SPU/WTD GSI Program Support Services Contract

TECHNICAL MEMORANDUM

SUBJECT: Design Guidance for Presettling Upstream of Bioretention Facilities
GSI PSS – Task 3; Subtask 3.1.11 Presettling Guidance

Date: August 7, 2023

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Executive Summary

This Technical Memorandum (TM) provides updated design guidance for the application of presettling upstream of bioretention facilities for King County Wastewater Treatment Division (KCWTD) and Seattle Public Utilities (SPU) capital projects and describes the process used to develop the guidance. SPU requested this evaluation in response to questions that emerged on recent projects about best practices for presettling upstream of bioretention facilities, including anecdotal observations of sediment (or lack thereof) in existing facilities and feedback from maintenance on the challenges of removing sediment from existing presettling zones within bioretention facilities. Additionally, several recent GSI capital projects are in areas of the city with curbless streets and informal drainage systems with inherently larger drainage basins. Maintenance staff have provided initial feedback that, in these settings, the presettling zones (splash pads) specified in the stormwater manual are ineffective at sediment capture. They report that these pads do not have adequate containment and therefore do not appear to capture much sediment and debris and require little maintenance as the sediment passes through the pads to the bioretention facility bottom. Further, it appears that smaller distributed bioretention facilities that capture approximately one city block of right-of-way runoff do not receive enough sediment from their basins to warrant presettling.

The purpose of this effort is to re-evaluate and update KCWTD and SPU's design guidance for the use of presettling upstream of bioretention facilities on capital projects with a focus on prioritizing presettling and consolidating presettling maintenance activities, to where they are most needed and most effective. These updates are based on an analysis of the performance of, and maintenance frequency and activities for, existing bioretention; an analysis of proprietary and non-proprietary presettling BMP effectiveness; a review of the science of basin TSS production and particle settling; and KCWTD and SPU's policies, procedures, and standards for capital projects. The updated guidance will support KCWTD and SPU in focusing their investments in presettling practices that increase water quality performance and reduce overall O&M effort, both by reducing the number of presettling practices installed and by implementing of presettling practices that effectively capture sediment.

Herrera Environmental Consultants, Inc. (Herrera) worked in close coordination with SPU GSI program staff on this effort, led by Masako Lo from August 2020 until her retirement in November 2021 and subsequently by Shasta McKinley. This TM summarizes the work performed and presents the findings and recommendations.

Current Design Guidance

Current guidance for the implementation of presettling for bioretention can be found in:

1. Section 7.5.4 of the KCWTD and SPU's Green Stormwater Infrastructure Manual for Capital Improvement Projects Volume III: Design Phase, dated August 2018 (GSI Manual)
2. Table 5.19 and 5.20 of the City of Seattle (COS) Stormwater Manual, dated July 2021 (COS Stormwater Manual) (see Figure 1 in the *Introduction* section)
3. Standard plans 295x and 299 of the COS Standard Plans for Municipal Construction, 2020 edition (COS Standard Plans)

The current guidance recommends a presettling zone consisting of a roughened concrete pad surrounded by cobbles for larger bioretention systems. See the "Current Guidance" section below for additional detail.

Proposed Design Guidance

The following proposed guidance was developed based on the process described herein. Table ES-1 below is recommended as a replacement to COS Stormwater Manual Tables 5.19 and 5.20 for capital projects.

The revised criteria are simplified and are based on the size and slope of the contributing basin and the amount of Effective Impervious Area (EIA) in the basin, which appear to be the most significant determinants of TSS loading (see the "Anticipated Influent TSS Loading" section for additional detail). The most likely applicable options for presettling upstream of bioretention facilities were evaluated for this analysis and include: Manufactured Treatment Devices (MTDs), lamella plate clarifiers, "fat pipes," and extended sumps. These guidance updates result in the elimination of presettling for bioretention facilities with smaller and flatter basins when compared to the current guidance, while providing best fit options for larger, more impervious, and steeper basins. For these presettling solutions, the guidance recommends designing for settling of an 80-micron particle, typical of sand.

Table ES-1. Proposed Presettling Requirements for Bioretention Facilities on Capital Improvement Projects.

Contributing Basin Size and Slope	Presettling Requirement for Bioretention Facilities
Total Basin Size[a] <1.5 acre **OR** Total Basin Size[a] 1.5–3 acres ***and*** <50% EIA **OR** Total Basin Size[a] 3–6 acres ***and*** <50% EIA ***and*** average basin slope[b] <5 percent	No presettling required.
Total Basin Size[a] 1.5–3 acres ***and*** >50% EIA **OR** Total Basin Size[a] 3–6 acres ***and*** average basin slope[b] >5 percent (***and either*** <=50% EIA or >50% EIA)	Extended Sump required.
Total Basin Size[a] >6 acres	MTD, Extended Sump, or "fat pipe" required.

[a] Total basin size: the total area (pervious and impervious) contributing runoff to a single cell or series of connected cells from both piped inflow and sheet flow from adjacent surfaces. The size of the basin producing the runoff is considered irrespective of any flow splitters that may be in use.

[b] Basin slope: overall slope estimated across an entire city block.

Introduction

Stormwater runoff contains various amounts of sediment, composed of particles of gravel, sand, silt, clay, and fine organic matter, which, in aggregate, can be measured as total suspended solids (TSS). TSS also contains stormwater pollutants of concern that can adhere to the sediment particles. TSS is typically removed from stormwater by simple settling, hydrodynamic settling, or filtration. In addition to TSS, stormwater runoff can contain larger particles of organic matter (e.g., leaves, sticks) and trash. Presettling practices also need to remove this larger material and store it for removal without inhibiting the removal of the TSS.

Presettling and pre-treatment both refer to the removal of TSS from stormwater and are sometimes used interchangeably. In the context of this TM, "pre-treatment" is the removