity as the Seattle and Portland designs. In order to explore ways in which recovery of stormwater to the greatest capacity is possible, this thesis examines two alternatives. Alternative 1 captures and infiltrates runoff only in the planted swales and curb extensions, as did the Northwestern prototypes. Alternative 2 offers a more extensive approach, going beyond the Northwestern precedents, by capturing runoff not only in the planted areas, but also at the sidewalks, parking egresses, parking lanes, and new driveway aprons by utilizing interlocking pervious pavers. Both alternatives can be achieved within the plan layouts shown in Figures 14, 15, 16, and 17.

Alternative 1

In this alternative, similar to the Northwestern prototypes, only the vegetated swales and curb extensions are used for infiltration. Figure 16 illustrates the drainage components, including the planting soil media, which is 85-88% sand, 8-12% fines, and 3-5% organic matter (NCDENR 2007). In this design, the available area for infiltration in Area 1 is 0.08 acres, which includes all of the planted swales and planted areas of the curb extensions. Based on the infiltration rates of the associated soils of 0.18 feet/day and a maximum ponding time of 4 days, this design area is capable of infiltrating 0.13 acre-feet of stormwater runoff. In Area 2, the available area for infiltration is 0.13 acres, resulting in an infiltration volume of 0.34 acre-feet of runoff.

With a stormwater flow volume (Qvol) of 0.29 acre-feet and an infiltration volume of 0.13 acre-feet, Area 1 is able to capture 44.83% of stormwater runoff for infiltration. In Area 2, with a Qvol of 0.88 acre-feet and an infiltration volume of 0.34 acre-feet, 38.64% of the runoff is captured.

In order to ensure infiltration in this design, the parking egress crossings act as check dams as shown in Figure 19, preventing runoff from simply flowing to the lowest points in the swale. Compacted subgrade beneath the crossings prevent lateral flow and force infiltration, while 4” PVC overflow pipes allow for proper drainage in storm events larger than the 2-year design storm.

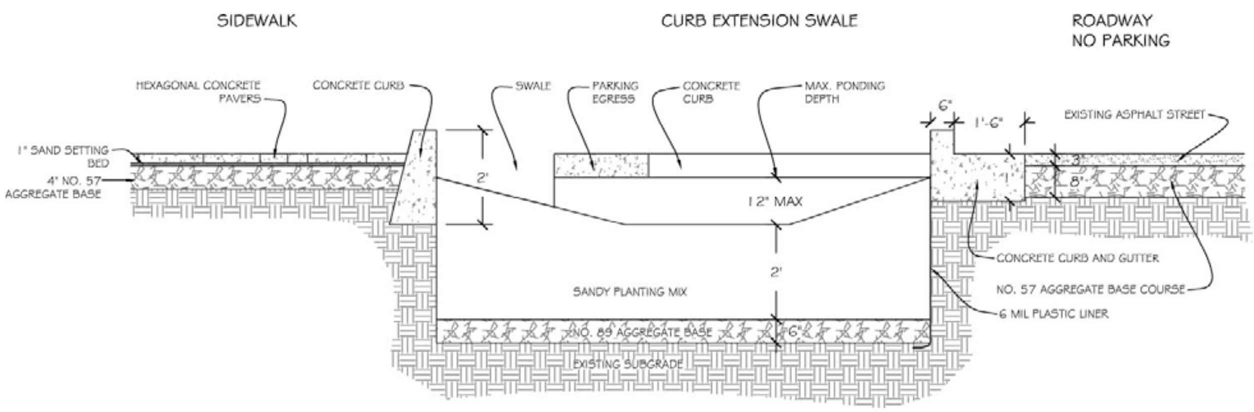


Figure 18 :: Section A-A'

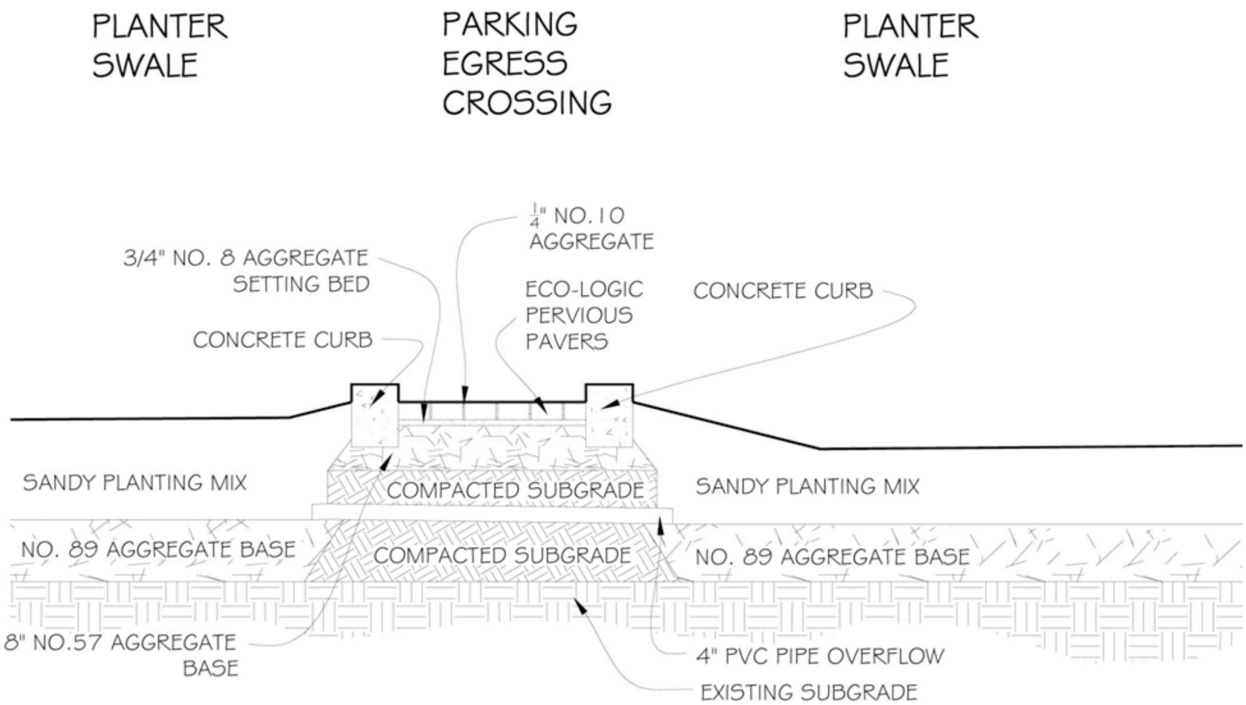


Figure 19 :: Section B-B' **Longitudinal Section at Swale Crossing**

Alternative 2

As discussed above, this design goes further than Alternative 1 by utilizing void space beneath pervious pavers in order to increase the available infiltration area. This design incorporates 4" x 8" Eco-logic pavers with 1/4" spacers by Capitol Concrete (refer to Appendix B for product specifications) into the parking lanes, new driveway aprons, and parking egresses. Figure 20 shows details of the street edge.

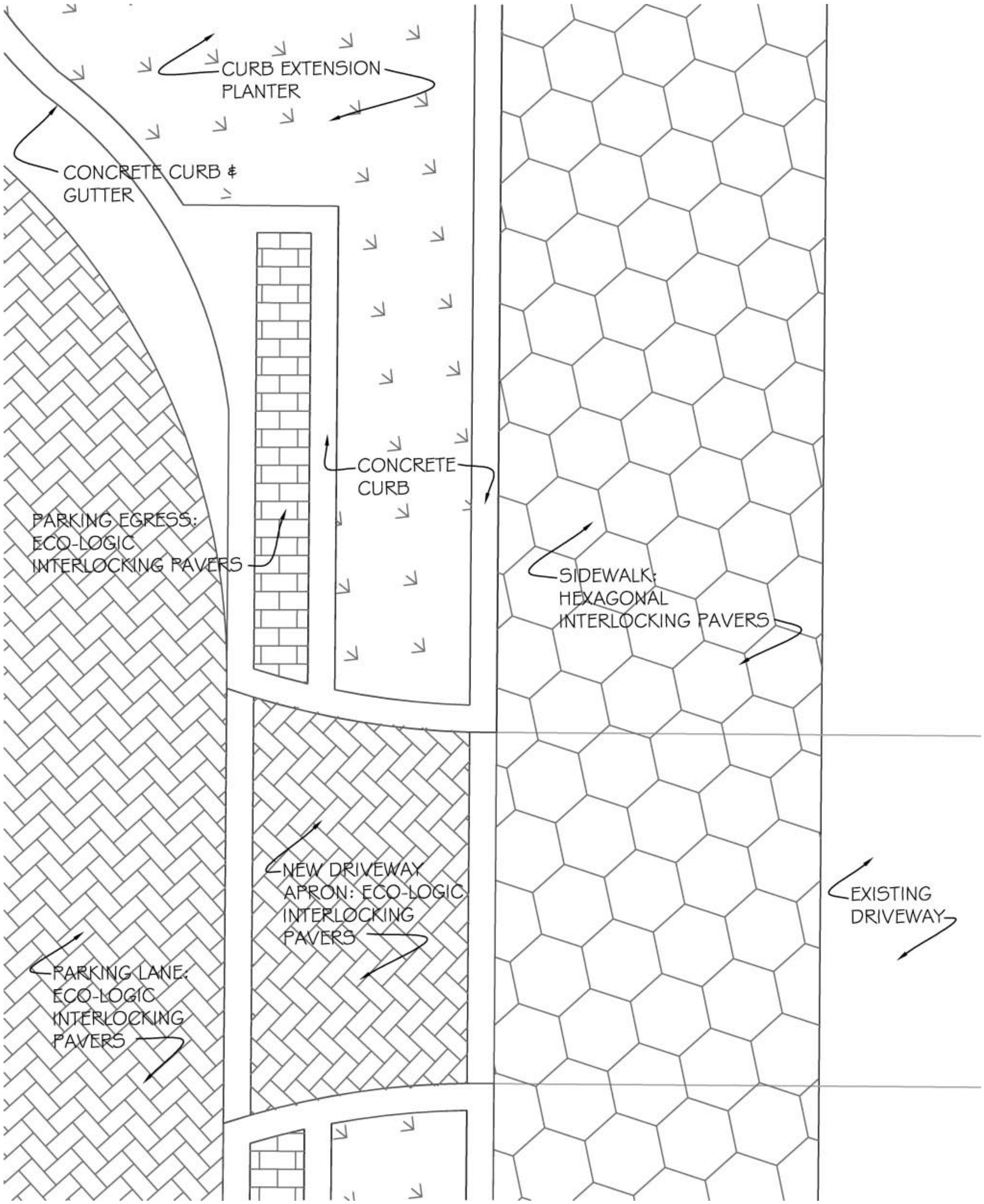


Figure 20 :: Paving Pattern Detail for Alternative 2

For the sidewalks, an interlocking pervious hexagonal paver was desired that would meet the Inman Park Neighborhood Association design guidelines and match Lake Avenue's existing sidewalk pavers, while also satisfying the retrofit's infiltration needs. However, at the time of this design, pervious hexagonal pavers were not commercially available. Thus, this thesis proposes the introduction to the trade of a 2 ¼" thick, 15 7/8" across flat pervious hexagonal paver with 1/4" spacers as shown in Figure 20. For permeability, the aggregate in the 1/4" joints would be ASTM No. 10, which is also utilized between the joints of the Eco-logic pavers.

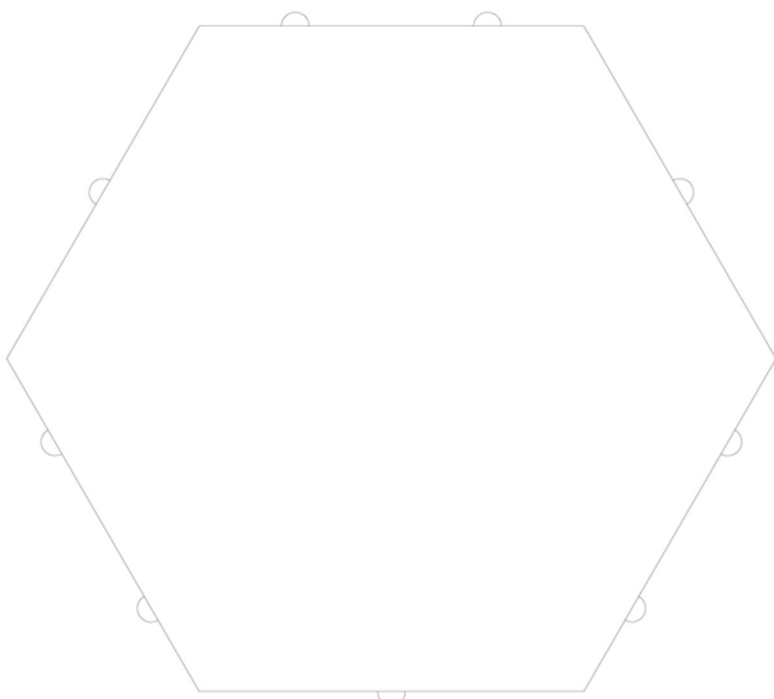


Figure 21 :: Hexagonal Pervious Paver Detail

In Area 1, using this sidewalk paver along with the other measures described above, the available area for infiltration becomes 0.32 acre-feet, resulting in an infiltration volume of 0.50

acre-feet. Area 2 expands the area available to 0.48 acre-feet with an infiltration volume of 1.26 acre-feet.

With a stormwater flow volume (Qvol) of 0.29 acre-feet and an infiltration volume of 0.50 acre-feet, Area 1 is able to capture 172% of stormwater runoff for infiltration. In Area 2, with a Qvol of 0.88 acre-feet and an infiltration volume of 1.26 acre-feet, 143% of the runoff is captured. This excess capacity allows the two areas to infiltrate 100% of the runoff in the reduced time of about 2 or 3 days, thus providing superior stormwater performance as compared with the 4 days originally assumed necessary. Alternatively, the excess capacity could allow for a slight reduction in the expense of the retrofit project by allowing for the omission of the specially manufactured permeable sidewalk pavers from the design.

Also in this design, forced infiltration occurs not only in the planted swales, but also along the areas of pervious paving. Impermeable geomembrane barriers located in the parking lanes prevent stormwater from simply flowing down the length of the road. This is illustrated in Figures 19 and 23 (Refer to Appendix C for calculation details).

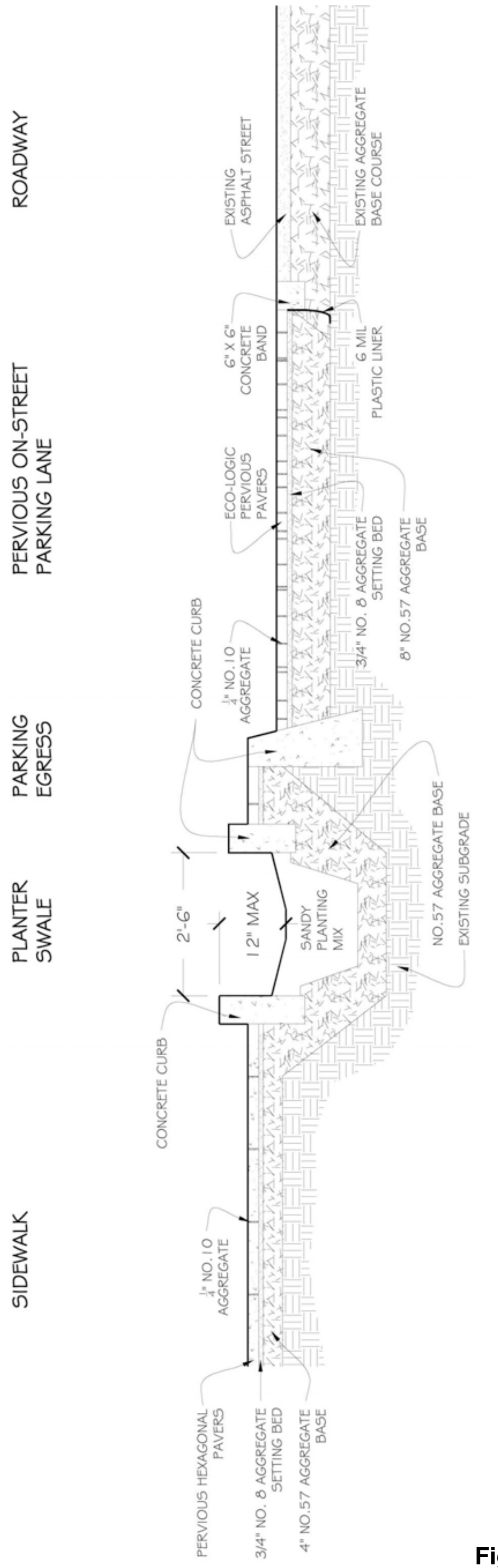


Figure 22 :: Section C-C'

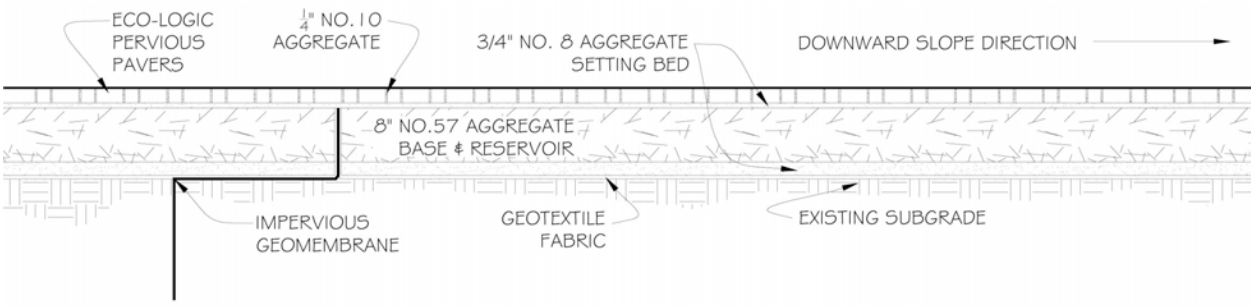
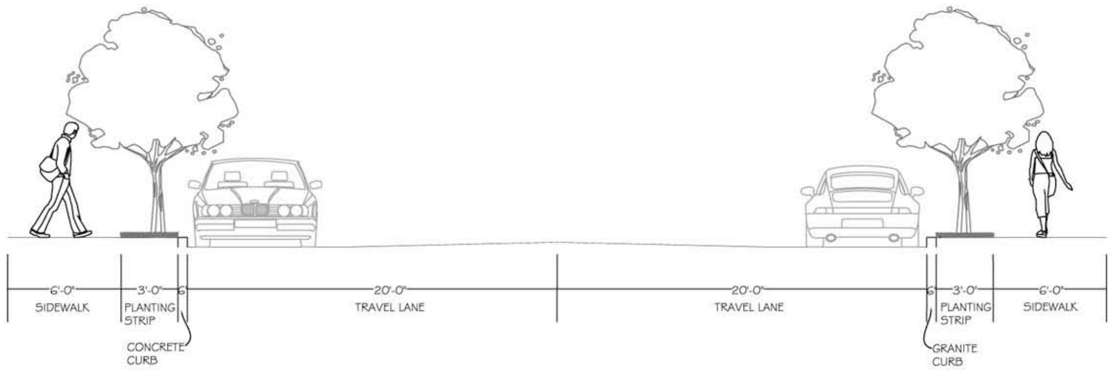
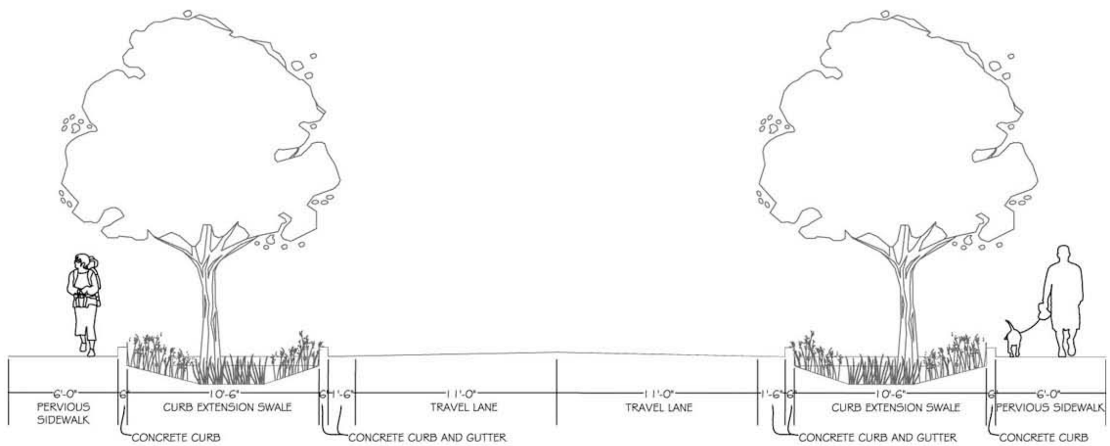


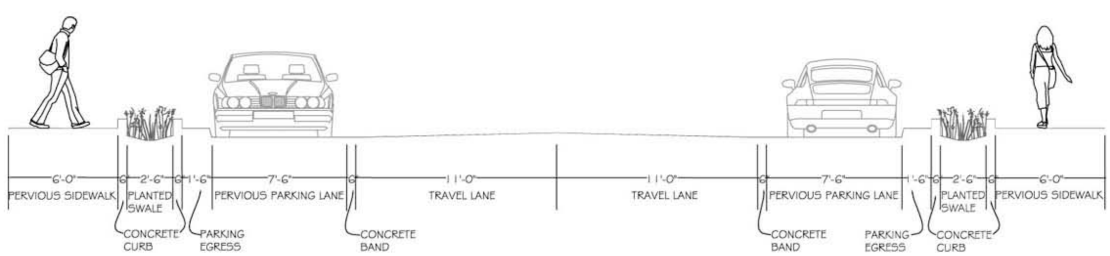
Figure 23 :: Section D-D' **Forced Infiltration in Parking Lanes**



Cross-section A :: Existing Conditions



Cross-section B :: At Curb Extensions



Cross-section C :: At Parking Lanes

Figure 24 :: Cross-section Comparisons

Chapter Seven
Conclusions

In this thesis, the overall goal was to determine whether or not modifications would become necessary when the Pacific Northwest stormwater retrofits were relocated into the Piedmont region of the Southeast. In fact, as the application discussed in the previous chapter illustrates, modifications were needed. The following pages highlight observed changes and point out areas for further investigation.

Design synthesis

In order for the design application to highlight similarities and differences between a Southeastern sample and the Pacific Northwestern prototypes, a design area had to be chosen that would provide an adequate portrayal of design constraints typical of sites in urban areas throughout the Southeast. In general, residential streets in such areas include a range of densities, from single-family lots with low percentages of impervious cover to multi-family, medium density lots to mixed-use, commercial, high density lots with high percentages of impervious cover. Because the Northwestern prototypes are found in low-density residential areas, this investigation sought to determine whether such designs could also provide beneficial effects in higher density areas and how the design forms would have to evolve in order to effectively achieve these benefits. The following questions arose when critiquing the theoretical application and could be used in future investigations. First, are such designs effective only in moderately dense single-family residential streets or can they also function well in high density, commercial or multi-use areas? How would the design forms change as one moves through low-density streets to high-density ones? Does a sense of citizen ownership, and thus stewardship of the design, exist in multi-use areas? Where would the responsibility for maintenance shift to in such locations? Another aspect of such stormwater system designs that could use further investigation is the very different social views of ownership of the systems in the Pacific Northwestern sites versus the Southeastern site. Do greater hurdles to implementation exist in the Southeast in terms of community wants versus municipal codes and perceptions?

Due to the higher urban density, less available infiltration area, more intense rainfall, and slow permeability of the soils of the Southeastern site, using only vegetated swales for capturing stormwater runoff, as has been done in the Pacific Northwest, provided insufficient infiltration capacity. The results of the application section of this thesis demonstrate that more-than-adequate capacity can be found with a more aggressive design in which both vegetated swales and porous pavements are utilized. While this combined application is entirely located within the public right-of-way, as are the Northwestern prototypes, the Southeastern design is more technologically diverse and aggressive in order to address the more demanding stormwater conditions of the region and of the site. Additionally, in order to adjust the design forms in a future application to accommodate greater volumes of stormwater runoff, as would be needed in more dense areas with higher percentages of impervious surfaces and less area for vegetated swales, the base coarse of aggregate beneath the pervious paver surfaces could be expanded to create a larger reservoir.

While the provision of features in the hypothetical Southeastern designs is driven by the need for at-source stormwater management and restoration in line with low-impact development principles, following the Pacific Northwestern prototypes' influence, these designs provide multiple environmental and social benefits. As they do in the Northwest, these designs aid in expansion of the urban tree canopy and general additions of urban greenspace, definition of parking lanes, traffic calming, pollution abatement, and a multitude of other environmental benefits.

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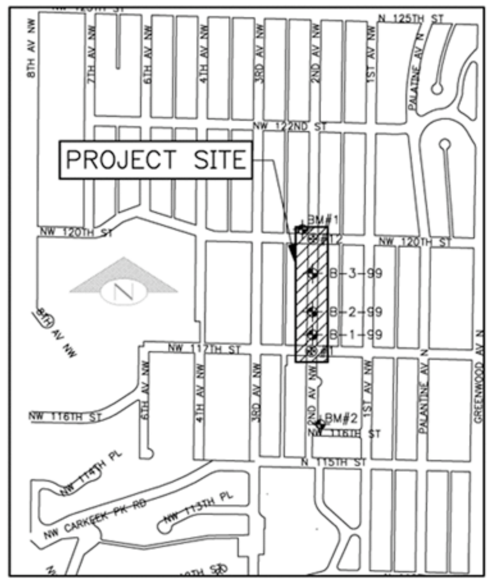
Appendix A
Seattle Plans



VICINITY MAP
SCALE:1"=400'

DRAINAGE NOTES
UNLESS OTHERWISE NOTED:

1. DATUM: CITY OF SEATTLE. (SEE DATUM/SURVEY CONTROL)
2. PIPE LESS THAN 12" DIAMETER SHALL BE CONCRETE PER ASTM C14 CLASS 3.
3. PIPES GREATER THAN OR EQUAL TO 12" DIAMETER SHALL BE ASTM C76 CLASS V.
4. DUCTILE IRON PIPE SHALL BE PER ANSI A21.51 CLASS 52 WITH PUSH-ON JOINTS. FITTINGS FOR DUCTILE IRON PIPE SHALL BE DUCTILE PER ANSI A21.10 OR ANSI A21.53 WITH PUSH-ON JOINTS.
5. PVC PIPE AND FITTINGS SHALL BE PER ASTM D 1785, SCH 40, WITH EITHER RUBBER GASKET JOINTS OR SOLVENT WELDED JOINTS. PVC PSS AND PSD PIPES SHALL BE TESTED FOR EXCESSIVE DEFLECTION WITH A MANDREL PER SECTION 7-17.3(4) OF THE SPECIFICATIONS.
6. SUBSURFACE DRAIN (SSD) PIPE AND FITTINGS SHALL BE PVC PER ASTM D1785, SCH 40 WITH SOLVENT WELDED JOINTS. PIPE SHALL HAVE SLOTTED PERFORATIONS. SLOTS ARE TO BE 0.040" WIDE BY 1.0" LONG AND SPACED 0.25" APART. SLOT LOCATIONS SHALL BE LOCATED PER SLOT DETAIL ON PLAN.
7. BEDDING SHALL BE CLASS B FOR ALL PIPE EXCEPT DUCTILE IRON PIPE, WHICH SHALL BE CLASS D. BEDDING MATERIAL FOR PVC PIPE SHALL BE MINERAL AGGREGATE TYPE 22. BEDDING MATERIAL FOR PVC PIPE AND CMP SHALL BE MECHANICALLY COMPACTED TO 90% OF MAXIMUM DRY DENSITY AS MEASURED BY ASTM D-698.
8. WHERE A NEW PIPE CLEARS AND EXISTING OR UTILITY BY 6" OR LESS, POLYETHYLENE PLASTIC FOAM SHALL BE PLACED AS A CUSHION BETWEEN EACH UTILITY.
9. TEES, CATCH BASIN CONNECTIONS, SIDE SEWER, AND SERVICE DRAINS SHALL BE PLACED AT A MINIMUM SLOPE OF 0.5% AND A MAXIMUM SLOPE OF 50%.
10. SERVICE DRAINS AND SIDE SEWERS SHALL BE CONNECTED/RECONNECTED AS APPROVED BY THE ENGINEER.
11. RELAY EXISTING SERVICE DRAINS/SIDE SEWERS TO CLEAR OVER OR UNDER THE NEW UTILITY AS APPROVED BY THE ENGINEER.
12. SERVICE DRAINS AND SIDE SEWERS SHALL NOT BE BACKFIELD UNTIL THE PIPE HAS BEEN INSPECTED AND APPROVED AND THE LOCATION AND DEPTH IS RECORDED BY THE ENGINEER.
13. TEES ON NEW PIPE SHALL BE PREFABRICATED.
14. SOILS TEST BORING LOCATIONS ARE INDICATED ON THE VICINITY MAP. TEST DATA IS INCLUDED IN THE SPECIFICATIONS.
15. THE CONTRACTOR SHALL PROVIDE SUPPORTS FOR POWER POLES NEAR EXCAVATIONS PER SEATTLE CITY LIGHT STANDARDS NO. D3-6.
16. GRADING PLAN TO BE PROVIDED AT TIME OF PRECONSTRUCTION MEETING. STATIONING & ELEVATION MAY BE MODIFIED IN THE FIELD AS DIRECTED BY ENGINEER.

Sheet Index

Sht No.	Sheet Description
1	VICINITY MAP, GENERAL NOTES, DETAIL AND SECTION REFERENCING
2	REMOVAL & RELOCATION PLAN
3	DRAINAGE PLAN & PROFILE
4	DRAINAGE PLAN & PROFILE
5	DRAINAGE PROFILE WEST SIDE
6	CROSS SECTION DETAILS
7	DRAINAGE DETAILS SHEET
8	DRAINAGE DETAILS SHEET
9	PAVING ALIGNMENT PLAN
10	PAVING PLAN
11	PAVING PLAN
12	LANDSCAPING PLAN
13	LANDSCAPING PLAN
14	TREE SCHEDULE AND PLANTING SCHEDULE

PAVING NOTES
UNLESS OTHERWISE NOTED:

1. JOINTS BETWEEN EXISTING PAVEMENT AND NEW ASPHALT SHALL BE BUTT JOINTS.
2. EXISTING ASPHALT PAVING SHALL BE REMOVED ON A NEAT LINE ADJACENT TO NEW CONSTRUCTION.
3. IF SUBGRADE SOFT SPOTS ARE ENCOUNTERED, THE CONTRACTOR SHALL OBTAIN REQUIRED COMPACTION IN ACCORDANCE WITH SECTIONS 2-06.3 (2) AND 2-06.3 (3) OF THE STANDARD SPECIFICATIONS.
4. PAVEMENT RESTORATION FOR CONCRETE STREETS AND CONCRETE WALKS WHICH ARE NOT SHOWN ON THE PLANS SHALL BE IN ACCORDANCE WITH THE "STREET AND SIDEWALK PAVEMENT OPENING AND RESTORATION RULES", THE CURRENT VERSION.
5. REPLACEMENT OF CASTINGS AND COVERS WILL BE PROVIDED BY THE OWNER(S) OF THE UTILITIES. THE CONTRACTOR SHALL ADJUST ALL UTILITY CASTINGS AND METER BOXES TO GRADE PRIOR TO THE INSTALLATION OF THE FINAL WEARING COURSE. CASTINGS AND METER BOXES DAMAGED DUE TO THE CONTRACTOR SHALL BE REPLACED BY THE CONTRACTOR AT THE CONTRACTOR'S EXPENSE.
6. HYDRANTS, WATER METERS, AND OTHER WATER SERVICES SHALL BE ADJUSTED OR RELOCATED BY SPU WATER OPERATIONS.
7. CONTRACTOR SHALL NOTIFY THE LANDSCAPE ARCHITECT (SHANE DEWALD AT 206-684-5041) FOUR (4) WORKING DAYS PRIOR TO TRIMMING ANY TREES.
8. EXISTING MONUMENT CASTINGS WITHIN THE CONSTRUCTION AREA SHALL BE ADJUSTED OR RESET. CONTRACTOR SHALL CONTACT SPU SURVEY (W.M. BLANKENSHIP AT 684-5073) FOUR (4) WORKING DAYS PRIOR TO REMOVING MONUMENT CASTINGS TO ENSURE THAT THE MONUMENTS ARE "TIED OUT" PRIOR TO REMOVAL.
9. CONTRACTOR SHALL NOTIFY TRANSPORTATION DIVISION (ROBERT BURNS AT 206-684-5370) FOUR (4) WORKING DAYS PRIOR TO SIGN AND PARKING METER REMOVAL AND INSTALLATIONS. INSTALLATIONS ARE TO BE INSTALLED IN ACCORDANCE WITH STANDARD PLANS.
10. PARKING AREAS SHALL BE FIELD MARKED BY THE ENGINEER. STALL WIDTHS ARE 9'.

DETAIL AND SECTION REFERENCING

4/8 — DETAIL REFERENCE NUMBER / SHEET ON WHICH DETAIL APPEARS

(Title) (Scale) 4/9 — DETAIL REFERENCE NUMBER / SHEET FROM WHICH DETAIL WAS TAKEN

("TYP" SPECIFIES THAT DETAIL IS UNIFORMLY TYPICAL THROUGHOUT PROJECT EXCEPT WHERE OTHERWISE NOTED.)
("VAR" SPECIFIES THAT DETAIL WAS TAKEN FROM SEVERAL SHEETS.)

A — A 32 — SECTION A-A IS SHOWN ON SHEET 32.

Section A-A (Scale) 30 — SECTION A-A IS TAKEN FROM SHEET 30.

ABBREVIATIONS

TSE: TOP SWALE ELEVATION
BSE: BOTTOM SWALE ELEVATION
ORF DIAM: ORFICE DIAMETER
• PERF: PREFERRED

DATUM/SURVEY CONTROL

1. VERTICAL DATUM: CITY OF SEATTLE.
   BM#1 EL: 380.11 FIELDBOOK 2086-N / PAGE 43
   FND. CHISELED SQUARE, CENTER CONC WALK, 6' N. OF S. END, AT NW CORNER 2ND AVE NW AND NW 120TH ST.
   BM#2 EL: 366.23 FIELDBOOK 2086-N / PAGE 43
   FND. CHISELED SQUARE, ON S SIDE PRIVATE CONC WALK AT FIRST SEAM, HOUSE #11602, AT NE CORNER INTX OF 2ND AVE NW AND NW 116TH ST.
2. HORIZONTAL DATUM: HPGN/NAD83/91 PER CITY DETERMINED COORDINATES ON MONUMENTS AT STREET INTERSECTIONS.
   #1 N:264234.82 E:1264726.57
   MON IN CASE AT INTX 2ND AVE NW AND NW 117TH ST
   #12 N:264897.30 E:1264735.09
   CONC MON IN CASE AT INTX 2ND AVE NW AND NW 120TH ST

EROSION CONTROL

FLOW MONITORING POOL CONSTRUCTION SHALL BE FIRST ORDER OF WORK AND SHALL BE CONSTRUCTED AND OPERATED TO CHANNEL ALL SURFACE DRAINAGE THROUGH AND DURING CONSTRUCTION. THIS SHALL BE OPERATED AS A SEDIMENT CONTAINMENT AREA SO THAT NO SEDIMENT ENTERS THE DOWN STREAM DRAINAGE SYSTEM OR PIPERS CREEK AND IT'S TRIBUTARIES (SEE SHEET 3).

RECORD DRAWING

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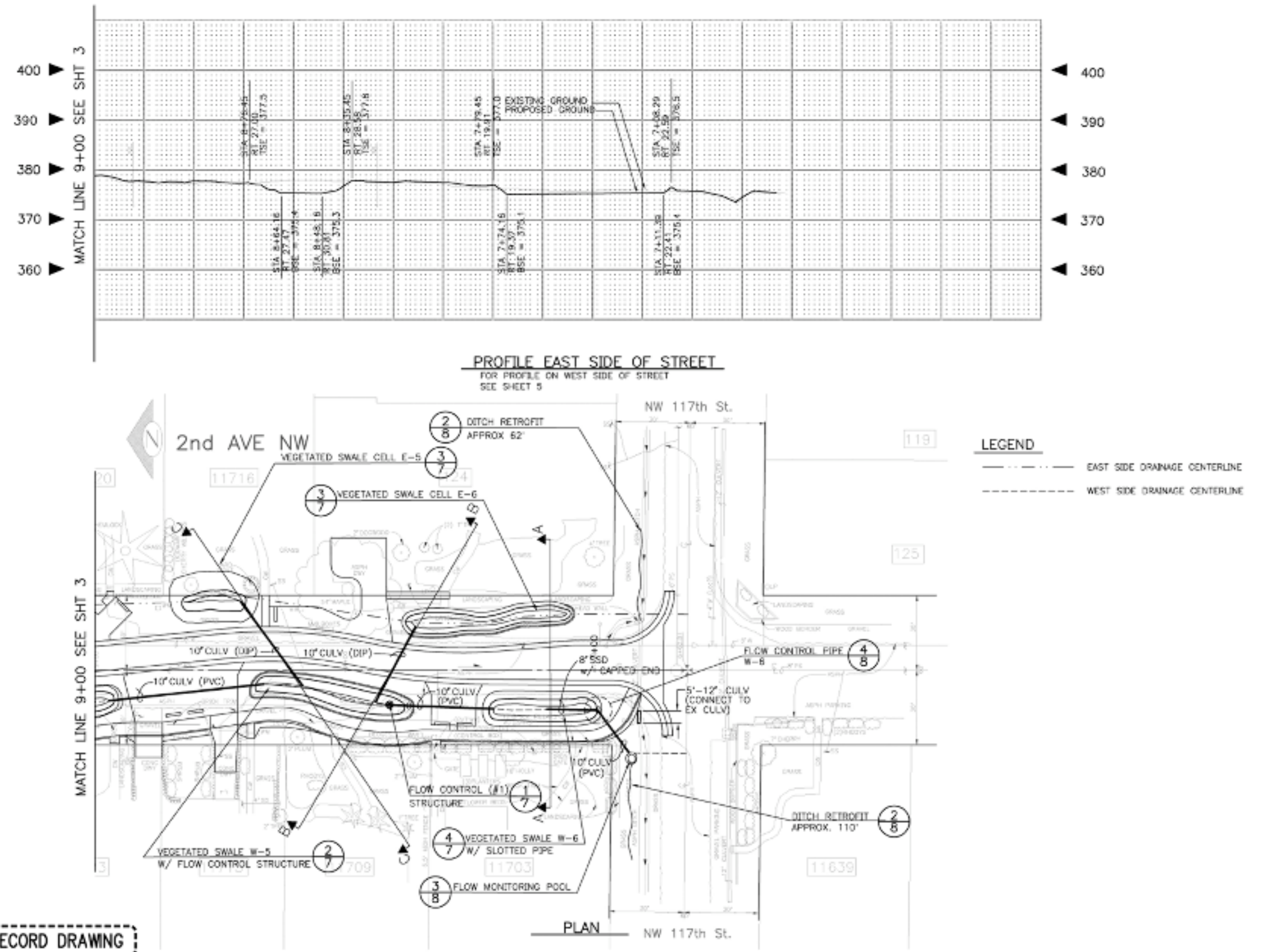
VAULT PLAN NO. 777-162
SHEET 1 OF 14



FOR PAVING PLAN, SEE SHEET 10&11
FOR DRAINAGE PLAN, SEE SHEET 3&4
FOR LANSCAPING PLAN, SEE SHEET 12&13

RECORD DRAWING

DRAINAGE PLAN & PROFILE

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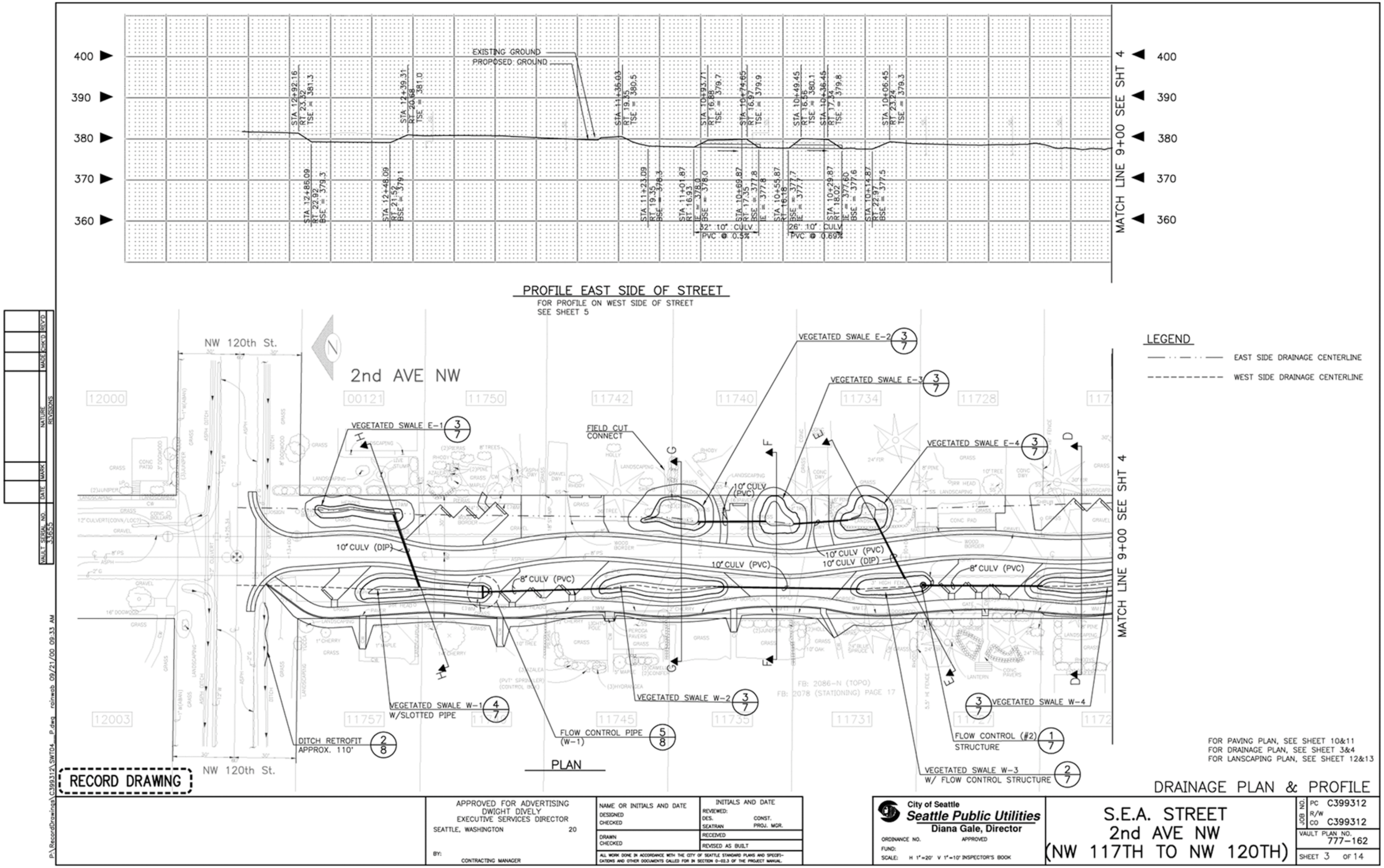
SHEET 4 OF 14



PROFILE EAST SIDE OF STREET
FOR PROFILE ON WEST SIDE OF STREET SEE SHEET 5
EXISTING GROUND
PROPOSED GROUND
400
390
380
370
360
MATCH LINE 9+00 SEE SHT 4
32' 10" CULV PVC @ 0.5%
26' 10" CULV PVC @ 0.69%
LEGEND
EAST SIDE DRAINAGE CENTERLINE
WEST SIDE DRAINAGE CENTERLINE
NW 120th St.
2nd AVE NW
VEGETATED SWALE E-1
VEGETATED SWALE E-2
VEGETATED SWALE E-3
VEGETATED SWALE E-4
FIELD CUT CONNECT
10" CULV (PVC)
10" CULV (DIP)
10" CULV (PVC)
8" CULV (PVC)
VEGETATED SWALE W-1 W/SLOTTED PIPE
VEGETATED SWALE W-2
VEGETATED SWALE W-3 W/ FLOW CONTROL STRUCTURE
VEGETATED SWALE W-4
DITCH RETROFIT APPROX. 110'
FLOW CONTROL PIPE (W-1)
FLOW CONTROL (#2) STRUCTURE
PLAN
RECORD DRAWING
FOR PAVING PLAN, SEE SHEET 10&11
FOR DRAINAGE PLAN, SEE SHEET 3&4
FOR LANSCAPING PLAN, SEE SHEET 12&13
DRAINAGE PLAN & PROFILE
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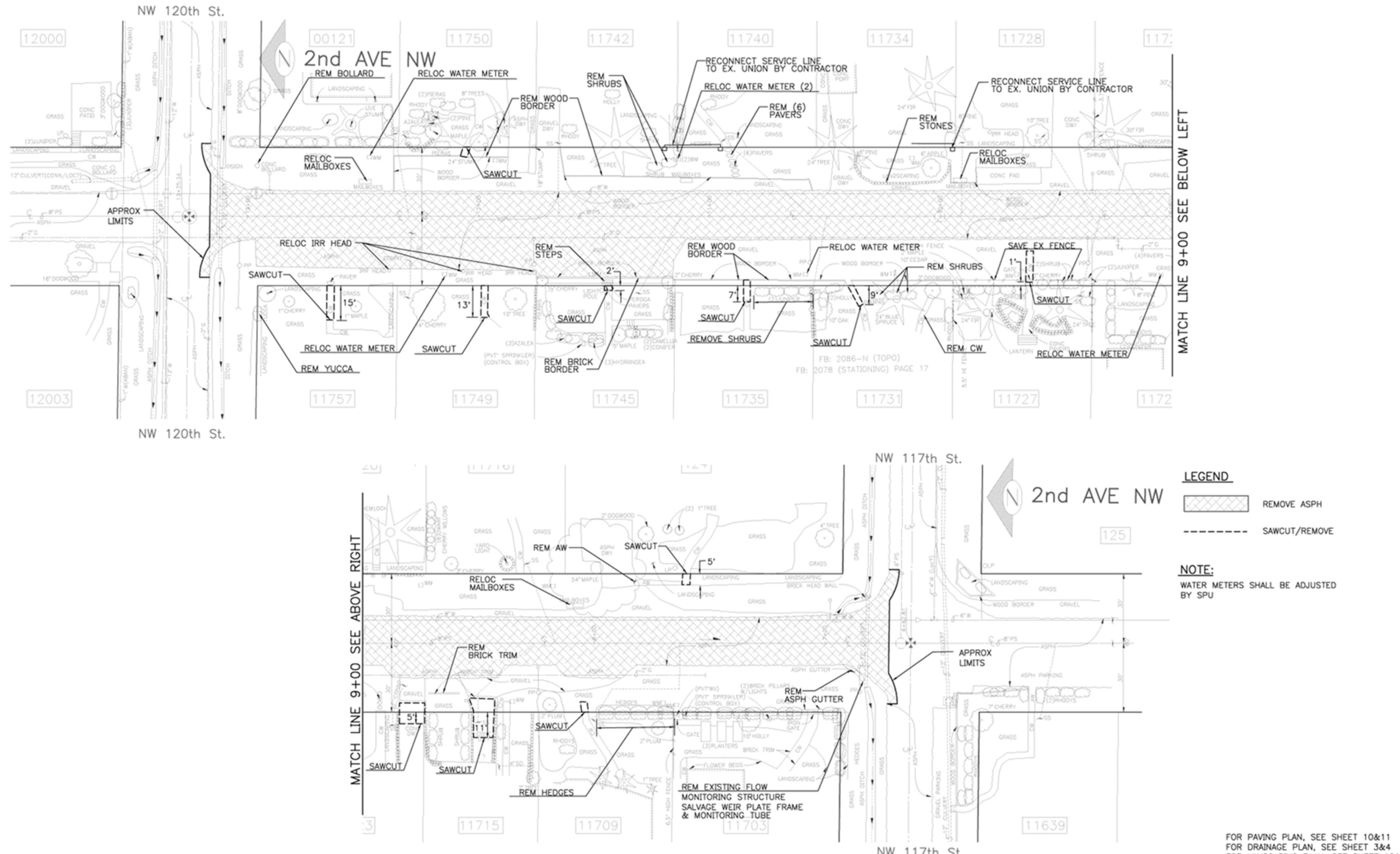
CO C399312
VAULT PLAN NO. 777-162
SHEET 3 OF 14



FOR PAVING PLAN, SEE SHEET 10&11
FOR DRAINAGE PLAN, SEE SHEET 3&4
FOR LANSCAPING PLAN, SEE SHEET 12&13

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REMOVAL & RELOCATION PLAN

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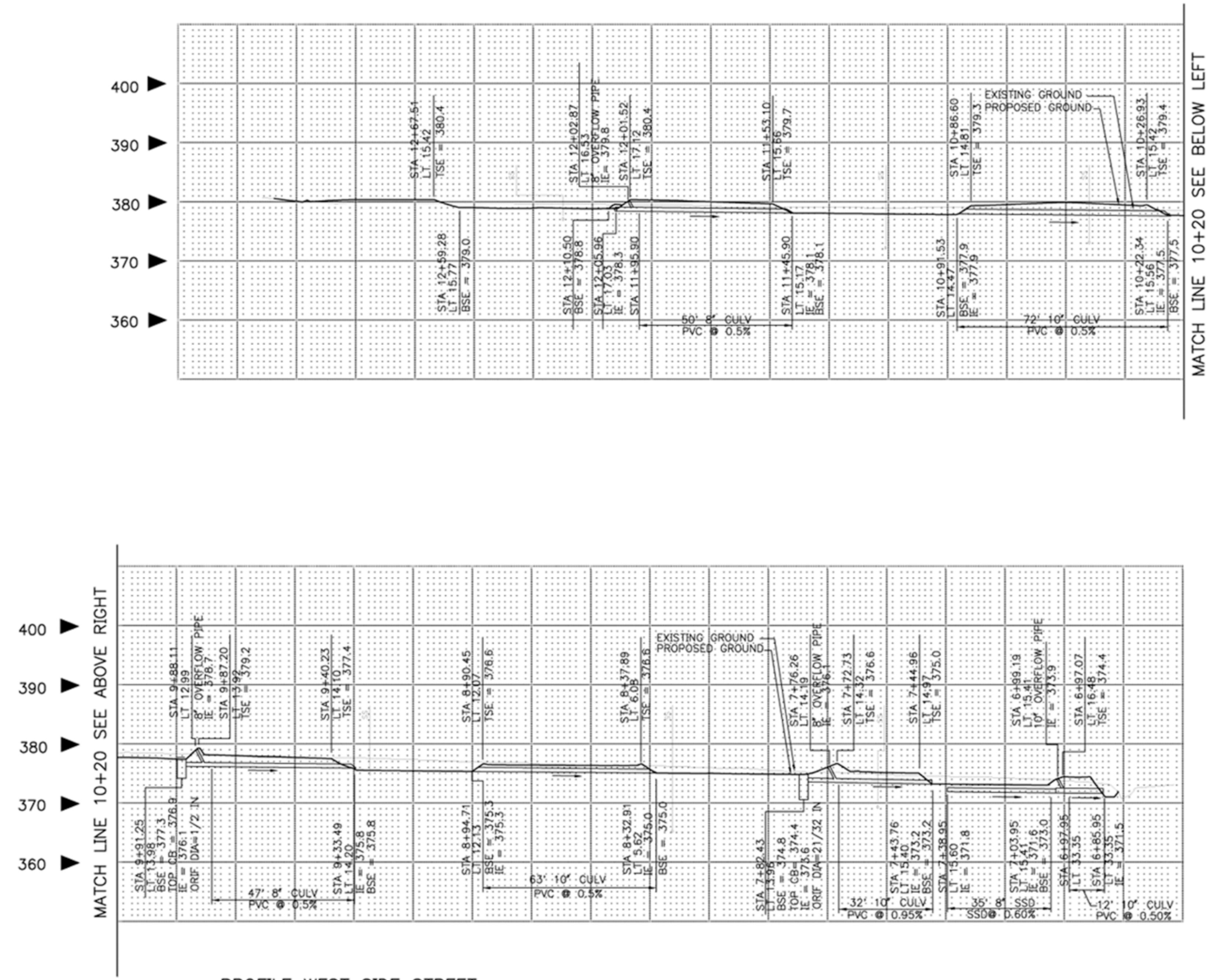
SHEET 2 OF 14



PROFILE WEST SIDE STREET

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DRAINAGE PROFILE WEST SIDE

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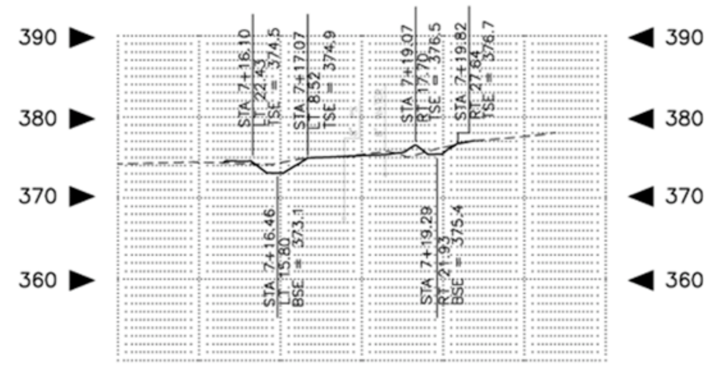
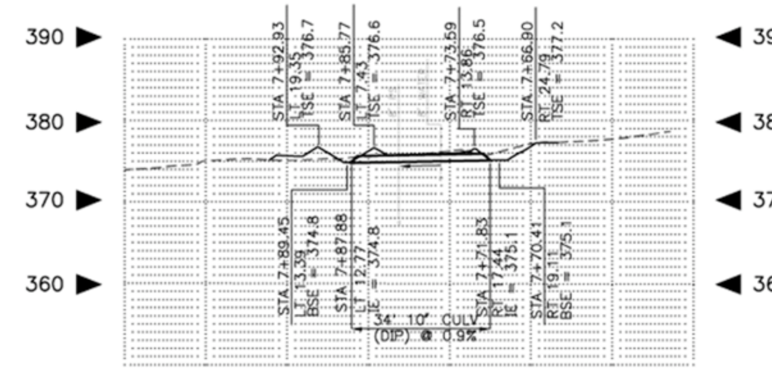
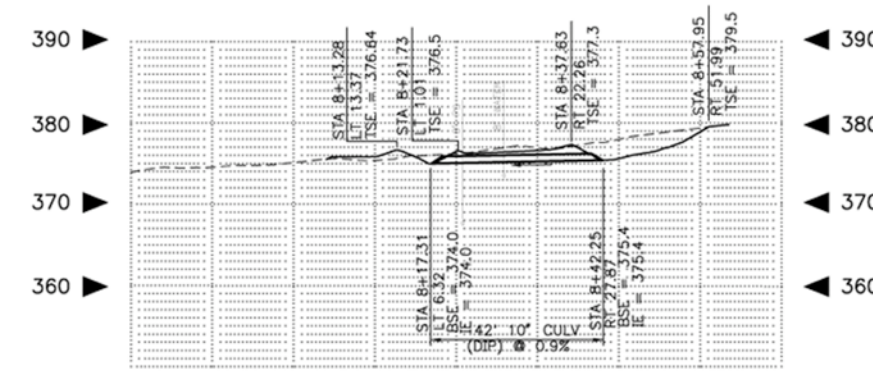
VAULT PLAN NO. 777-162
SHEET 5 OF 14



SECTION A–A: VEGETATED SWALE W6,E6



SECTION B–B: VEGETATED SWALE W5,E6



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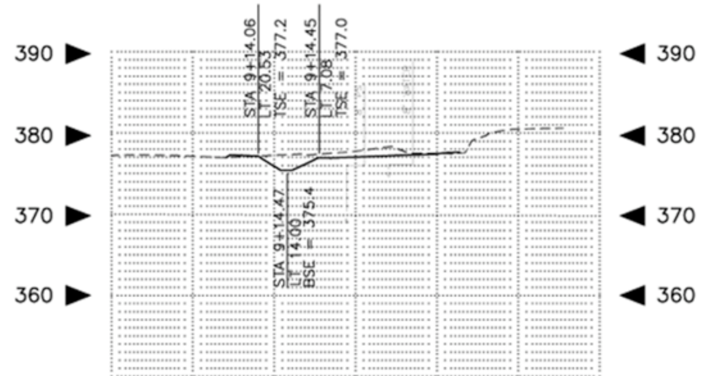

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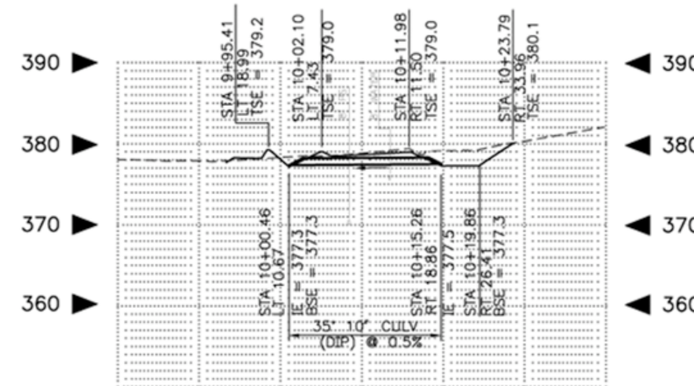
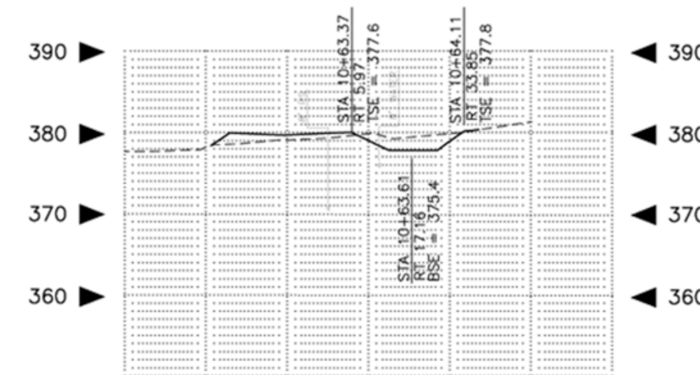


SECTION E–E: VEGETATED SWALE W3,E4



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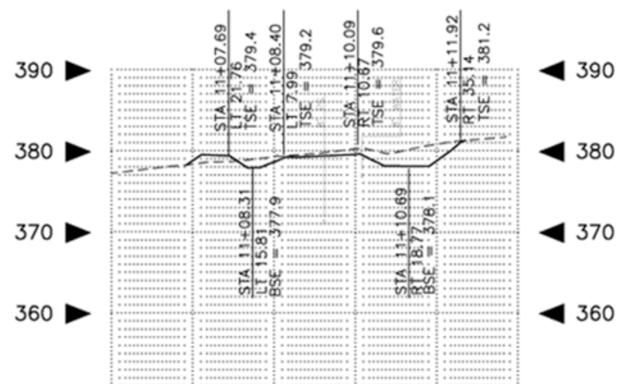

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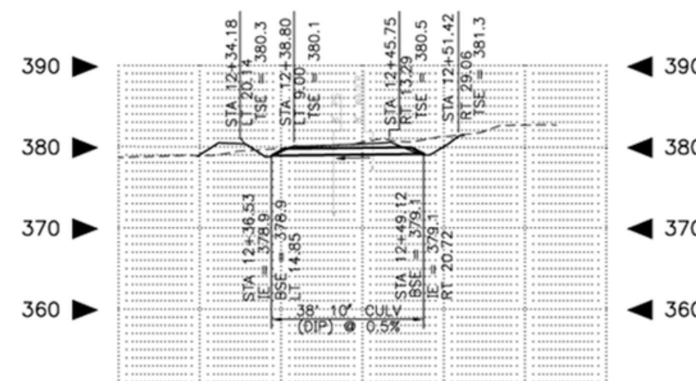

SECTION H–H: VEGETATED SWALE W1,E1

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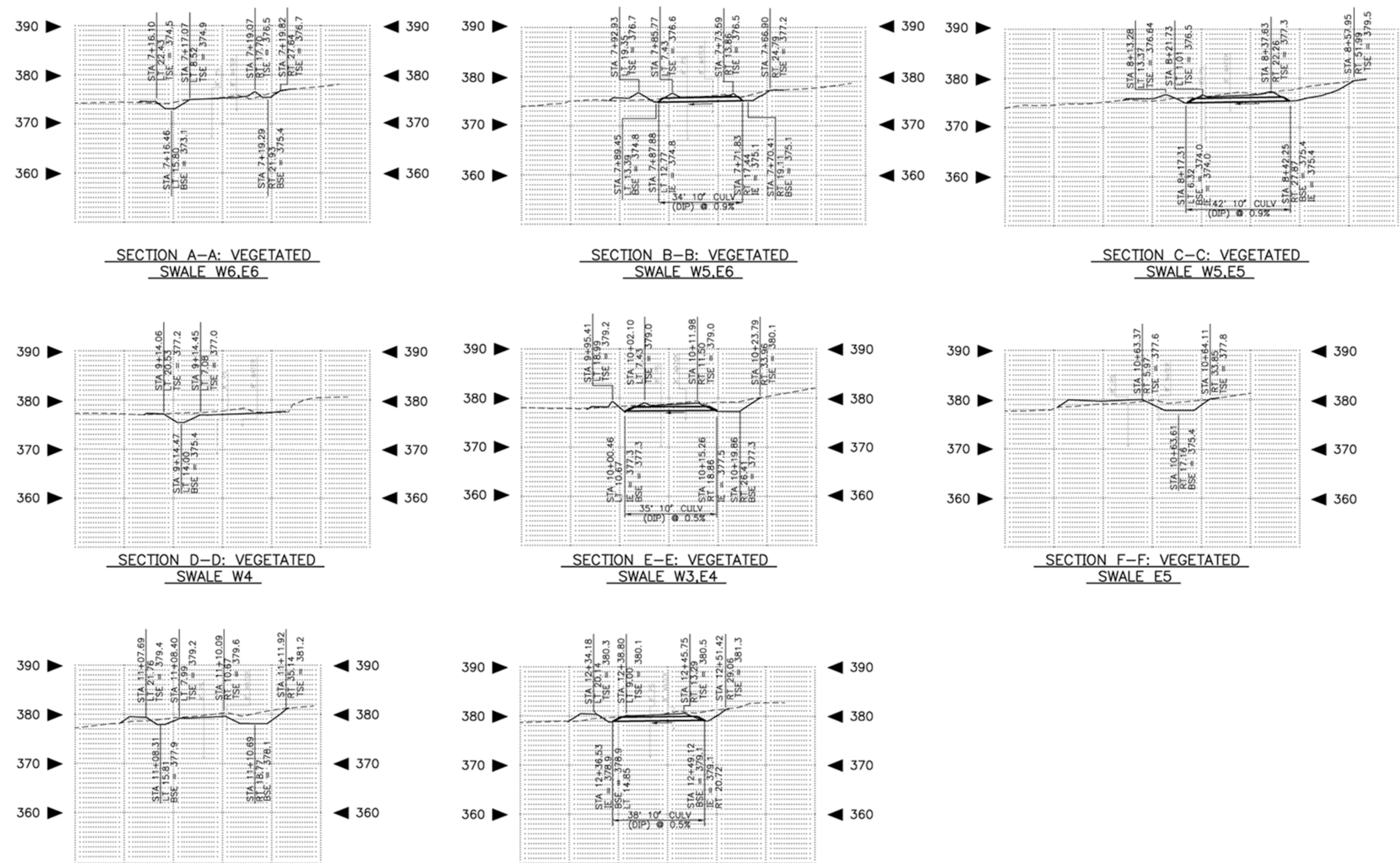

SECTION A–A: VEGETATED SWALE W6,E6

SECTION B–B: VEGETATED SWALE W5,E6

SECTION C–C: VEGETATED SWALE W5,E5

SECTION D–D: VEGETATED SWALE W4

SECTION E–E: VEGETATED SWALE W3,E4

SECTION F–F: VEGETATED SWALE E5

SECTION G–G: VEGETATED SWALE W2,E2

SECTION H–H: VEGETATED SWALE W1,E1

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SHEET 6 OF 14

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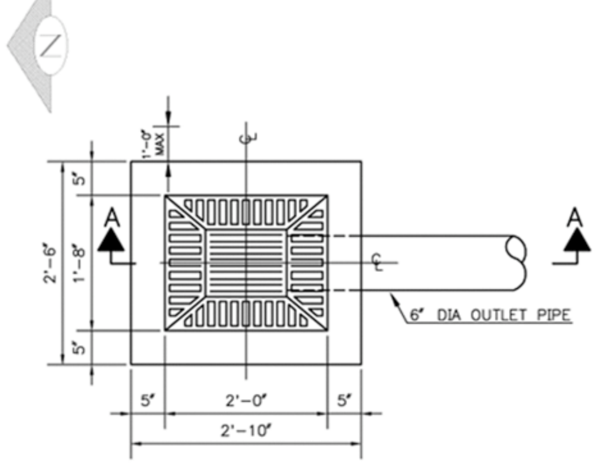
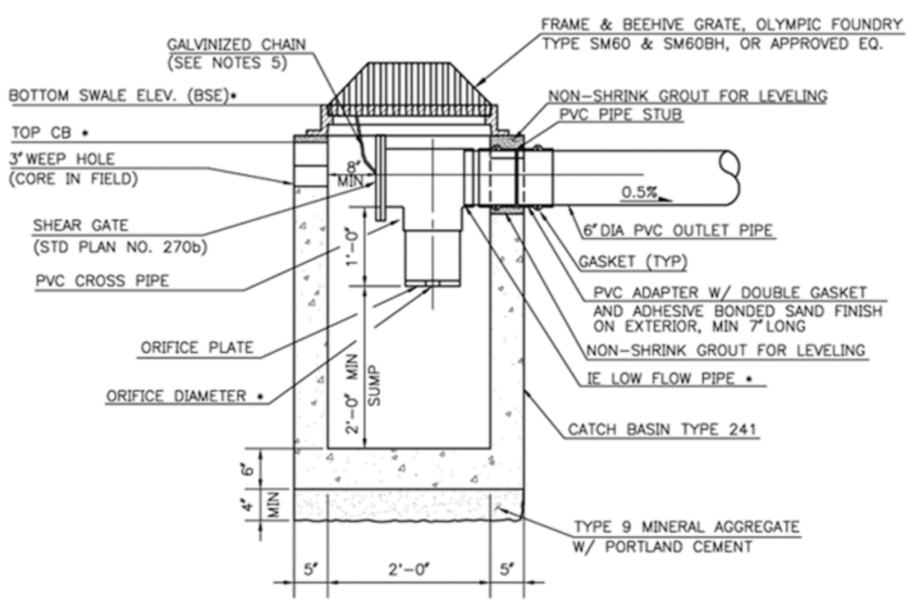


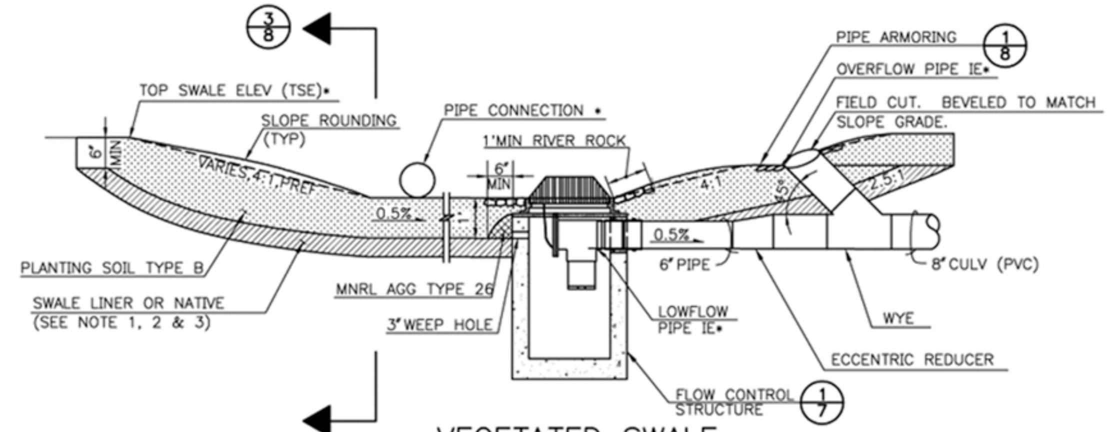
PLAN



SECTION A-A

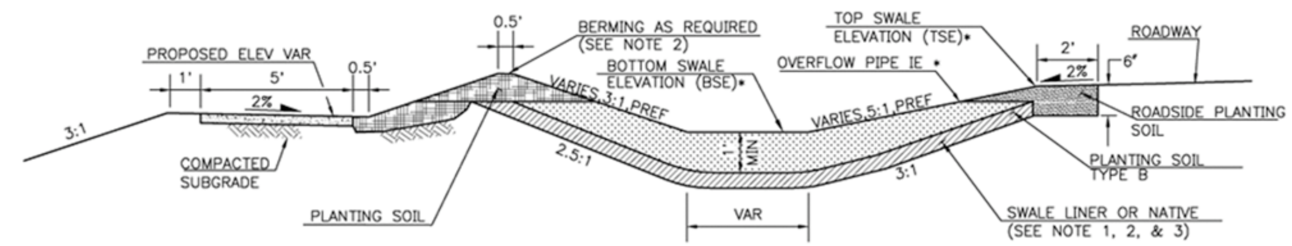
FLOW CONTROL STRUCTURE (1 / 3,4)

SCALE:1"=1'-0"



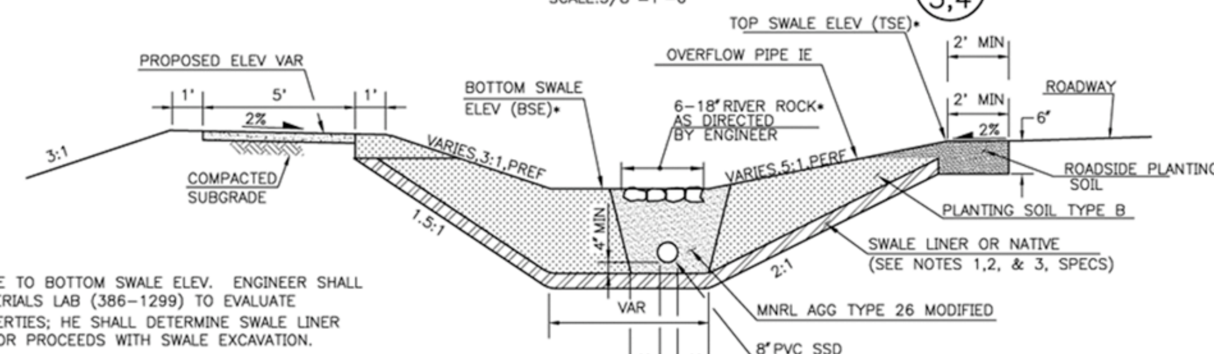
VEGETATED SWALE W/FLOW CONTROL STRUCTURE (2 / 3,4)

SCALE:1/2"=1'-0"



CROSS-SECTION VEGETATED SWALE (TYP) (3 / 3,4)

SCALE:3/8"=1'-0"



CROSS-SECTION VEGETATED SWALE W/ SUB SURFACE DRAIN (4 / 3,4)

SCALE:3/8"=1'-0"

NOTES:

1. CONTRACTOR SHALL EXCAVATE TO BOTTOM SWALE ELEV. ENGINEER SHALL CONTACT AL RICE, SPU MATERIALS LAB (386-1299) TO EVALUATE NATIVE SOIL MATERIAL PROPERTIES; HE SHALL DETERMINE SWALE LINER MATERIAL BEFORE CONTRACTOR PROCEEDS WITH SWALE EXCAVATION.
2. WHEN TOP SWALE ELEV. IS ACHIEVED THROUGH BERMING MORE THAN 1', (SEE SPECS) PVC SWALE LINER SHALL BE PLACED IN BERMED AREA AND SECURED.
3. SWALE LINER SHALL EXTEND, AT MINIMUM, TO ELEV. OF OVERFLOW PIPE IE.
4. ALL EXPOSED PIPE ENDS SHALL USE PIPE ARMORING. (1 / 8)
5. GALVINIZED CHAIN SHALL BE CONNECTED TO DRIFT WOOD (PROVIDE BY OTHERS)

* SPECIFIC DESIGN INFORMATION AS INDICATED ON PLAN SHEETS.

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DRAINAGE DETAILS SHEET

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BY: CONTRACTING MANAGER	CHECKED	SEATRAN PROJ. MGR.
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SCALE: AS SHOWN INSPECTOR'S BOOK

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VAULT PLAN NO. 777-162
SHEET 7 OF 14

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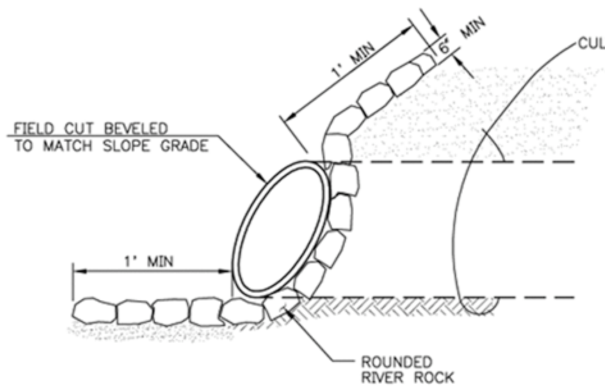
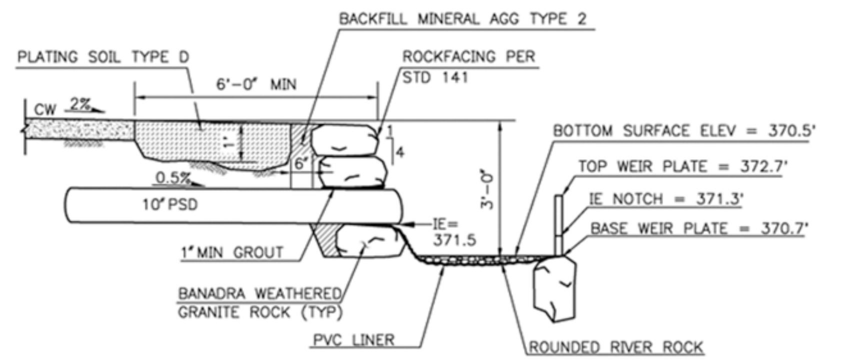
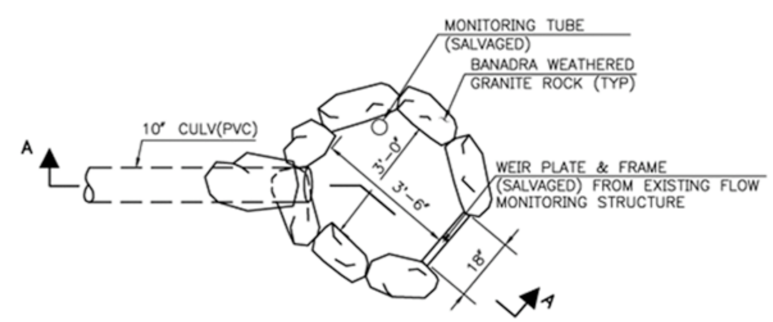


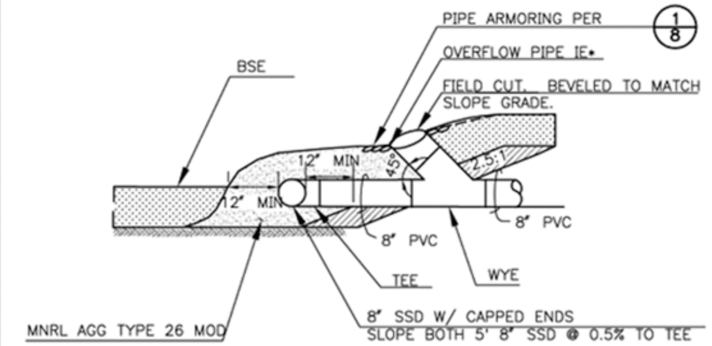
PIPE ARMORING (1 / 3,4)
N.T.S.



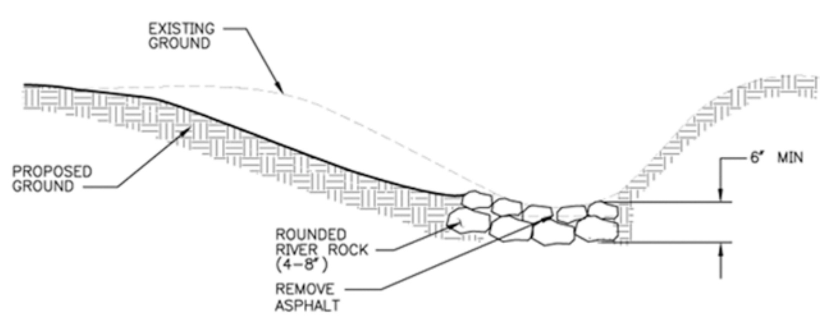
SECTION A-A



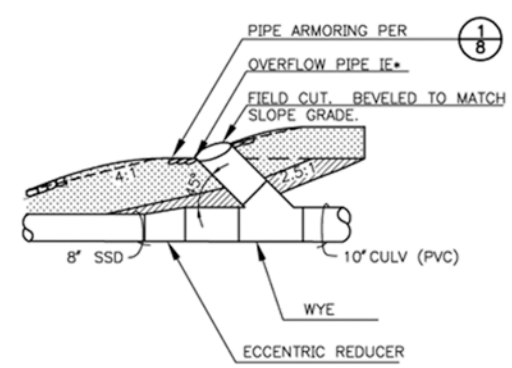
FLOW MONITORING POOL (3 / 4)
SCALE: 1/2" = 1'-0"



FLOW CONTROL PIPE (W1) (5 / 3)
SCALE: 1/2" = 1'-0"

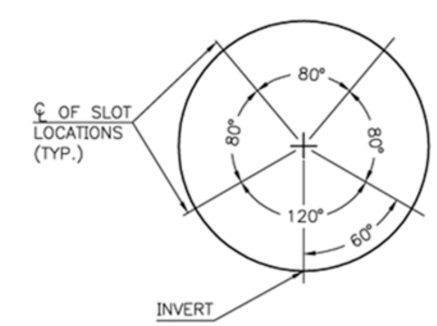


DITCH RETROFIT (2 / 3,4)
N.T.S.



* SPECIFIC DESIGN INFORMATION
AS INDICATED ON PLAN SHEETS

FLOW CONTROL PIPE (W-6) (4 / 4)
SCALE: 1/2" = 1'-0"



SLOT LOCATION DETAIL (6 / 8)
NO SCALE

RECORD DRAWING

DRAINAGE DETAILS SHEET

VAULT SERIAL NO.	33655
DATE	
MARK	
NATURE REVISIONS	
MADE	
CHK'D	
REV'D	

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BY:
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DESIGNED	REVIEWED: DES. / CONST.
CHECKED	SEATRAN / PROJ. MGR.
DRAWN	RECEIVED
CHECKED	REVISED AS BUILT

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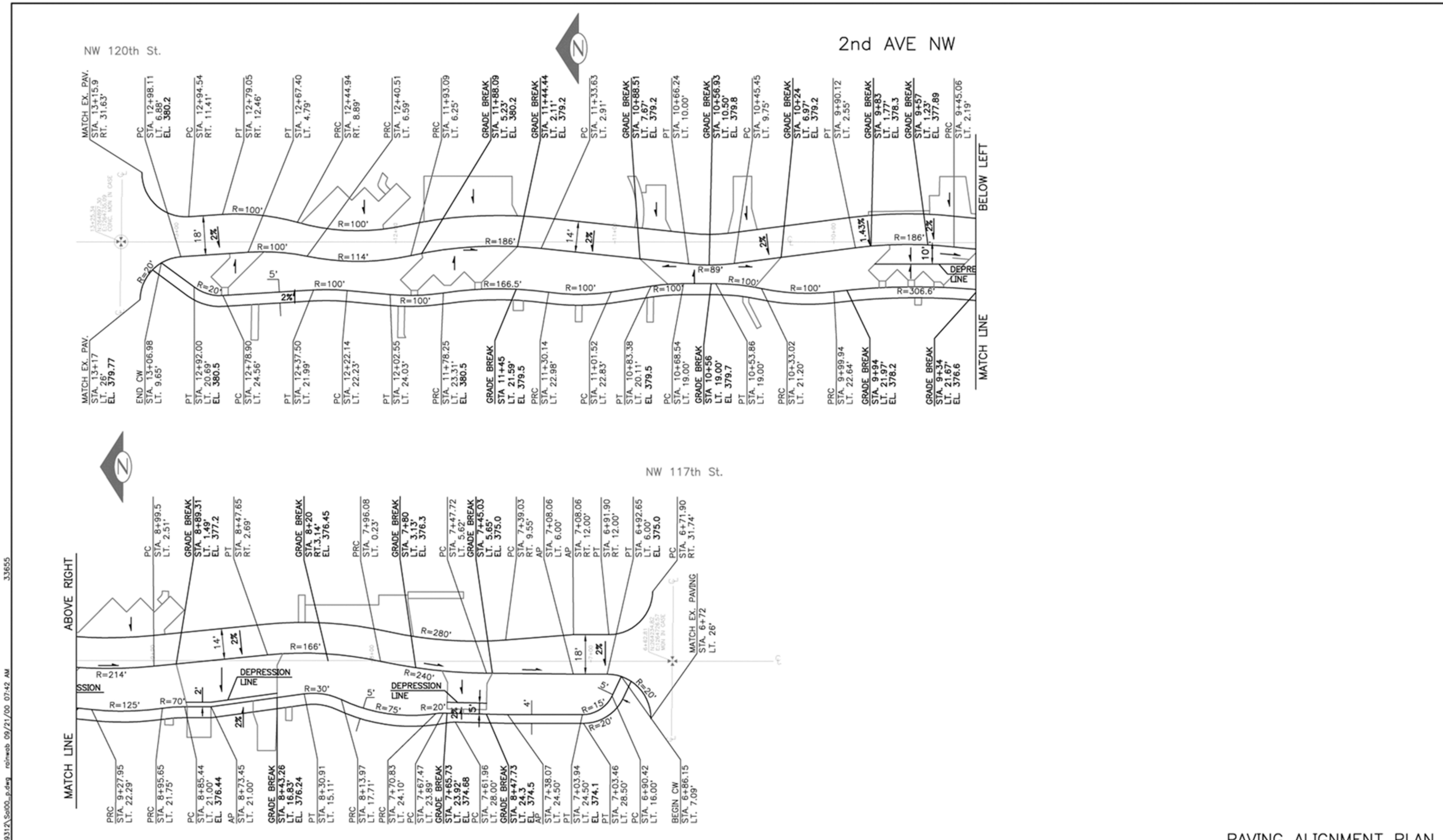
City of Seattle
Seattle Public Utilities
Diana Gale, Director
ORDINANCE NO. APPROVED
FUND:
SCALE: AS SHOWN INSPECTOR'S BOOK

S.E.A. STREET
2nd AVE NW
(NW 117TH TO NW 120TH)

JOB NO. PC C399312
R/W
CO C399312
VAULT PLAN NO. 777-162
SHEET 8 OF 14



PAVING ALIGNMENT PLAN

BUILT	ORIG. NO.	REVISIONS	DATE	MARK	MADE	CHK'D	REV'D	DESCRIPTION

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INITIALS AND DATE
REVIEWED:
DES. . . . . SPU CONST. . . .
SEATRAN . . . . PROJ. MGR.
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REVISED AS BUILT

ALL WORK DONE IN ACCORDANCE WITH THE CITY OF SEATTLE STANDARD PLANS AND SPECIFICATIONS AND OTHER DOCUMENTS CALLED FOR IN SECTION 0-03.3 OF THE PROJECT MANUAL.

City of Seattle
SEATRAN
Seattle Transportation

ORDINANCE NO. . . . . . . APPROVED . . . .
FUND: . . . .
SCALE: H. V. INSPECTOR'S BOOK . . . . .

S.E.A. STREETS
2ND AVENUE NW
(NW 117TH TO NW 120TH)

JOB NO.	
PC	C399312
R/W	
CO	C399312

VAULT PLAN NO. 774-162

SHEET 9 OF 14

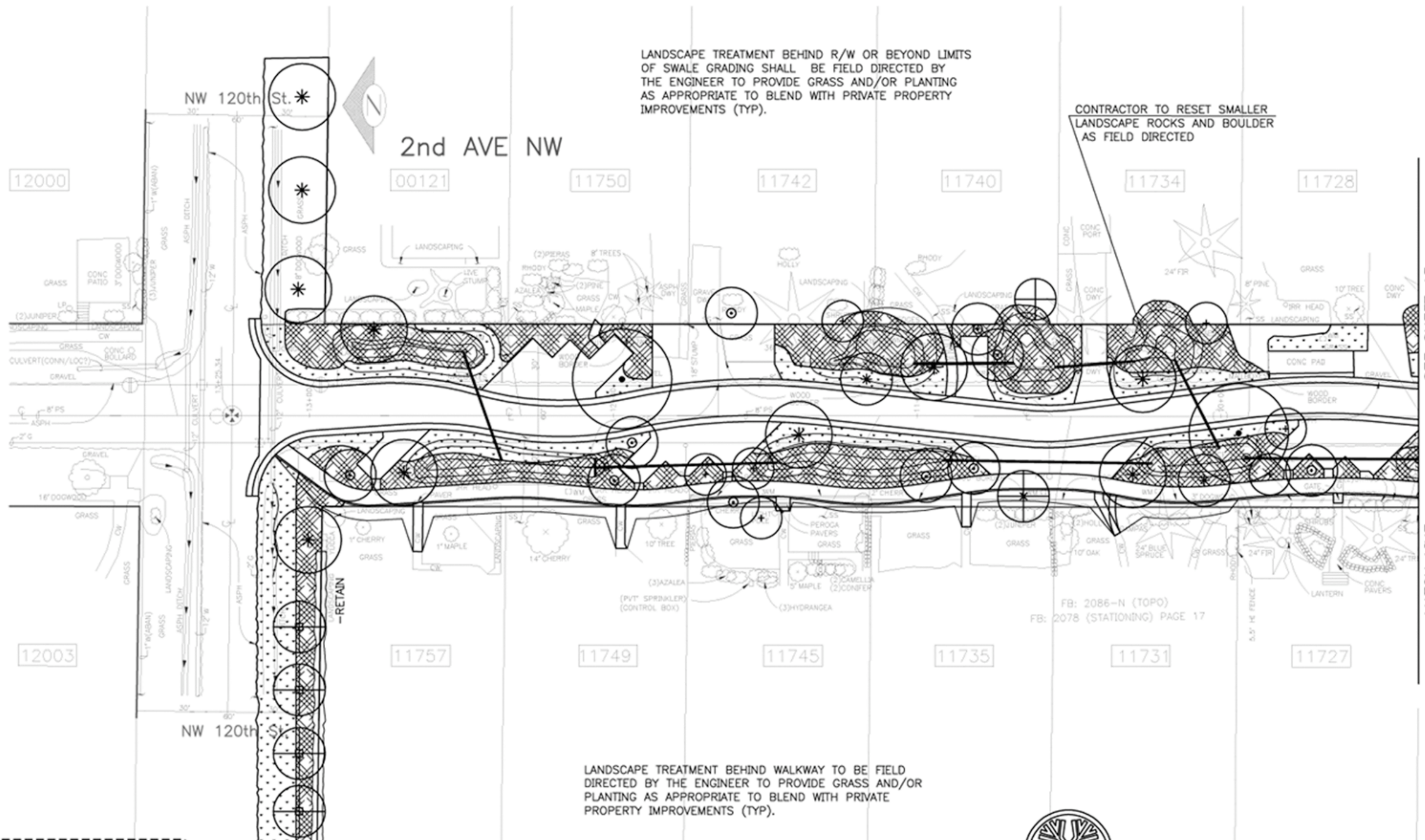
TREE SYMBOL LEGEND

(SIZES/QUANTITIES ON PLANT SCHEDULE)

- FRAXINUS OXYCARPA 'RAYWOOD' RAYWOOD ASH
- ACER TRUNCATUM 'PACIFIC SUNSET' PACIFIC SUNSET MAPLE
- CORNUS NUTALLI HYBRID 'EDDIES WHITE WONDER'
- AMELANCHIER LAEVIS 'CUMULUS'
- CHAMAECYPARIS 'PLUMOSA'
- PINUS THUNBERGIANA JAPANESE BLACK PINE
- ARBUTUS UNEDO STRAWBERRY TREE
- CHAMAECYPARIS OBTUSA HINOKI CYPRESS

LANDSCAPING LEGEND

- PLANTING AREA PREPARATION
- SEEDED LAWN INSTALLATION



NOTES:

1. ALL TREE LOCATIONS ARE CONCEPTUAL AND ARE TO BE FIELD VERIFIED BY THE ENGINEER PRIOR TO EXCAVATION OF PLANTING PITS TO ENSURE PROPER PLACEMENT WITH RESPECT TO VIEWS, SIGHT DISTANCES, AND CLEARANCES FROM STREET EDGE AND/OR UTILITIES.
2. PRIOR TO CONSTRUCTION, THE CONTRACTOR SHALL NOTIFY THE ENGINEER TO REQUEST FIELD MARKING OF PLANT MATERIALS TO BE REMOVED (48 HOUR NOTICE). ALL PLANT MATERIALS NOT DESIGNATED TO BE REMOVED SHALL BE RETAINED AND PROTECTED. LIMITS OF GRADING SHALL BE FIELD MARKED BY THE ENGINEER. WHERE GRADING EXTENDS WITHIN THE DRIPLINE OF EXISTING TREES AND SHRUBS TO BE RETAINED, THE CONTRACTOR SHALL REQUEST FIELD DIRECTION TO EITHER TRANSPLANT OR TO ALTER GRADING TO MINIMIZE IMPACTS TO THE PLANT MATERIALS. PLANT MATERIAL DESTROYED AND/OR IRREPARABLY DAMAGED DUE TO LACK OF DIRECTION AND/OR LACK OF PROPER CARE BY THE CONTRACTOR SHALL BE REPLACED IN KIND AND/OR EVALUATED TO ASSESS DAMAGE WITH VALUE DEDUCTED FROM THE CONTRACT.

FOR TREE SCHEDULE AND PLANTING SCHEDULE, SEE SHEET 14
FOR REMOVAL PLAN, SEE SHEET 2
FOR DRAINAGE PLAN, SEE SHEET 3 & 4
FOR PAVING PLAN, SEE SHEET 10 & 11

RECORD DRAWING

LANDSCAPING PLAN

APPROVED FOR ADVERTISING
DWIGHT DIVELY
EXECUTIVE SERVICES DIRECTOR
SEATTLE, WASHINGTON 20
BY: CONTRACTING MANAGER

NAME OR INITIALS AND DATE: DESIGNED, CHECKED, DRAWN, CHECKED
INITIALS AND DATE: REVIEWED: DES. SPU CONST. SEATRAN PROJ. MGR. RECEIVED REVISED AS BUILT

ALL WORK DONE IN ACCORDANCE WITH THE CITY OF SEATTLE STANDARD PLANS AND SPECIFICATIONS AND OTHER DOCUMENTS CALLED FOR IN SECTION 0-02.3 OF THE PROJECT MANUAL.

STATE OF WASHINGTON REGISTERED LANDSCAPE ARCHITECT
SHANE E DeWALD
CERTIFICATE NO. 473

City of Seattle
SEATRAN
Seattle Transportation
ORDINANCE NO. APPROVED
FUND:
SCALE: H. V. INSPECTOR'S BOOK

S.E.A. STREETS
2ND AVENUE NW
(NW 117TH TO NW 120TH)

JOB NO. PC C399312
R/W
CO C399312
VAULT PLAN NO. 774-162
SHEET 12 OF 14

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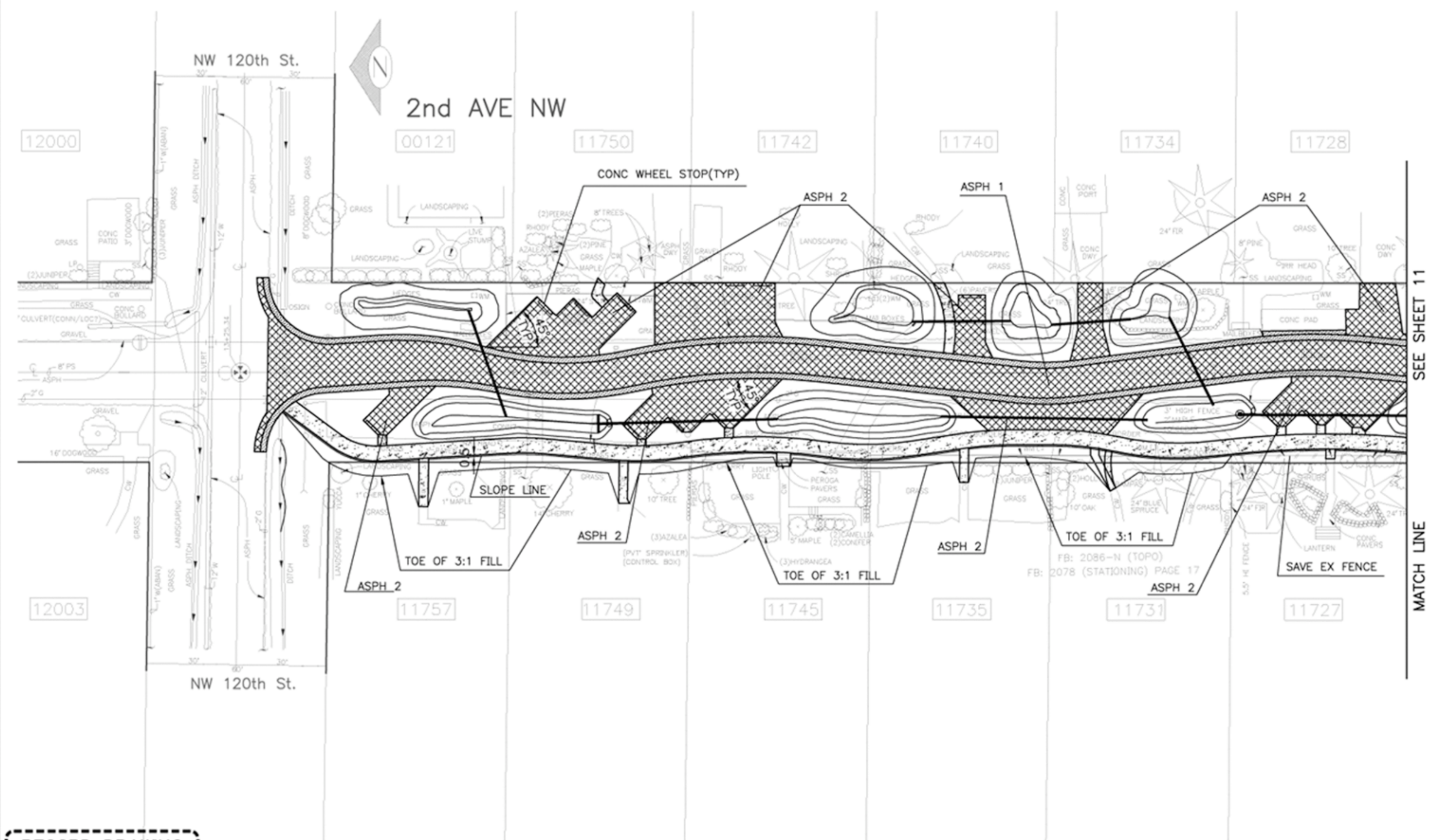

PAVING LEGEND

ASPH 1 – 3" CL A ASPH OVER 6" TYPE 2 MNRL AGG.

ASPH 2 – 3" CL A ASPH OVER 4" TYPE 2 MNRL AGG.

CW – TYPE 420A

CONC DWY – 6" TYPE 430A OR MODIFIED CURB AND GUTTER TYPE 410B(NO CURB)

FOR REMOVAL PLAN, SEE SHEET 2
FOR DRAINAGE PLAN, SEE SHEET 3 & 4
FOR LANDSCAPING PLAN, SEE SHEET 12 & 13

RECORD DRAWING

PAVING PLAN

APPROVED FOR ADVERTISING
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EXECUTIVE SERVICES DIRECTOR
SEATTLE, WASHINGTON 20
BY: CONTRACTING MANAGER

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City of Seattle
SEATRAN
Seattle Transportation

ORDINANCE NO. APPROVED
FUND:
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S.E.A. STREETS
2ND AVENUE NW
(NW 117TH TO NW 120TH)

JOB NO. PC C399312 R/W CO C399312
VAULT PLAN NO. 774–162
SHEET 10 OF 14

33655

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TREE SCHEDULE

ADDRESS	@ L.F.	@ S.F. SEEDED	@ S.F. PLANTED	ORGANIC MULCH C.Y.	BARK MULCH C.Y.	DECIDUOUS TREES 2-2½" CAL.		DECIDUOUS TREES 1½-1¾" CAL.				EVERGREEN TREES 5-6' HT.					DECIDUOUS SHRUBS 2 GALLON								EVERGREEN SHRUBS 2 GALLON			
						FRAXINUS OXYCARPA 'RAYWOOD' RAYWOOD ASH	ACER TRUNCATUM PACIFIC SUNSET MAPLE	CORNUS HYBRID 'EDDIES WHITE'	AMELANCHIER LAEVIS 'CUMULUS'	CORYLUS CORNUTA HAZELNUT	ACER CIRCINATUM VINE MAPLE	ARBUTUS UNEDO STRAWBERRY TREE	PINUS THUNBERGIANA JAPANESE BLACK PINE	CALOCEDRUS DECURRENS INCENSE CEDAR	CHAMAECYPARIS OBTUSA HINOKI CYPRESS	CHAMAECYPARIS 'PLUMOSA'	VACCINIUM PARVIFLORUM	PHILADELPHUS LEWIS MOCKORANGE	RIBES SANGUINEUM RED CURRANT	ROSA NUTKANA NOOTKA ROSE	CORNUS SERICEA RED TWIG DOGWOOD	CORNUS SERICEA 'FLAVIRAMEA' YELLOW DOGWOOD	RUBUS SPECTABILIS SALMONBERRY	RUBUS PARVIFLORA THIMBLEBERRY	RHODODENDRON 'PJM'	STRANVAESIA DAVIDIANA 'UNDULATA'	ARBUTUS UNEDO 'COMPACTA'	VACINIUM OVATUM EVERGREEN HUCKLEBERRY
121 (2ND)	80'	600	700	5	5	–	1	–	–			–	–	–	–	–									6			6
(120TH)	120'	1000	100	3	1	–	3	–	–			–	–	–	–	–												
11750	60'	100	500	3	4	1																			3	3	3	3
11742	60'	200	600	4	5			1	1			1					3		3	3	3		6		3		3	3
11740	60'	300	1150	5	6		1	2							1		3	1	3	3	3		6		3		3	3
11734	60'	300	1100	5	6		1					1					3	1	3	3	3		6		3		3	3
11728	60'	200	125	2	1																				6			
11720	60'	140	360	2	2	1																			3	3	3	3
11716	140'	400	1000	5	6	1	1	1	1								6	3	6	6	3		12		6		6	6
124 (2ND)	120'	660	1000	5	6		1	–					–	–		1												
(117TH)	80'	1800	500	4	6		3																		6			
11757 (2ND)	120'	450	600	4	4		1	1						–				3		6	6	6			3			6
(120TH)	60'	1200	1200	6	6		1						4												5			
11749	60'	300	460	3	4			2										2		3	3	3						3
11745	60'	200	600	3	4	–	1	1				3	–	–	–	–		2	–	6	–	–	–	–	2		3	–
11735	60'	180	320	2	2	–	1	2					–	–		1		–	–						3	3	3	–
11731	60'	180	400	3	3	1	1		1			–	–	–	–	–			3		3		3		3		3	3
11727	60'	120	400	3	3	–	–	1	–	–	–	2	–	–	–	–		–	3	–	3	3	–	–	3	2	3	2
11723	60'	270	600	4	4			1	2								3			6	6		6		3		3	3
11715	50'	180	200	2	2				1										3						3		3	3
11709	60'	480	600	3	4	1	1								1		3		6	6	6		6		3		6	6
11703 (2ND)	90'	350	660	3	4		1	1	1									–	9	–	9	3			3	2	–	5
(117TH)	120'	1200	1200	6	8	4												–		–					5	3	–	2
ADDITIONAL / FIELD LOCATED				18	4	4	2	3	3	12	12	6	2	4	2	2	6	3	6	12	12	6	12	12	12	12	12	12
PROJECT TOTALS		11,000	15,000	100	100	13	20	16	10	12	12	13	6	4	4	4	27	15	45	63	60	21	57	12	87	28	57	72

PLANTING SCHEDULE

ADDRESS	DECIDUOUS SHRUBS 1 GALLON				GROUNDCOVER 1 GALLON			PERENNIALS/FERNS 1 GALLON										GROUNDCOVER 4" POTS		WETLAND PLANTS 6" POTS					
	CORNUS 'KELSEYII' DWARF RED DOGWOOD	ROSA RUGOSA 'PAVEMENT SERIES' (MIXED VARIETIES)	POTENTILLA FRUITICOSA 'MOONLIGHT'	SYMPHORICARPOS ALBUS SNOWBERRY	GAULTHERIA SHALLON SALAL	MAHONIA REPENS CREEPING MAHONIA	POLYSTICHUM MUNITUM SWORDFERN	TOLMIEA MENZIESII YOUTH-ON-AGE	IRIS DOUGLASIANA PACIFIC COAST IRIS	SMILACINA RACEMOSA FALSE SOLOMON'S SEAL	CORNUS CANADENSIS	LUPINE	GERANIUM SANGUINEUM	ASARUM CAUDATUM WILD GINGER	MAIANTHEMUM DILATATUM WILD LILY OF THE VALLEY	GEUM MACROPHYLLUM	SIBERIAN IRIS	ARCTOSTAPHYLOS UVA URSI KINNIK-KINNIK	FRAGARIA CHILDENSIS WILD STRAWBERRY	SAGITARIA LATIFOLIA ARROWHEAD	SCIRPUS MICROCARPUS SMALL-FRUITED BULRUSH	CAREX LENTICULARIS	RANUNCULUS REPENS CREEPING BUTTERCUP	JUNCUS ENSIPOLUOS DAGGERLEAF RUSH	JUNCUS EFFUSUS SOFT RUSH
121 (2ND)	24	16	16		24				6				12					36							
(120TH)																									
11750	6	16	6	6	32	12	6		6	3			9				6	24							
11742	24	12	6		24		6	6	6	6	6	6	6	6	6	6	6	24		12	12	12		12	12
11740	24	12	6		24		6	6	6	6	6	6	6	6	6	6	6	24		12	12	12		12	12
11734	24	12	6		24		6	6	6	6	6	6	6	6	6	6	6	24		12	12	12		12	12
11728																									
11720	6	6	3		12	6	3		3	3			6				3	24							
11716	36	24	12		36		9	9	9	9	9	9	9	9	9	9	9	36		18	18	18		18	18
124 (2ND)		16			36						12							36	120						
(117TH)																									
11757 (2ND)	24	24	12		12		9	3	6	3	3	3	12	3	–		12			12	12	12		12	12
(120TH)																									
11749	12	12	12		12		3	3	3	3	3	3	6	3			6			12	12	12		12	12
11745	–	24	24	6	36	–	6		3	6			8	6	3			36							
11735	12	6	6	–	24	–	6		3				6	3	3			12		6	6	6		6	6
11731	24	6	6		12	12	3	3	6	3	3	3	6	3	3	3	6	12		6	6	6		6	6
11727	18	–	–		–	–	6	–	3	–	–	–	–	6	2		3	34		3	3	3		3	3
11723	24	12	12		24	12	6	6	3	6			6	3	3		6			12	12	12		12	12
11715	6	3	3		12		3		3	3				3			3	12		3	3	3		3	3
11709	24	12	12		24		6		3	6			6	6	6		6	24		12	12	12		12	12
11703 (2ND)	24				24		6		6	9	12	6	6					24		12	12	12		12	12
(117TH)																			250	12	12	12	250	12	12
	130	130	120	12	160	60	12	12	12	12	12	12	12	12	12	12	12	200	100	24	24	24	24	24	24
TOTALS	442	243	162	24	552	102	102	54	93	84	72	54	122	75	59	42	90	582	470	268	268	268	274	268	268

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33655

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DRAWN ....
CHECKED ....
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DES. ...... SPU CONST. ......
SEATRAN ...... PROJ. MGR. ......
RECEIVED ....
REVISED AS BUILT ....

STATE OF WASHINGTON
REGISTERED LANDSCAPE ARCHITECT
SHANE E DeWALD
CERTIFICATE NO. 473

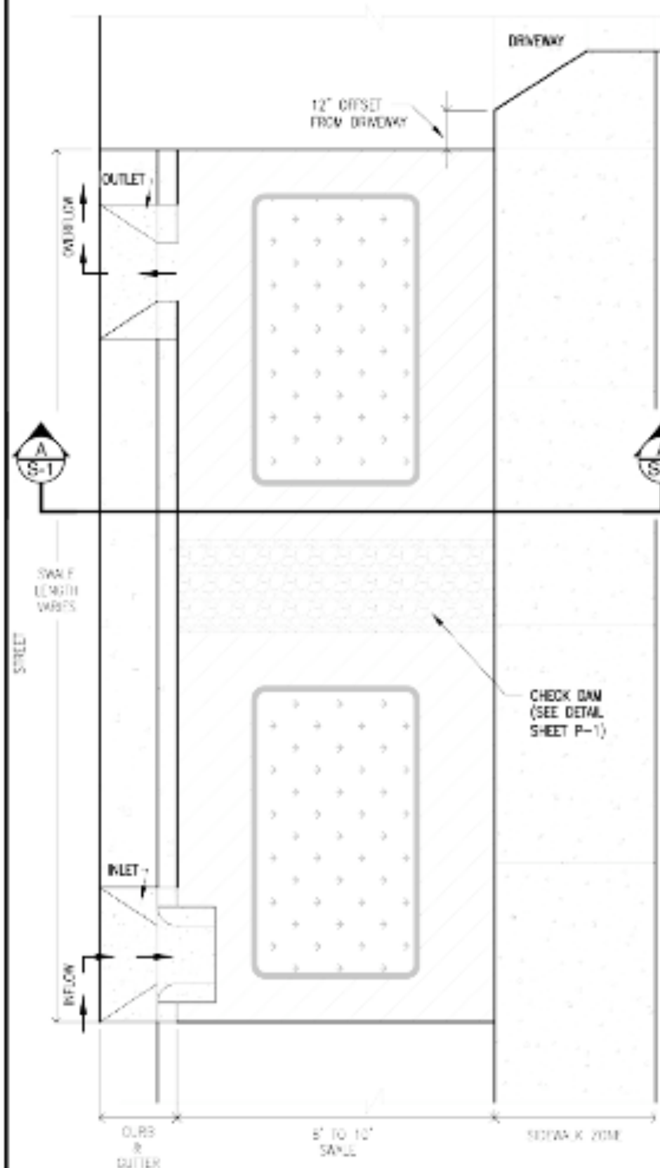
City of Seattle
SEATRAN
Seattle Transportation
ORDINANCE NO. .... APPROVED ....
FUND: ....
SCALE: H. V. INSPECTOR'S BOOK ......

TREE SCHEDULE AND
PLANTING SCHEDULE

S.E.A. STREETS
2ND AVENUE NW
(NW 117TH TO NW 120TH)

JOB NO. PC C399312
R/W
CO C399312
VAULT PLAN NO. 774-162
SHEET 14 OF 14

Appendix B
Portland Plans



SWALE PLAN

NOTES:

1. See City of Portland Standard Construction Specifications Section 00415 - Vegetated Stormwater Facilities.
2. Width of swale: 8' minimum from inside curbs. Depth of swale: 6" minimum from inlet at gutter elevation to bottom of swale.
3. Longitudinal slope of swale: matches road. (Typical cross slope of road 2-5%, cross slope of gutter 8%.)
4. Special requirements may be necessary on steep slopes & for swales designed to include disposal.
5. Include beginning and ending station elevations for each facility. Provide the top and bottom elevation of facility at each station specified. Include elevations at every inlet and outlet.
6. Sidewalk elevation must be set above inlet and outlet elevations to allow overflow to drain to street before sidewalk.
7. Inlets and outlets required: See sheets D-1 & D-2 for details.
8. Check dams required: See sheet P-1 for details.
9. Monitoring port required for facilities designed for stormwater storage: See sheet P4 for detail
10. Special soil and planting requirements: See sheets P-1, P-2 & P-3 for details.
11. Special requirements for water lines, meters, and fire hydrants: See sheet W-1 for details.
12. Depending on location, utility lines may need to be sleeved.
13. Curb and Gutter: ODOT Standard Detail D 700. Use 1'-6" gutter with bike lanes and 2' gutter without bike lanes.

IMPORTANT: Utility conflicts and existing conditions can create major design variables. Locate utilities and survey existing conditions prior to beginning design work.

The Portland Department of Transportation (PDOT), Portland Water Bureau (PWB), and Bureau of Environmental Services (BES) are responsible for the review and approval of Stormwater Swales in the public right of way. Stormwater facilities in *Well Field Protection Areas* may require special containment measures.

For more information contact:
PDOT (503) 823-7884
PWB (503) 823-7368
BES (503) 823-7189

VEGETATED STORMWATER FACILITIES IN THE PUBLIC RIGHT-OF-WAY

TITLE

SWALE

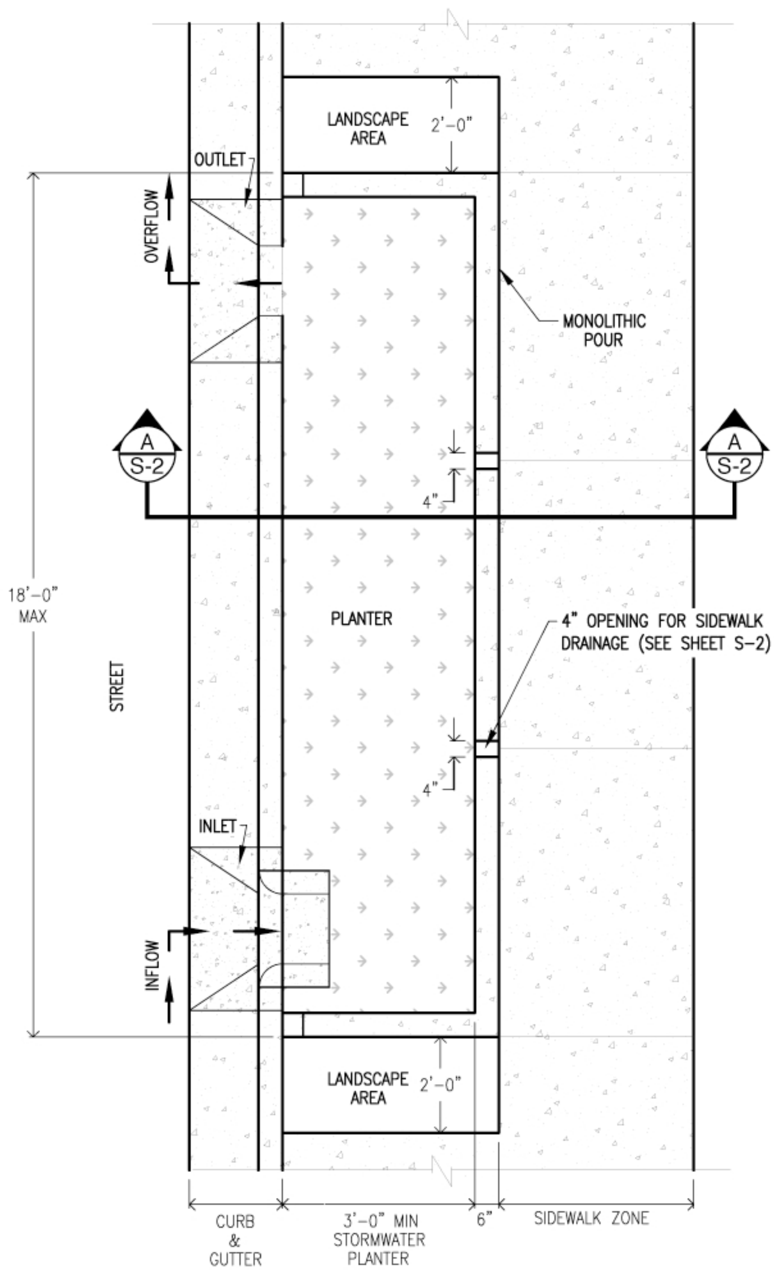
SHEET NUMBER

1

APPROVED 2/16/07
CHIEF ENGINEER, BES — DATE 2/21/07
CITY ENGINEER, PDOT — DATE 2/20/07
CHIEF ENGINEER, PWB — DATE

NO	REVISIONS	DATE	BY
	FINAL DRAFT – SWAT.DWG	2/16/07	RMS
	DRAFT – SWAT.DWG	11/16/06	RMS

File name: SWAT.dwg Mar 01, 2007 - 3:35pm -RICKSC



PLANTER PLAN

SCALE: 1" = 4'
0 2' 4'

NOTES:

1. See City of Portland Standard Construction Specifications Section 00415 - Vegetated Stormwater Facilities.
2. Width of planter: 3' minimum from inside curbs
   Length of planter based on engineering calculations: 18' maximum, 12' minimum.
   Depth of planter:12" max from top of curb to top of soil.
3. Longitudinal slope of planter matches road: flat as possible, 3% maximum. Longitudinal and cross slope of soil within planter: none, flat as possible. (Typical cross slope of road 2-6%, cross slope of gutter 8%.)
4. Special requirements may be necessary on steep slopes & for planters designed to include disposal.
5. Include beginning and ending station elevations for each facility. Provide the top and bottom elevation of facility at each station specified. Include elevations at every inlet and outlet.
6. Sidewalk elevation must be set above inlet and outlet elevations to allow overflow to drain to street before sidewalk.
7. Inlets and outlets required:
   See sheets D-1 and D-2 for details.
8. Check dams may be required:
   See sheet P-1 for details.
9. Special soil and planting requirements:
   See sheets P-1, P-2 & P-3 for details.
10. Special requirements for water lines, meters, and fire hydrants: See sheet W-1 for details.
11. Depending on location, utility lines may need to be sleeved.
12. Curb and Gutter: ODOT Standard Detail D 700 with thickened 12" gutter. Use 1'-6" gutter with bike lanes and 2' gutter without bike lanes.

IMPORTANT: Utility conflicts and existing conditions can create major design variables. Locate utilities and survey existing conditions prior to beginning design work.

The Portland Department of Transportation (PDOT), Portland Water Bureau (PWB), and Bureau of Environmental Services (BES) are responsible for the review and approval of Stormwater Swales in the public right of way. Stormwater facilities in *Well Field Protection Areas* may require special containment measures.

For more information contact:
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PWB (503) 823-7368
BES (503) 823-7189

VEGETATED STORMWATER FACILITIES IN THE PUBLIC RIGHT-OF-WAY

TITLE

PLANTER

- Without Parking -

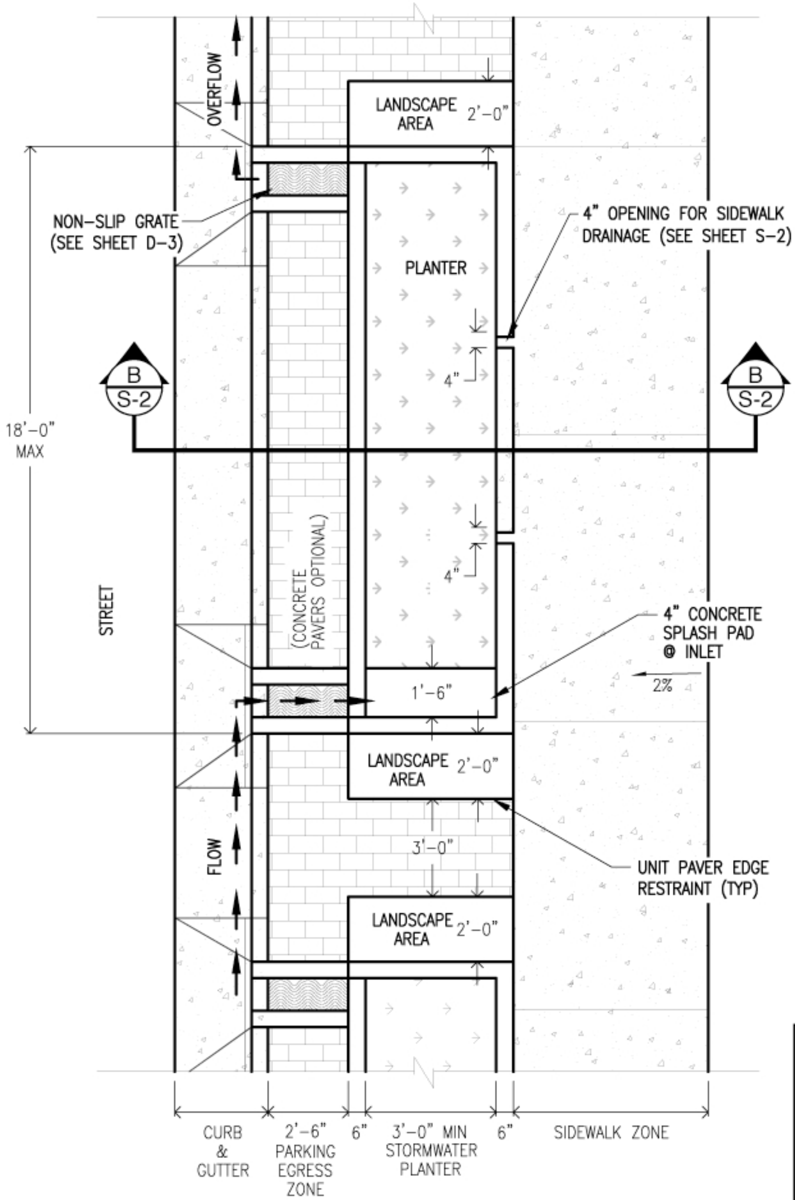
SHEET NUMBER

2

APPROVED	2/16/07	
CHIEF ENGINEER, BES	DATE 2/21/07	
CITY ENGINEER, PDOT	DATE 2/20/07	
CHIEF ENGINEER, PWB	DATE	

NO.	REVISIONS	DATE	BY
	FINAL DRAFT – SWAT.DWG	2/16/07	RMS
	DRAFT – SWAT.DWG	11/16/06	RMS

file name: SWAT.dwg Mar 01, 2007 - 3:30pm -RICKSC



PLANTER PLAN

SCALE: 1" = 4'

NOTES:

1. See City of Portland Standard Construction Specifications Section 00415 - Vegetated Stormwater Facilities.
2. Width of planter: 3' minimum from inside curbs Length of planter based on engineering calculations: 18' maximum, 12' minimum. Depth of planter: 12" max from top of curb to top of soil.
3. Longitudinal slope of planter matches road: flat as possible, 3% maximum. Longitudinal and cross slope of soil within planter: none, flat as possible. (Typical cross slope of road 2-6%, cross slope of gutter 8%.)
4. Special requirements may be necessary on steep slopes & for planters designed to include disposal.
5. Include beginning and ending station elevations for each facility. Provide the top and bottom elevation of facility at each station specified. Include elevations at every inlet and outlet.
6. Sidewalk elevation must be set above inlet and outlet elevations to allow overflow to drain to street before sidewalk.
7. Inlets and outlets required: See sheet D-3 for details.
8. Check dams may be required: See sheet P-1 for details.
9. Special soil and planting requirements: See sheets P-1, P-2 & P-3 for details.
10. Special requirements for water lines, meters, and fire hydrants: See sheet W-2 for details.
11. Depending on location, utility lines may need to be sleeved.
12. Curb and Gutter: ODOT Standard Detail D 700. Use 2' gutter without bike lanes.

IMPORTANT: Utility conflicts and existing conditions can create major design variables. Locate utilities and survey existing conditions prior to beginning design work.

The Portland Department of Transportation (PDOT), Portland Water Bureau (PWB), and Bureau of Environmental Services (BES) are responsible for the review and approval of Stormwater Swales in the public right of way. Stormwater facilities in *Well Field Protection Areas* may require special containment measures.

For more information contact:
PDOT (503) 823-7884
PWB (503) 823-7368
BES (503) 823-7189

VEGETATED STORMWATER FACILITIES IN THE PUBLIC RIGHT-OF-WAY

TITLE

PLANTER

- With Parking -

SHEET NUMBER

3

APPROVED

2/16/07

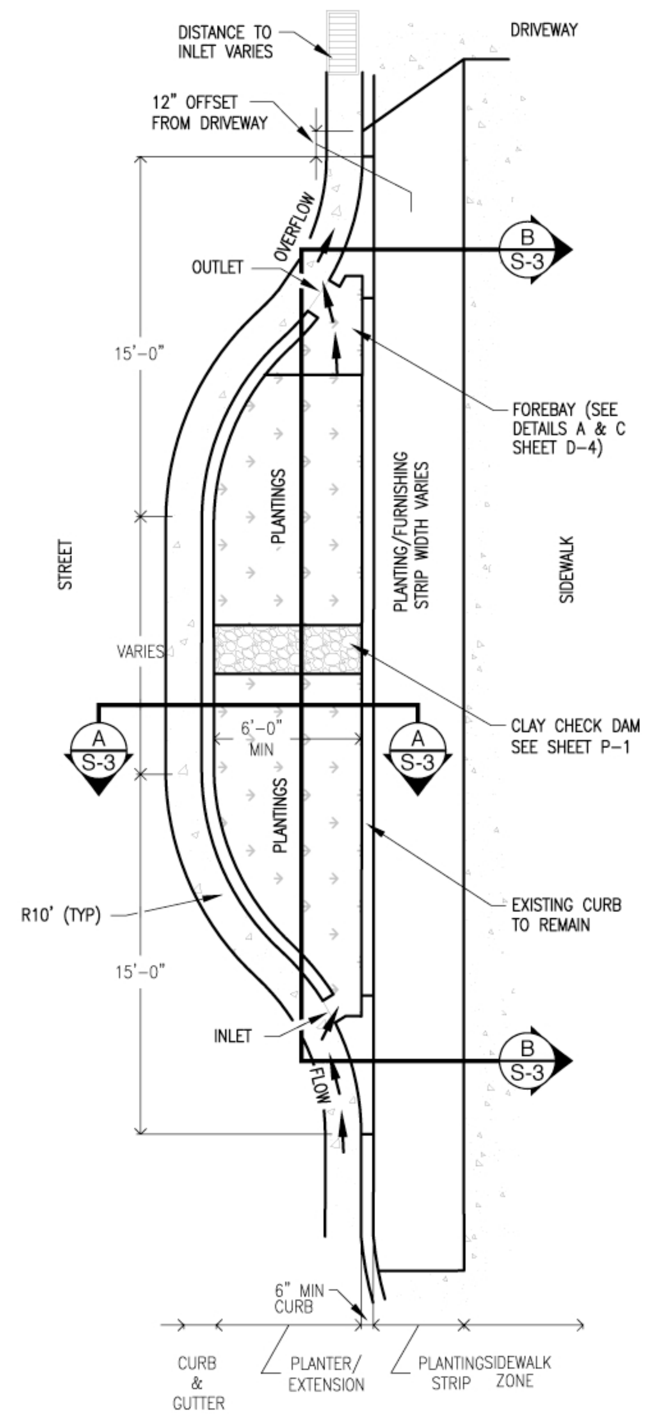
CHIEF ENGINEER, BES — DATE 2/21/07

CITY ENGINEER, PDOT — DATE 2/20/07

CHIEF ENGINEER, PWB — DATE

NO.	REVISIONS	DATE	BY
	FINAL DRAFT – SWAT.DWG	2/16/07	RMS
	DRAFT – SWAT.DWG	11/16/06	RMS

file name: SWAT.dwg Mar 01, 2007 - 3:30pm -RICKSC



CURB EXTENSION PLAN

SCALE: 1" = 8'
0 4' 8'

NOTES:

1. See City of Portland Standard Construction Specifications Section 00415 - Vegetated Stormwater Facilities.

2. Width of curb extension: 6' minimum from inside curbs. Depth of curb extension: 6" minimum from inlet at gutter elevation to bottom of facility.

3. Longitudinal slope of planter matches road: flat as possible, 3% maximum. Longitudinal and cross slope of soil within planter: none, flat as possible. (Typical cross slope of road 2-6%, cross slope of gutter 8%.)

4. Special requirements may be necessary on steep slopes & for facilities designed to include disposal.

5. Include beginning and ending station elevations for each facility. Provide the top and bottom elevation of facility at each station specified. Include elevations at every inlet and outlet.

6. Sidewalk elevation must be set above inlet and outlet elevations to allow overflow to drain to street before sidewalk.

7. Inlets and outlets required: See sheet D-1 and D-2 for details.

8. Check dams required: See sheet P-1 for details.

9. Special soil and planting requirements: See sheets P-1, P-2 & P-3 for details.

10. Special requirements for water lines, meters, and fire hydrants: See sheet W-3 for details.

11. Depending on location, utility lines may need to be sleeved.

12. Curb and Gutter: ODOT Standard Detail D 700 with 1'-6" gutter. Modified curb may be necessary to avoid conflict with water line (see sheet D-4 for details).

13. Where feasible width of stormwater facility may extend into existing planting strip, in which case, existing curb would be removed.

IMPORTANT: Utility conflicts and existing conditions can create major design variables. Locate utilities and survey existing conditions prior to beginning design work.

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For more information contact:
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PWB (503) 823-7368
BES (503) 823-7189

VEGETATED STORMWATER FACILITIES IN THE PUBLIC RIGHT-OF-WAY

TITLE

CURB EXTENSION

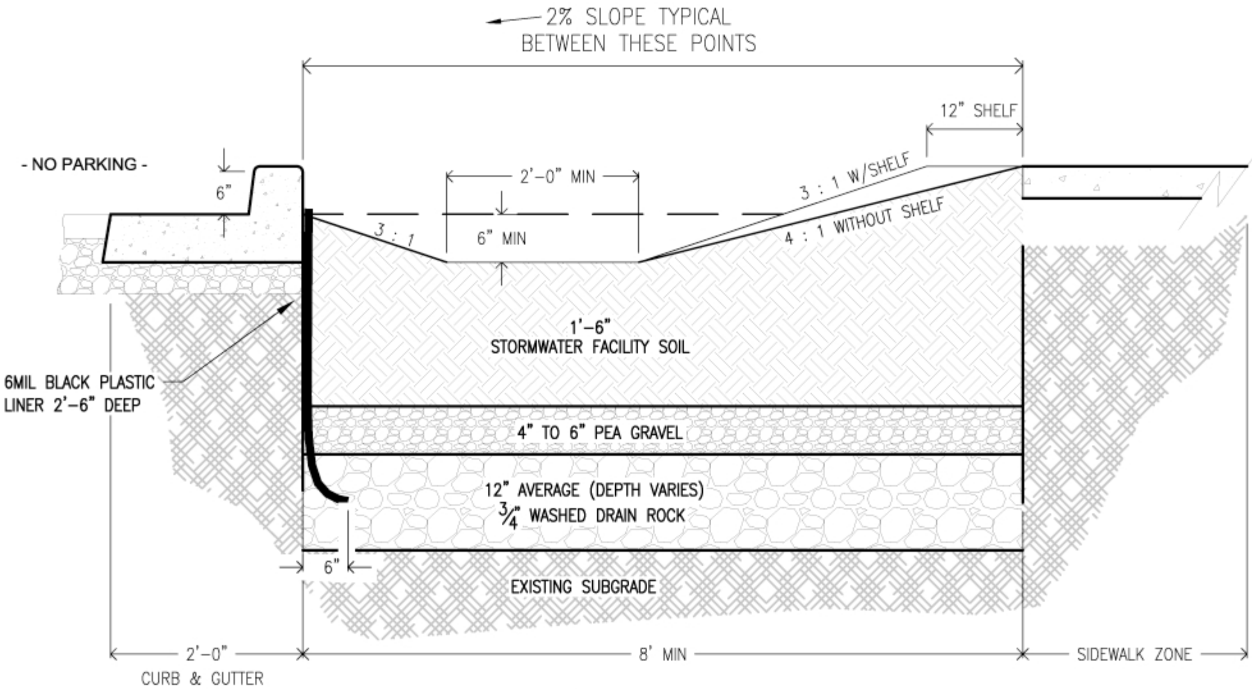
SHEET NUMBER

4

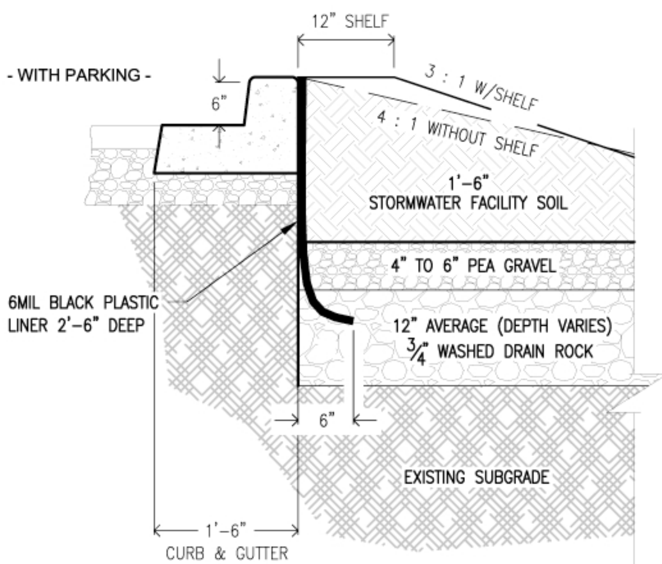
APPROVED
2/16/07
CHIEF ENGINEER, BES — DATE
2/21/07
CITY ENGINEER, PDOT — DATE
2/20/07
CHIEF ENGINEER, PWB — DATE

NO.	REVISIONS	DATE	BY
	FINAL DRAFT – SWAT.DWG	2/16/07	RMS
	DRAFT – SWAT.DWG	11/16/06	RMS

file name: SWAT.dwg Mar 01, 2007 - 3:31pm -RICKSC



SECTION A-A
SWALE WITHOUT PARKING



SECTION A-A
SWALE WITH PARKING

SCALE: 1" = 2'
0 1' 2'

file name: SWAT.dwg Mar 01, 2007 - 3:31pm -RICKSC

VEGETATED STORMWATER FACILITIES IN THE PUBLIC RIGHT-OF-WAY

TITLE

SWALE SECTIONS

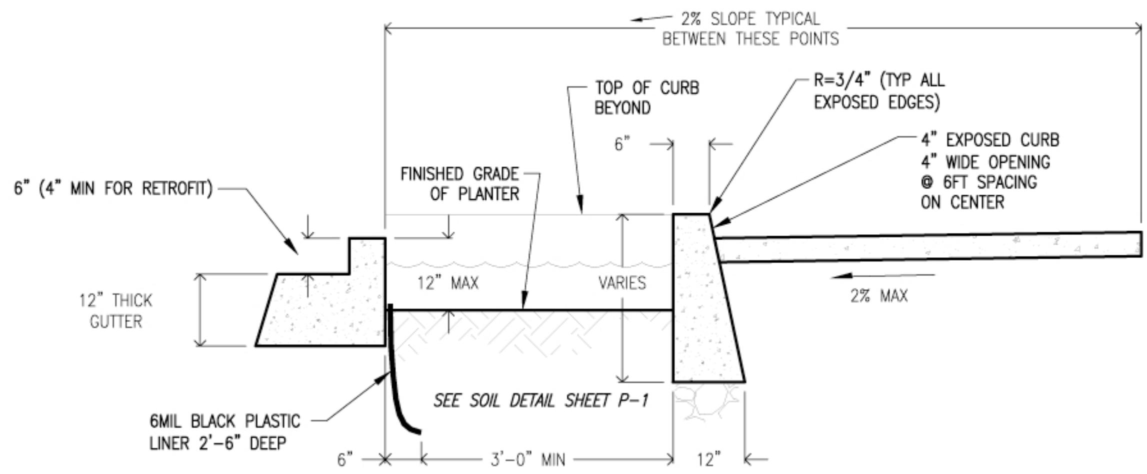
- With and Without Parking -

SHEET NUMBER

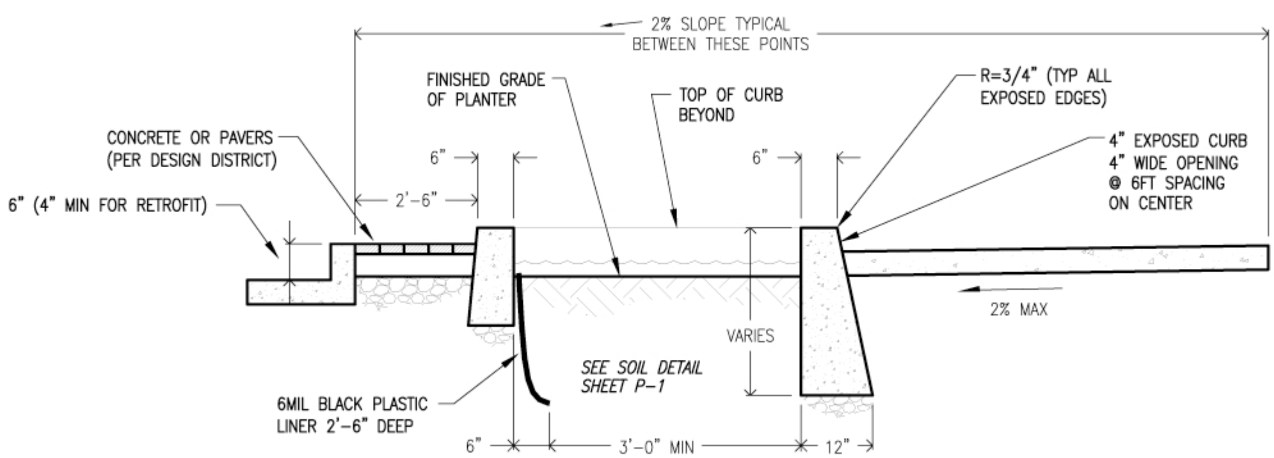
S-1

APPROVED 2/16/07
CHIEF ENGINEER, BES DATE 2/21/07
CITY ENGINEER, PDOT DATE 2/20/07
CHIEF ENGINEER, PWB DATE

NO.	REVISIONS	DATE	BY
	FINAL DRAFT – SWAT.DWG	2/16/07	RMS
	DRAFT – SWAT.DWG	11/16/06	RMS



SECTION A-A
PLANTER WITHOUT PARKING



SECTION B-B
PLANTER WITH PARKING

SCALE: 3/8" = 1'
0 1' 2'

VEGETATED STORMWATER FACILITIES IN THE PUBLIC RIGHT-OF-WAY

TITLE

PLANTER SECTIONS

- With and Without Parking -

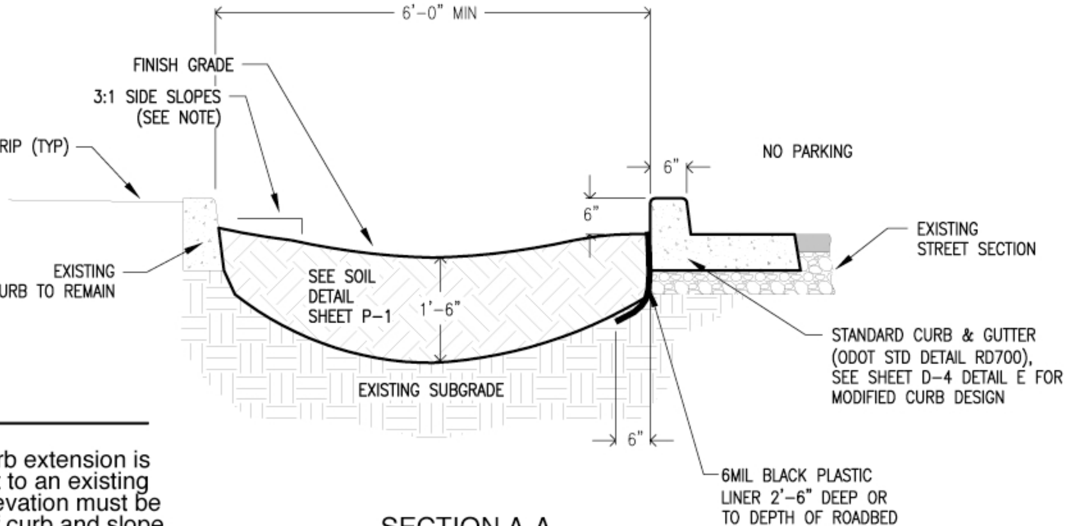
SHEET NUMBER

S-2

APPROVED
2/16/07
CHIEF ENGINEER, BES — DATE
2/21/07
CITY ENGINEER, PDOT — DATE
2/20/07
CHIEF ENGINEER, PWB — DATE

NO.	REVISIONS	DATE	BY
	FINAL DRAFT – SWAT.DWG	2/16/07	RMS
	DRAFT – SWAT.DWG	11/16/06	RMS

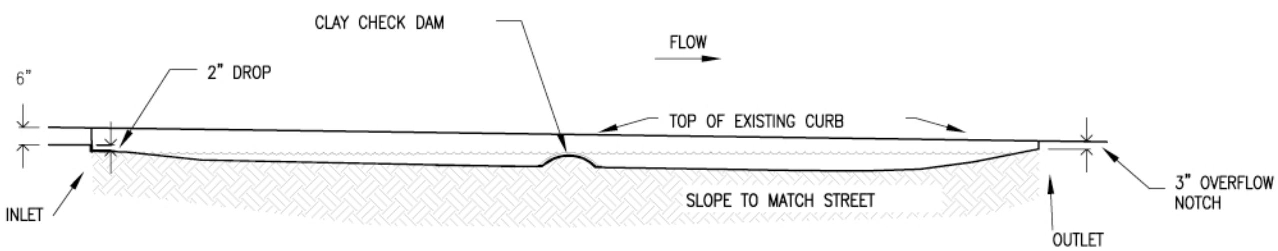
file name: SWAT.dwg Mar 01, 2007 - 3:31pm -RICKSC



NOTE:

1. If stormwater curb extension is constructed next to an existing sidewalk, soil elevation must be brought to top of curb and slope away from curb at a 4:1 slope.

SECTION A-A
CURB EXTENSION SECTION



SECTION B-B
CURB EXTENSION PROFILE

VEGETATED STORMWATER FACILITIES IN THE PUBLIC RIGHT-OF-WAY

TITLE

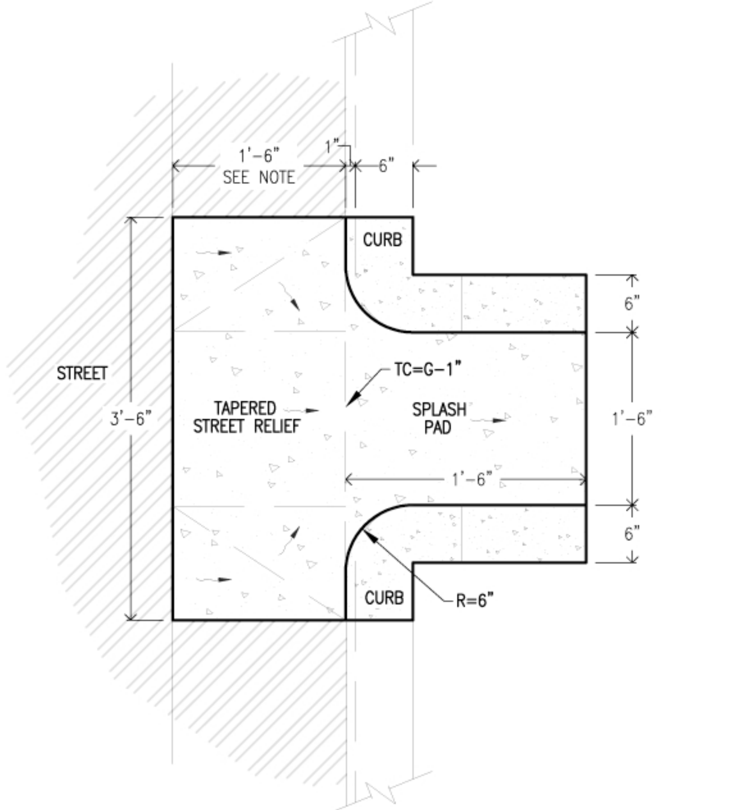
CURB EXTENSION SECTIONS

SHEET NUMBER

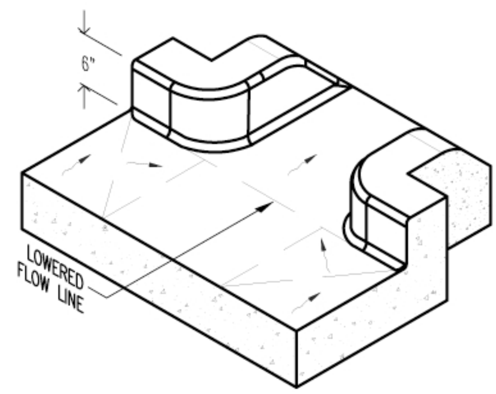
S-3

APPROVED	DATE
[signature]	2/16/07
CHIEF ENGINEER, BES	
[signature]	2/21/07
CITY ENGINEER, PDOT	
[signature]	2/20/07
CHIEF ENGINEER, PWB	

NO.	REVISIONS	DATE	BY
	FINAL DRAFT – SWAT.DWG	2/16/07	RMS
	DRAFT – SWAT.DWG	11/16/06	RMS



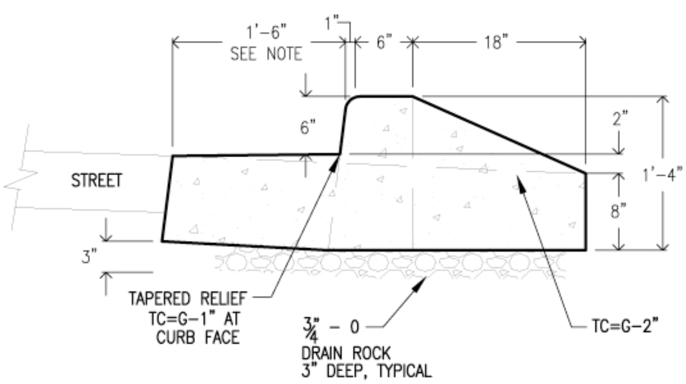
PLAN



ISOMETRIC

NOTES:

1. Concrete splash pad necessary only where water enters facility.
2. For planters, install washed pea gravel or river rock to transition from splash pad to topsoil.
3. Reference ODOT Standard Detail D 700. Use 1'-6" gutter with bike lanes and 2' gutter without bike lanes or match existing.



TC = TOP OF CONCRETE
G = GUTTER

SECTION

VEGETATED STORMWATER FACILITIES IN THE PUBLIC RIGHT-OF-WAY

TITLE

CONCRETE INLET DETAILS, TYPE SW

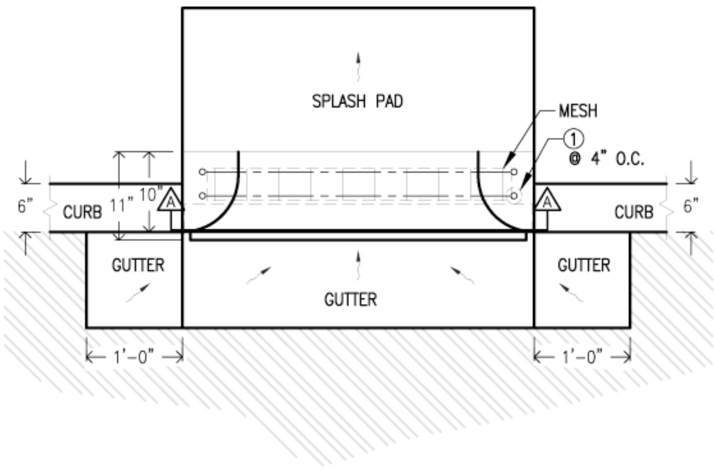
- For Local Service Streets -

SHEET NUMBER

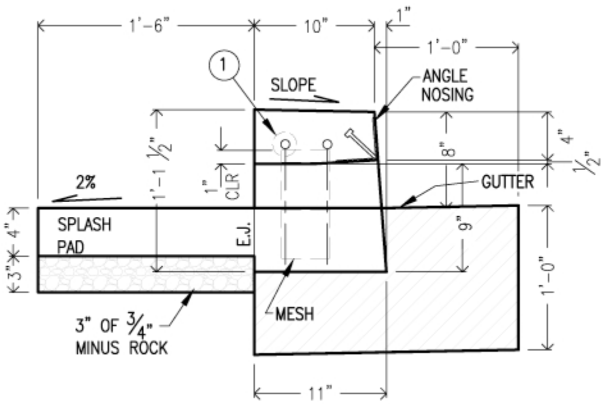
D-1

APPROVAL	DATE
CHIEF ENGINEER, BES	2/16/07
CITY ENGINEER, PDOT	2/21/07
CHIEF ENGINEER, PWB	2/20/07

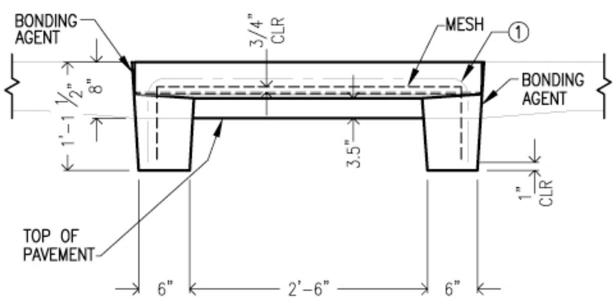
NO.	REVISIONS	DATE	BY
	FINAL DRAFT – SWAT.DWG	2/16/07	RMS
	DRAFT – SWAT.DWG	11/16/06	RMS



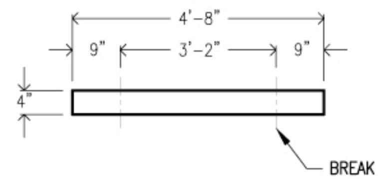
PLAN



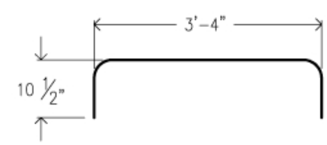
SECTION B-B



SECTION A-A



DETAIL MESH



DETAIL 1

E.J. = EXPANSION JOINT
CLR. = CLEAR
O.C. = ON CENTER

STRUCTURAL NOTES:

1. Concrete: 28 Day Strength f'c = 5,500 PSI.
2. Rebar: ASTM A-615 Grade 60.
3. Mesh: ASTM A-185 Grade 65.
4. Design: ACI-318 Building Code, ASTM C-857 "Min structural design loading for underground precast concrete utility structures".
5. Loads: H-20 truck wheel w/ 30% impact.

BILL OF MATERIAL				
	ANGLE NOSING	1	3.5"x3.5"x3'-7" GALV.	
MESH	W2.9/W2.9 4x4	1	SEE DETAIL MESH	2 SF
①	#6 GR 60	2	SEE DETAIL 1	15
PART	DESCRIPTION	QTY.	SIZE	TOTAL WT. LBS.

VEGETATED STORMWATER FACILITIES IN THE PUBLIC RIGHT-OF-WAY

TITLE

COVERED CONCRETE INLET DETAILS, TYPE PB

- For Neighborhood Collectors and Above -

SHEET NUMBER

D-2

APPROVED	DATE
[signature] CHIEF ENGINEER, BES	2/16/07
[signature] CITY ENGINEER, PDOT	2/21/07
[signature] CHIEF ENGINEER, PWB	2/20/07

NO.	REVISIONS	DATE	BY
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	DRAFT – SWAT.DWG	11/16/06	RMS

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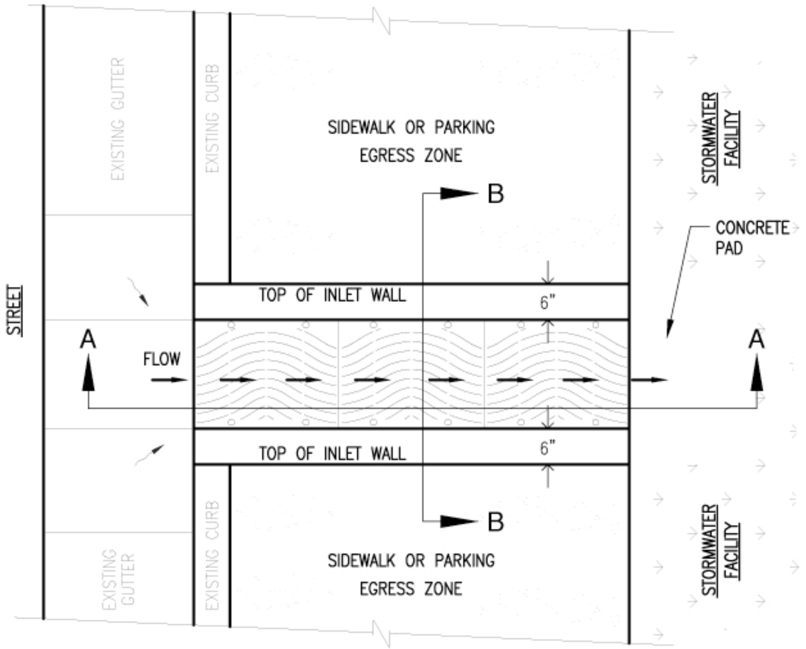
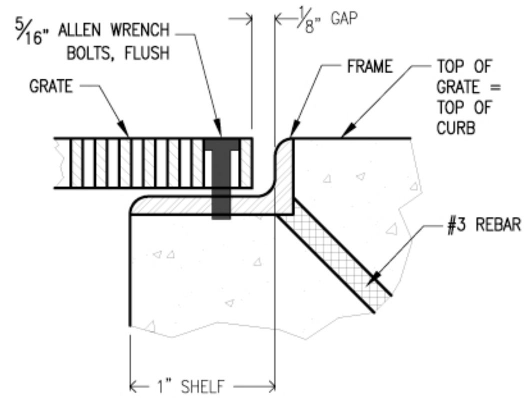
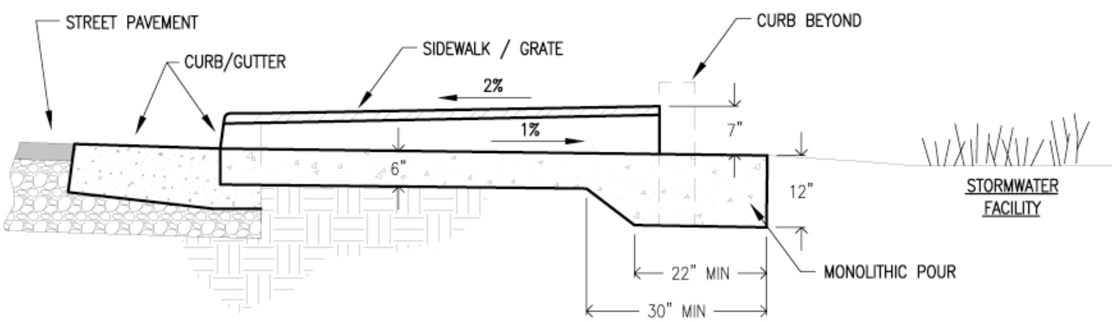


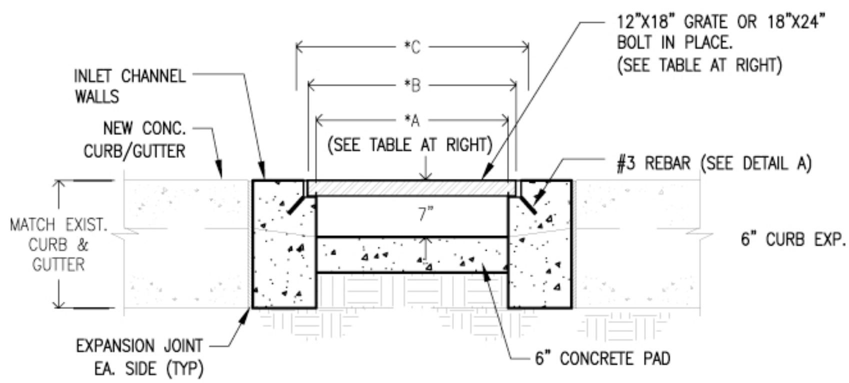
PLAN VIEW



DETAIL A



SECTION A-A



SECTION B-B

*TRENCH GRATING

A TRENCH WIDTH	B GRATE WIDTH	C FRAME WIDTH
10"	11 7/8"	12 1/8"
16"	17 7/8"	18 1/8"

NOTE: MAXIMUM GRATE HOLE WIDTH (OPEN) 1/4 INCH. GRATE SIZE 12"X18" OR 18"X24". CAST IRON URBAN ACCESSORIES TRENCH GRATE AND FRAME. TITLE WAVE MODEL OR EQUAL.

VEGETATED STORMWATER FACILITIES IN THE PUBLIC RIGHT-OF-WAY

TITLE

CONCRETE INLET DETAILS, TYPE CHANNEL & GRATE

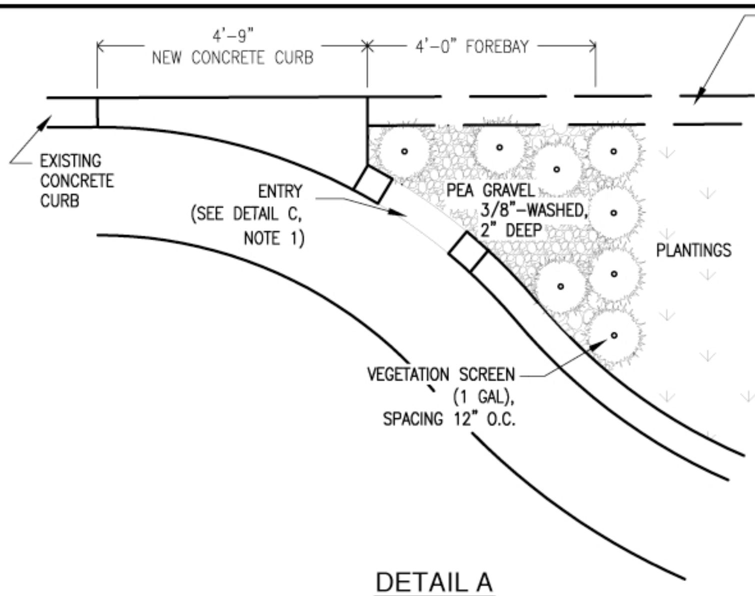
SHEET NUMBER

D-3

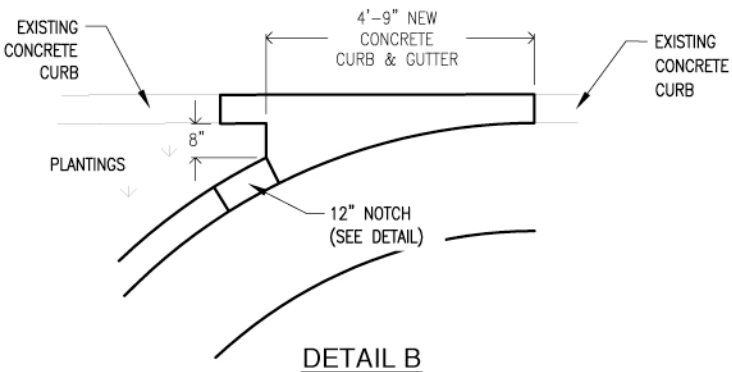
APPROVED	DATE
CHIEF ENGINEER, BES	2/16/07
CITY ENGINEER, PDOT	2/21/07
CHIEF ENGINEER, PWB	2/20/07

NO.	REVISIONS	DATE	BY
	FINAL DRAFT – SWAT.DWG	2/16/07	RMS
	DRAFT – SWAT.DWG	11/16/06	RMS

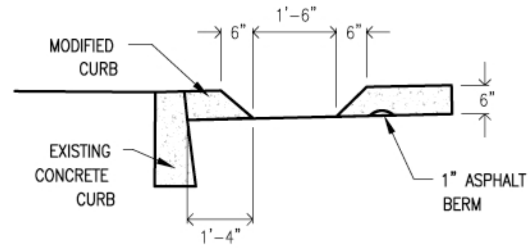
file name: SWAT.dwg Mar 01, 2007 - 3:32pm -RICKSC



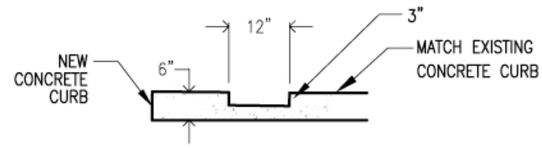
DETAIL A
PEA GRAVEL FOREBAY



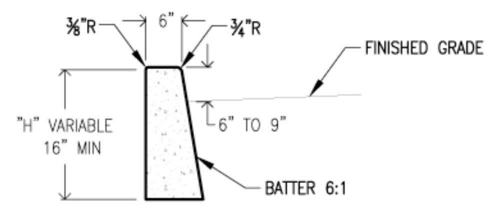
DETAIL B
OUTLET CURB PLAN



DETAIL C
MODIFIED INLET



DETAIL D
MODIFIED OUTLET



DETAIL E
MODIFIED CURB

NOTES:

1. Detail A: Pea gravel forebay for use with stormwater curb extensions only. Pea gravel forebay replaces standard concrete splash pad.
2. Detail C: To prevent ponding, position inlet closer to existing curb if the street cross-slope is >2%. Additional inlets can be added if necessary (preferably immediately downstream of each check dam to minimize potential backflow). Additional inlets are not recommended for streets sloped <1%.
3. Details B, C & D: For use on local service streets only.
4. Detail E: Modified curb may be necessary where standard curb and gutter conflicts with water lines.

VEGETATED STORMWATER FACILITIES IN THE PUBLIC RIGHT-OF-WAY

TITLE

INLET / OUTLET DETAILS

- For Curb Extensions -

SHEET NUMBER

D-4

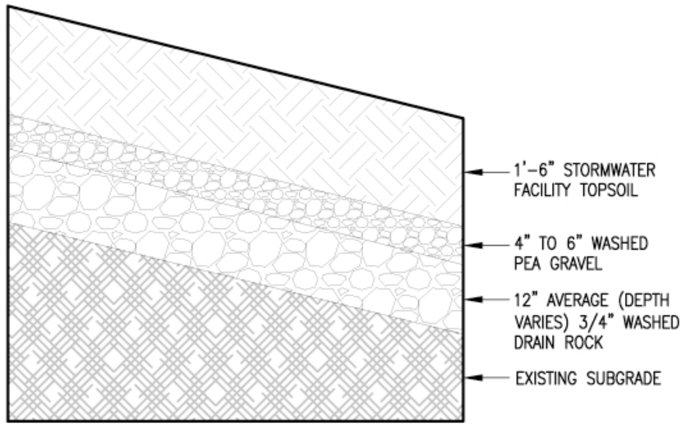
NO.	REVISIONS	DATE	BY
	FINAL DRAFT – SWAT.DWG	2/16/07	RMS
	DRAFT – SWAT.DWG	11/16/06	RMS

APPROVED
2/16/07
CHIEF ENGINEER, BES — DATE
2/21/07
CITY ENGINEER, PDOT — DATE
2/20/07
CHIEF ENGINEER, PWB — DATE

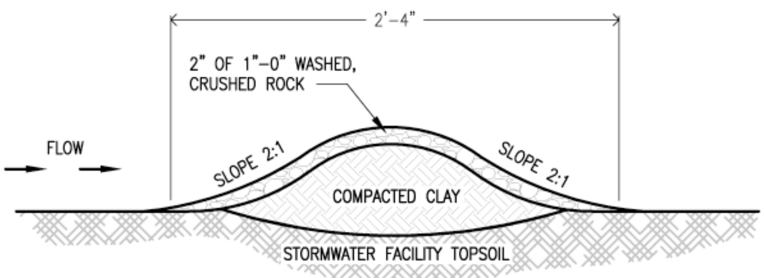
file name: SWAT.dwg Mar 01, 2007 - 3:33pm -RICKSC

SOIL NOTES:

1. See City of Portland Standard Construction Specifications Section 01040.14 (d) - Stormwater Facility Topsoil.
2. The soil mix shall consist of 67% sandy loam topsoil and 33% compost material by volume. Topsoil shall be a sandy loam as defined by the UDSA soil texture classification. Soil classification and other specifications must be evaluated and reported by an accredited soils testing laboratory and approved by the engineer prior to delivery of topsoil to project site.
3. If no drain rock or pea gravel is specified, excavate native soil 18" below the finish grade of the facility and rototill exposed native soil.
4. Install topsoil in a manner that ensures adequate infiltration. Place in two equal lifts. (If no drain rock is specified rototill the first lift into native soil.) Lifts should not be compacted, but rather placed in a manner to reduce excessive erosion or settlement. Lifts may be lightly watered to encourage natural compaction or, if necessary, rolled with a water-filled landscape roller. Slightly overfill the facility above proposed finished grade to accommodate natural settlement.
5. Pea gravel is specified to separate topsoil from drain rock, when drain rock is specified. Geotextile fabric can be used for this purpose but is prone to clogging when used in combination with soils than have high clay and/or silt content. Geotextile fabric can also be used when there are concerns for lateral flow along the walls of the facility or other specific design concerns.



SOIL PROFILE



CHECK DAM

CHECK DAM SPACING			
Facility Length	Longitudinal Street Slope	# of Check Dams *	Additional Inlets **
30	<=1%	0	None
	>1%	1	None
31 - 50	<=1%	1	None
	>1%	2	1
51 - 70	<=1%	2	1
	>1%	3	2
71-90	<=1%	3	2
	>1%	4	3
91 +	<=1%	4	3
	>1%	5	4

TABLE 1

CHECK DAM NOTES:

1. Check Dams to be evenly spaced between inlet and outlet. Additional requirements maybe necessary on steep slopes.
2. Additional inlets to be placed downstream of check dams.
3. Height of check dam 2" less than depth of facility typical.

VEGETATED STORMWATER FACILITIES IN THE PUBLIC RIGHT-OF-WAY

TITLE

SOIL & CHECK DAM DETAILS

SHEET NUMBER

P-1

APPROVED 2/16/07

CHIEF ENGINEER, BES DATE 2/21/07

CITY ENGINEER, PDOT DATE 2/20/07

CHIEF ENGINEER, PWB DATE

NO.	REVISIONS	DATE	BY
	FINAL DRAFT - SWAT.DWG	2/16/07	RMS
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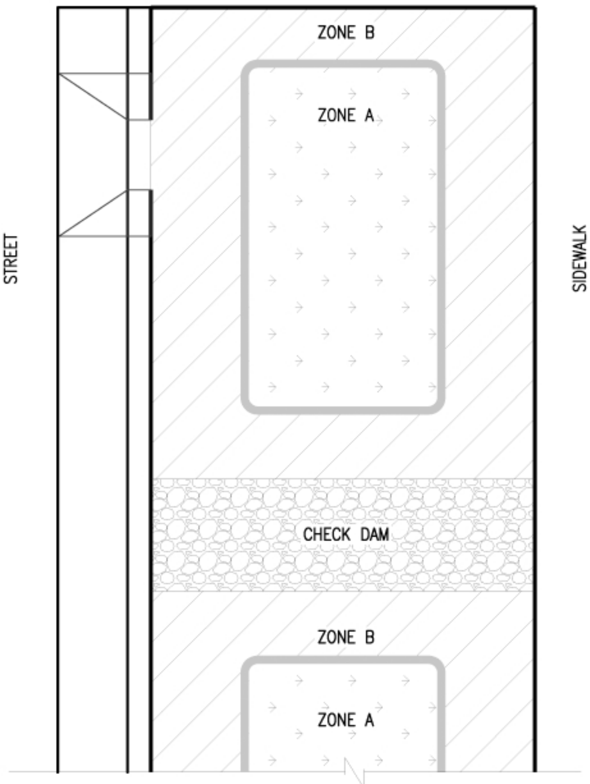
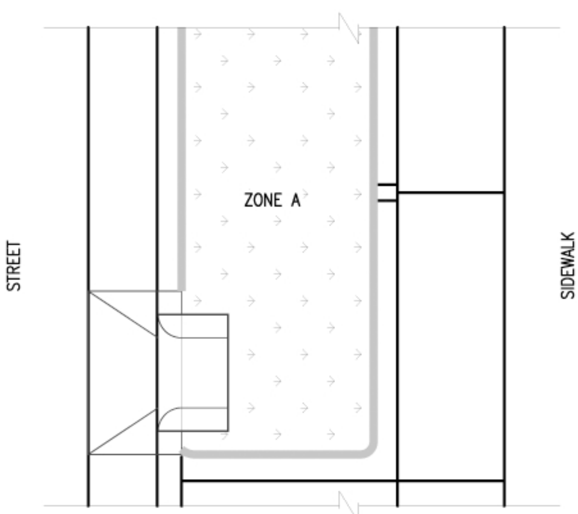
file name: SWAT.dwg Mar 01, 2007 - 3:33pm -RICKSC



SWALE & CURB EXTENSION
PLANTING TEMPLATE



PLANTER PLANTING TEMPLATE

RECOMMENDED PLANTS FOR VEGETATED STORMWATER FACILITIES IN THE PUBLIC RIGHT-OF-WAY	
Botanical Name	Common Name
ZONE A	
Bottom of facility, wet, evergreen, not more than 30" tall *Typically 1 gal pots, planted 12" on center*	
Carex aperta	Columbia sedge
Carex densa	Dense sedge
Carex pansa	
Carex testacae	New Zealand orange sedge
Carex tumilicola	Foothill sedge
Deschampsia caespitosa "Northern Lights"	Tufted hair grass
Eleocharis palustris	Creeping spikerush
Juncus balticus	Baltic rush
Juncus effusus 'Carmen's Japanese"	Common rush
Juncus effusus 'Gold Strike"	Common rush
Juncus effusus 'Carman's Gray'	Common rush
Juncus patens	Spreading rush
ZONE B	
Side slopes of facility, drought tolerant to moist, evergreen & deciduous, not more than 24" tall, *Typically 1 gal pots, planted 12" on center*	
Arctostaphyllos uva-ursi	Kinnickinnik
Blechnum spicant	Deer fern
Cornus sericea var. kelseyii	Dwarf redtwig dogwood
Liriope muscari 'Big Blue'	Big Blue lily turf
Gautheria shallon	Salal
Mahonia nervosa	Low Oregon grape
Mahonia repens	Creeping Oregon grape

TABLE 1

VEGETATED STORMWATER FACILITIES IN THE PUBLIC RIGHT-OF-WAY

TITLE

PLANTING TEMPLATE DETAILS

SHEET NUMBER

P-2

APPROVED	
2/16/07	
CHIEF ENGINEER, BES	DATE 2/21/07
CITY ENGINEER, PDOT	DATE 2/20/07
CHIEF ENGINEER, PWB	DATE

NO.	REVISIONS	DATE	BY
	FINAL DRAFT – SWAT.DWG	2/16/07	RMS
	DRAFT – SWAT.DWG	11/16/06	RMS

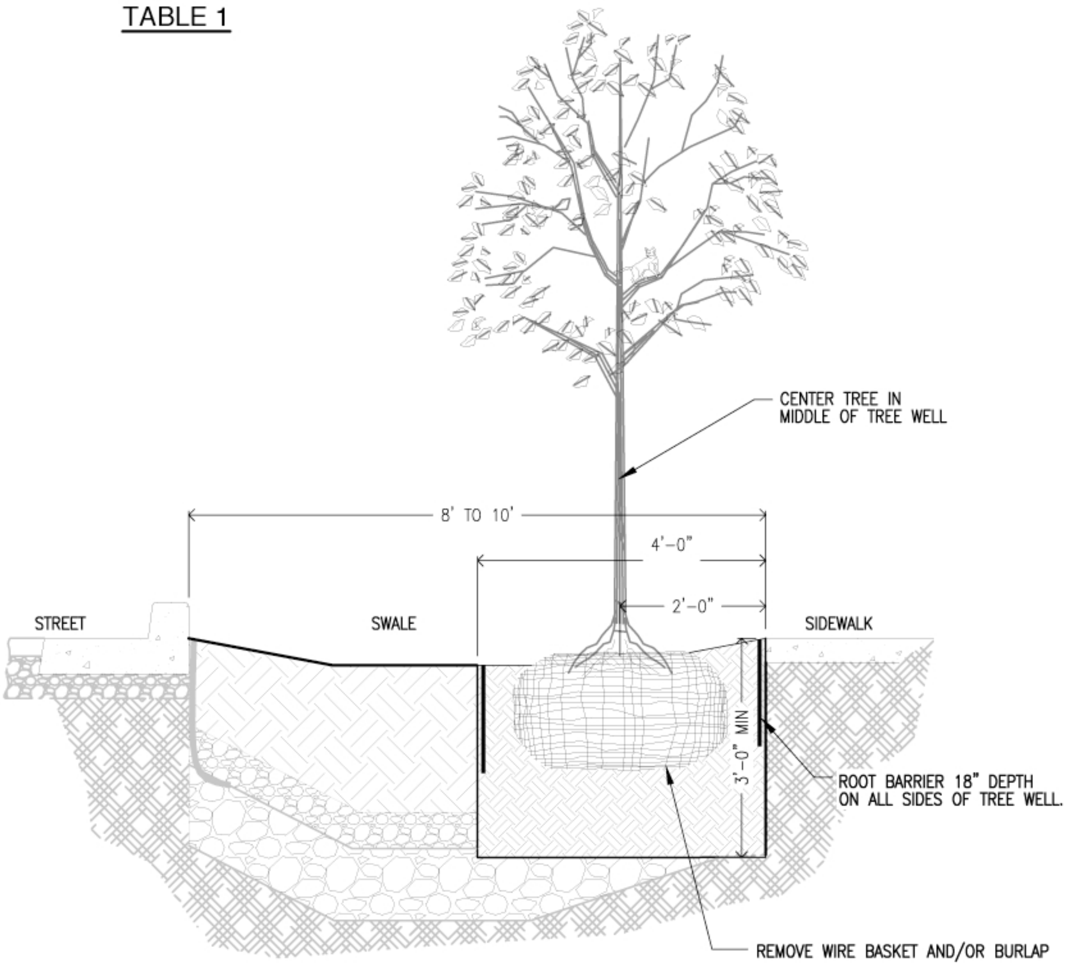
file name: SWAT.dwg Mar 01, 2007 - 3:34pm -RICKSC

RECOMMENDED STREET TREES	
Botanical Name	Common Name
WITH power lines	
Carpinus caroliniana	American Hornbeam
Cercis canadensis	Eastern Redbud
Fraxinus pennsylvanica 'Johnson'	Leprechaun Ash
Gleditsia triacanthos 'Impcole'	Imperial Honeylocust
Koelreuteria paniculata	Goldenrain Tree
Prunus virginiana "Canada Red'	Canada Red Chokecherry
WITHOUT power lines	
Nyssa sylvatica	Black tupelo
Celtis occidentalis	Hackberry
Quesrcus shumardii	Shumard Oak
Betula jacquemontii	Jacquemontii Birch
Acer campestre 'Evelyn'	Queen Elizabeth Hedge Maple
Gleditsia triacanthos 'Skycole'	Skyline Honeylocust

TABLE 1

NOTES:

1. Contact Urban Forester for review of tree installation (503) 823-4025.
2. Remove wire and burlap from root ball prior to backfilling.
3. Set top of root ball a minimum of 1" above topsoil surface.
4. Distance between trees varies: 20'-30' on center.
5. Minimum clearance of 10' between trees and water lines or meets Standard Plan 5-109 (tree root barrier).



STREET TREE IN SWALE

VEGETATED STORMWATER FACILITIES IN THE PUBLIC RIGHT-OF-WAY

TITLE

STREET TREE DETAILS

SHEET NUMBER

P-3

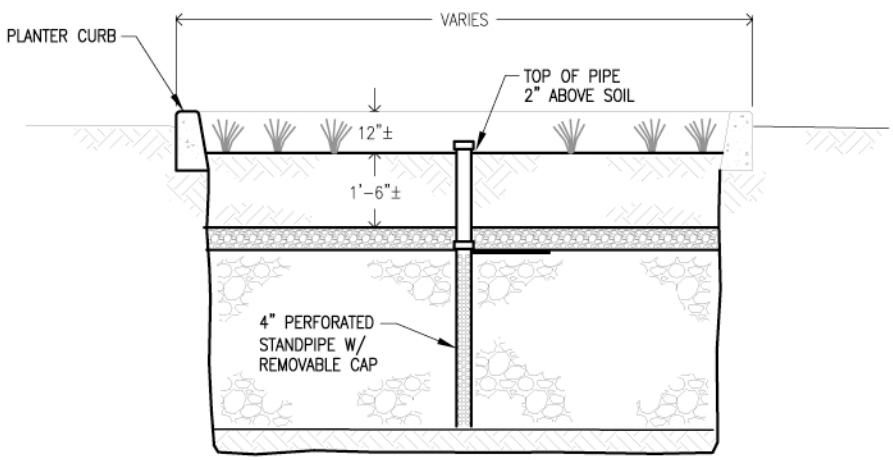
APPROVED	DATE	NO.	REVISIONS	DATE	BY
CHIEF ENGINEER, BES	2/16/07		FINAL DRAFT – SWAT.DWG	2/16/07	RMS
CITY ENGINEER, PDOT	2/21/07		DRAFT – SWAT.DWG	11/16/06	RMS
CHIEF ENGINEER, PWB	2/20/07				

SPECIFICATIONS
UNDER DEVELOPMENT

NOTE:

1. Curb marker provided by owner.

CURB MARKER DETAIL



FACILITY MONITORING PORT

NOTE:

1. Monitoring port required in facilities with rock trench that is designed for stormwater storage.

VEGETATED STORMWATER FACILITIES IN THE PUBLIC RIGHT-OF-WAY

TITLE

CURB MARKER & MONITORING PORT

SHEET NUMBER

P-4

APPROVED	DATE
CHIEF ENGINEER, BES	2/16/07
CITY ENGINEER, PDOT	2/21/07
CHIEF ENGINEER, PWB	2/20/07

NO.	REVISIONS	DATE	BY
	FINAL DRAFT – SWAT.DWG	2/16/07	RMS
	DRAFT – SWAT.DWG	11/16/06	RMS

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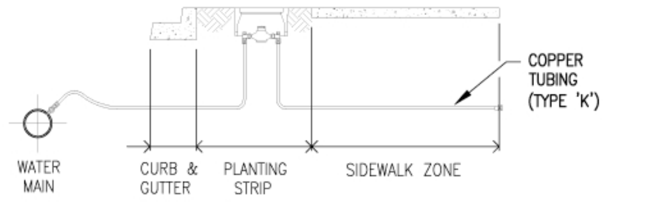

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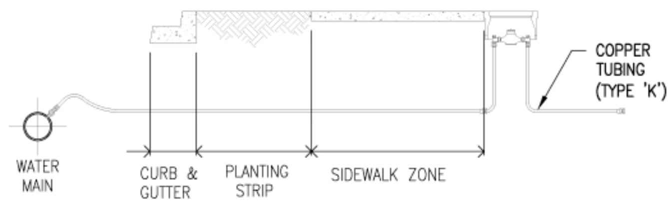

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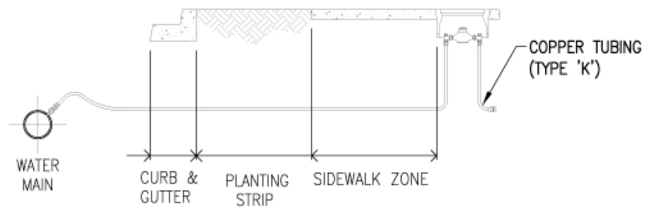

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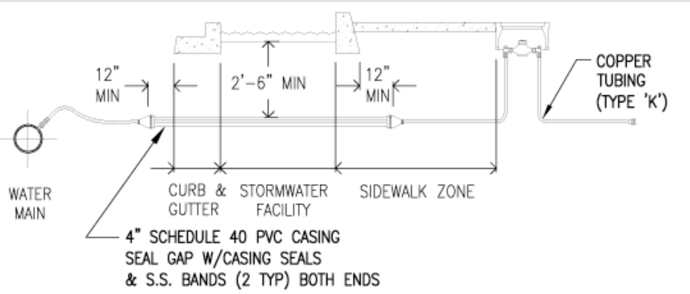

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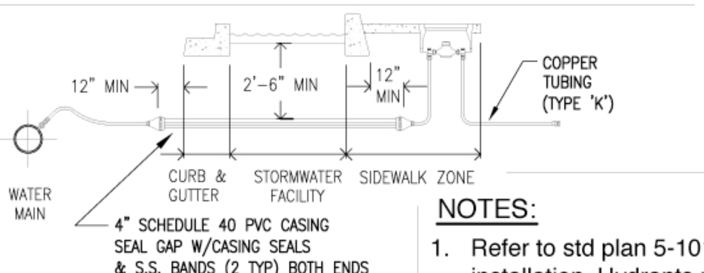

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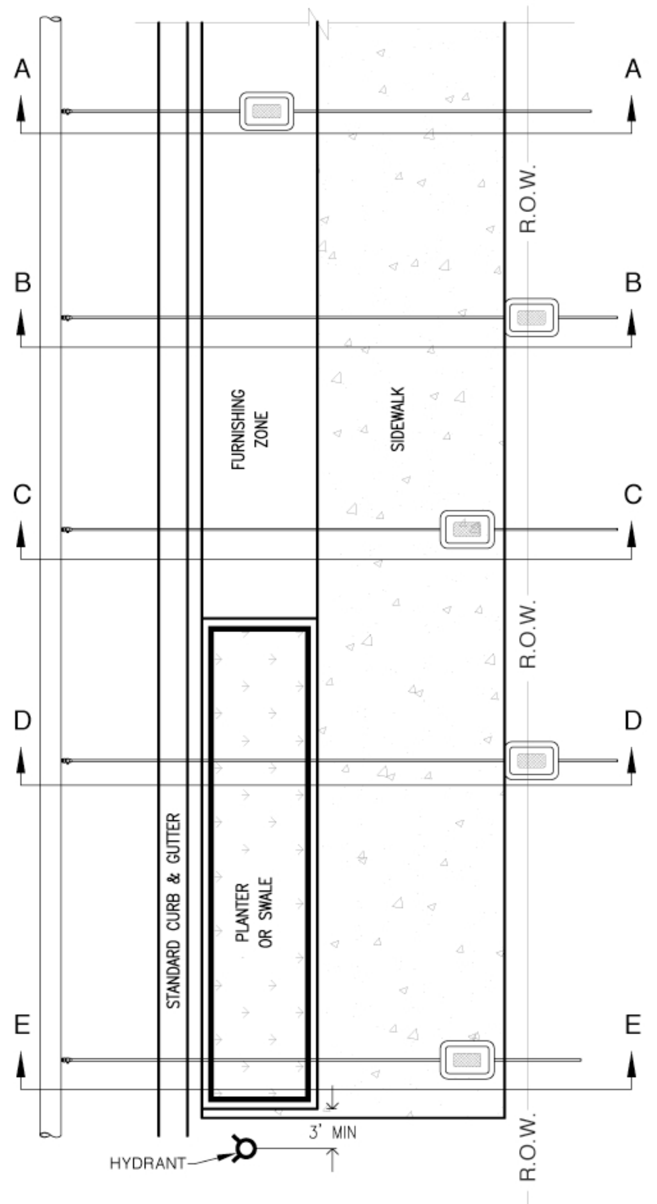


PLAN VIEW

NOTES:

1. Refer to std plan 5-101 for fire hydrant installation. Hydrants must have min 3' clearance from the edge of stormwater facility.
2. Preferred order of meter location is A, B, C, D, then E. Option B or D can be used only if meter box is fully within the Right-of-Way.
3. Refer to std plan 5-201, 5-202 & 5-205 for std small service installation or similar. For larger services or other appurtenances, contact PWB development services @ 503 823-7368. Water service line must be 2'-6" min below lowest point of ground surface of stormwater facility, typical.

VEGETATED STORMWATER FACILITIES IN THE PUBLIC RIGHT-OF-WAY

TITLE

METER & HYDRANT LOCATION DETAILS

- For Swales with or without Parking & Planters without Parking -

CITY OF PORTLAND OREGON 1851

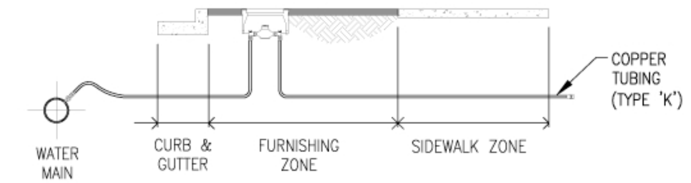
SHEET NUMBER

W-1

APPROVED	DATE
CHIEF ENGINEER, BES	2/16/07
CITY ENGINEER, PDOT	2/21/07
CHIEF ENGINEER, PWB	2/20/07

NO.	REVISIONS	DATE	BY
	FINAL DRAFT – SWAT.DWG	2/16/07	RMS
	DRAFT – SWAT.DWG	11/16/06	RMS

file name: SWAT.dwg Mar 01, 2007 - 3:35pm -RICKSC



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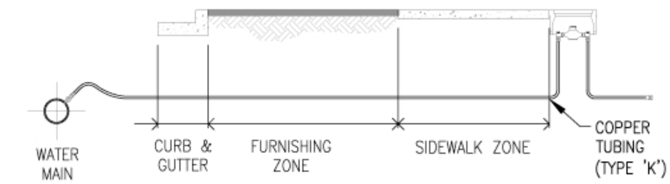

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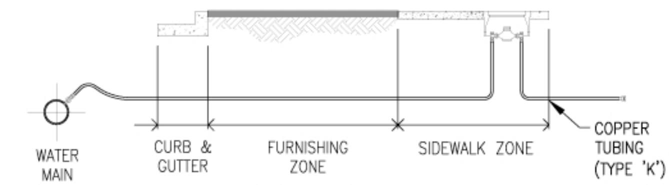

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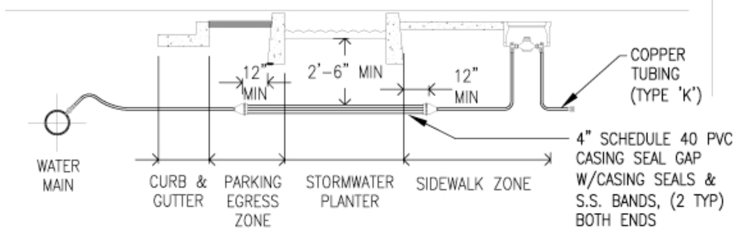

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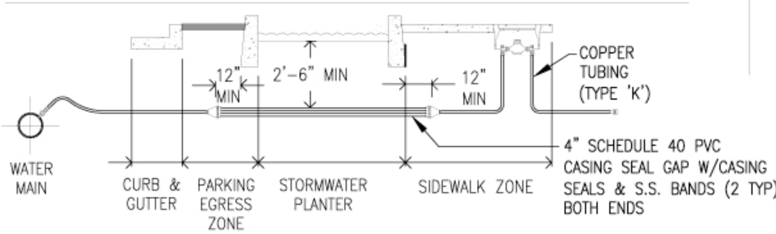

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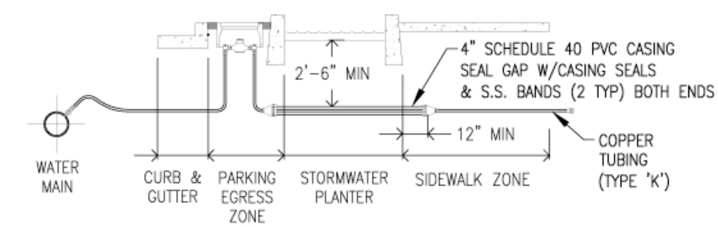

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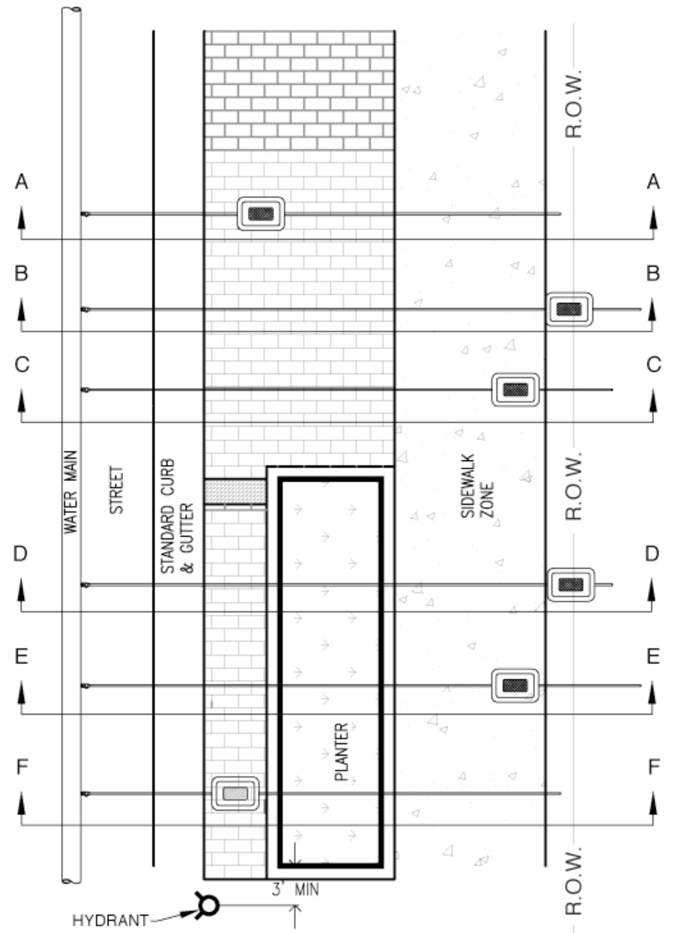

NOTES:

1. Refer to std plan 5-101 for fire hydrant installation. Hydrants must have min 3' clearance from the edge of a stormwater facility.

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VEGETATED STORMWATER FACILITIES IN THE PUBLIC RIGHT-OF-WAY

TITLE

METER & HYDRANT LOCATION DETAILS

- For Planters with Parking -

SHEET NUMBER

W-2

APPROVED 2/16/07

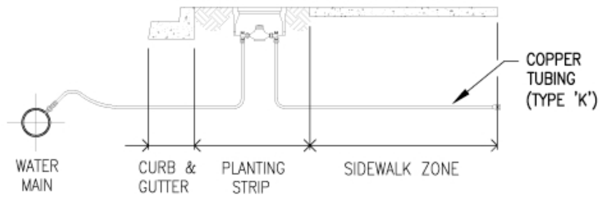
CHIEF ENGINEER, BES DATE 2/21/07

CITY ENGINEER, PDOT DATE 2/20/07

CHIEF ENGINEER, PWB DATE

NO.	REVISIONS	DATE	BY
	FINAL DRAFT – SWAT.DWG	2/16/07	RMS
	DRAFT – SWAT.DWG	11/16/06	RMS

file name: SWAT.dwg Mar 01, 2007 - 3:35pm -RICKSC



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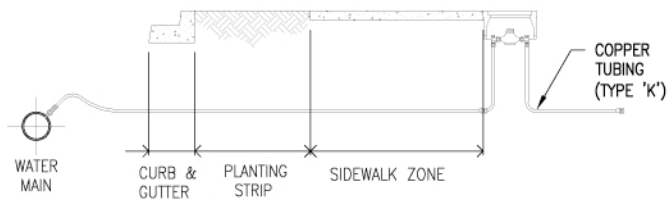

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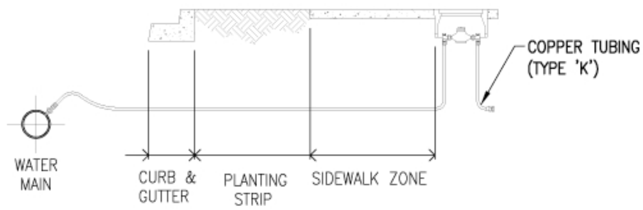
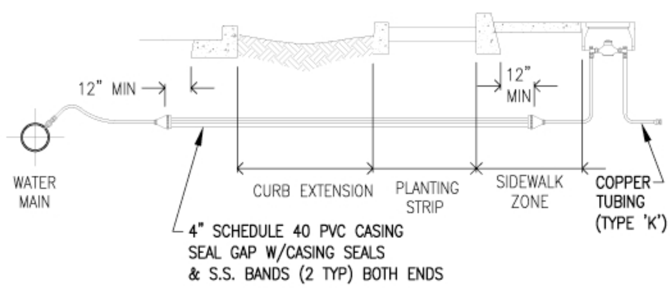


SECTION C-C



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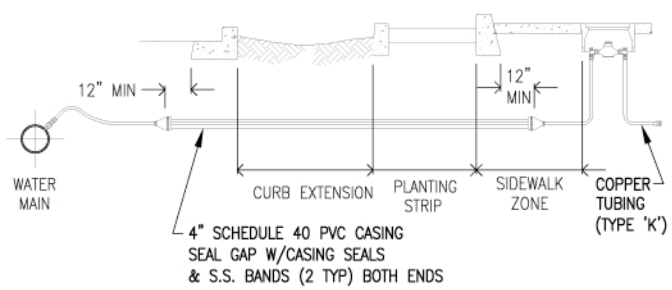

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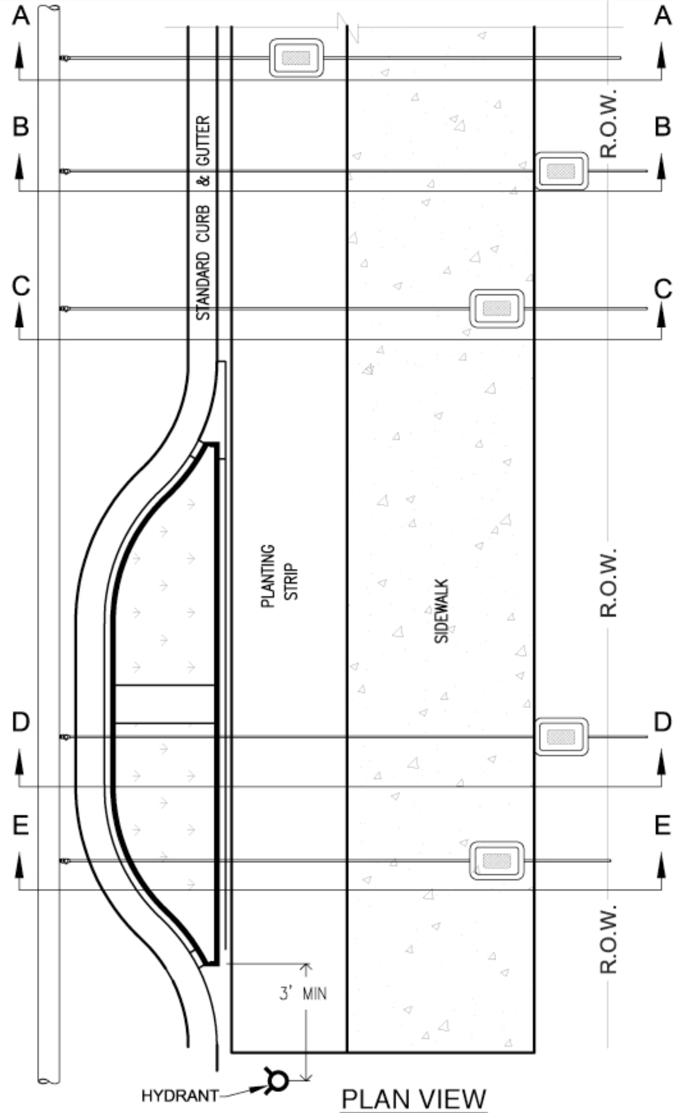

PLAN VIEW

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1) Refer to std plan 5-101 for fire hydrant installation. Fire hydrants must have min 3' clearance from the edge of a stormwater facility.

2) Preferred order of meter location is A, B, C, D, then E. Option B or D can only be used if the meter box is fully within the Right-of-Way.

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VEGETATED STORMWATER FACILITIES IN THE PUBLIC RIGHT-OF-WAY

TITLE

METER & HYDRANT LOCATION DETAILS

- For Curb Extensions -

SHEET NUMBER

W-3

APPROVED		NO.	REVISIONS	DATE	BY
CHIEF ENGINEER, BES	2/16/07 DATE		FINAL DRAFT – SWAT.DWG	2/16/07	RMS
CITY ENGINEER, PDOT	2/21/07 DATE		DRAFT – SWAT.DWG	11/16/06	RMS
CHIEF ENGINEER, PWB	2/20/07 DATE				

file name: SWAT.dwg Mar 01, 2007 - 3:35pm -RICKSC

Appendix C
Site Calculations

Area 1

Assumptions		Units
Runoff Volume		
24 hr rainfall P	3.7	in
Hydrologic soil group HSG	B	
Impervious area	50%	
Curve number of pervious surface	73	
Composite curve number	84	
Runoff depth Qd	1.6	in
Drainage area in square ft	95599.69	sf
Drainage area Ad	2.19	acres
Runoff Volume Qvol after development	**0.29**	acre/ft
Peak Rate of Flow		
Rato Ia/P	0.11	
Hydraulic length on turf	48	ft
Lcn factor for turf	3	
Slope on turf G	7%	
Travel time on turf t1	**1.15**	min
Hydraulic length on pavement	536	ft
Lcn factor for pavement	9	
Slope on pavement	1%	
Travel time on pavement t2	**9**	min
Time of concentration tc	**10.15**	min
Rainfall distribution type	ii	
Unit peak discharge qu	1.55	cfs/ac/in
Pond-and-swamp factor Fp	1	
Peak rate of flow qp after development	**5.44**	cfs

Area 2

Assumptions

<u>Runoff Volume</u>		
24 hr rainfall P	3.7	in
Hydrologic soil group HSG	B	
Impervious area	75%	
Curve number of pervious surface	79	
Composite curve number	93	
Runoff depth Qd	2.9	in
Drainage area in square ft	159082.71	sf
Drainage area Ad	3.65	acres
Runoff Volume Qvol after	**0.88**	acre/ft
<u>Peak Rate of Flow</u>		
Rato Ia/P	0.06	
Hydraulic length on turf	96	ft
Lcn factor for turf	1	
Slope on turf G	4%	
Travel time on turf t1	**0.5**	min
Hydraulic length on pavement	800	ft
Lcn factor for pavement	2	
Slope on pavement	4%	
Travel time on pavement t2	**1**	min
Time of concentration tc	**1.50**	min
Rainfall distribution type	ii	
Unit peak discharge qu	1.56	cfs/ac/in
Pond-and-swamp factor Fp	1	
Peak rate of flow qp after	**16.52**	cfs

Area 1

Determining Data		
Drainage Area Ad	2.19	ac
Curve Number CN	84	
Runoff Volume Qvol	0.29	af
Peak rate of runoff entering basin qp	5.44	cfs
Area available for basin B	0.08	ac/ac
Maximum ponding time tp	2	days
Soil infiltration rate K	**0.18**	ft/day
Basin Design		
Maximum basin depth D	0.36	ft
Basin area Ab	0.18	ac
Infiltration volume Qinf	**0.06**	af

Area 2

Determining Data		
Drainage Area Ad	3.65	ac
Curve Number CN	93	
Runoff Volume Qvol	0.88	af
Peak rate of runoff entering basin qp	5.44	cfs
Area available for basin B	0.48	ac/ac
Maximum ponding time tp	4	days
Soil infiltration rate K	**0.18**	ft/day
Basin Design		
Maximum basin depth D	0.72	ft
Basin area Ab	1.75	ac
Infiltration volume Qinf	**1.26**	af

Appendix D
Ecol-logic Specifications

CAPITOL PAVERS & RETAINING WALLS

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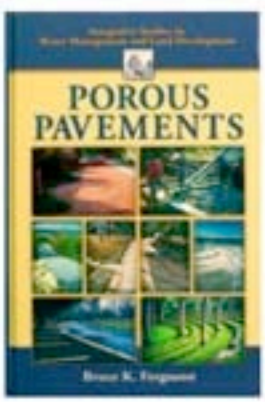
ECO-LOGIC BLOCKS

Order #	Y91	Y90
Style	4x4	4x8
Pieces/Pallet	76	528
Pieces/Sq. Ft.	9	4.5
Bands/Pallet	8	6

*Special order – sold to the nearest pallet



Interlocking Pavers

products > interlocking pavers

ECOLOGICAL PAVERS

The Eco-Logic Paver

The Eco-Logic Paver

"The Capitol Ornamental Concrete Specialties Company developed the Eco-Logic concrete block in the late 1990s in response to specifications by Arnold Wilday (a joint venture of landscape architects Henry Arnold and Cassandra Wilday) for Pier A Park in Hoboken, New Jersey (Michael Grossman, personal communication 2001). Having developed the manufacturing capability for this block and understanding its environmental advantages, Capitol gave the model its name and continues to make it available."

"The purpose of the porous Eco-Logic pavement at Pier A Park was the provision of viable rooting space for trees in the midst of considerable pedestrian traffic... Many trees are planted in the block-paved areas; many others are planted in areas surfaced with turf or aggregate... The pavement bears the load of very heavy pedestrian traffic and occasional park maintenance vehicles. The porous, permeable surface provides air and water to tree roots growing in the air-entrained soil below."

—Excerpt taken from p. 347- 348, Porous Pavements Written by Bruce K. Ferguson

The Eco-Logic blocks 1/4" spacers are wide enough to receive #10 aggregate and yet are still the narrowest width joints that you can have and still be significantly porous and permeable. This porous and permeable surface creates a viable rooting space for trees in the midst of considerable pedestrian traffic.

Click here to view more images in the gallery.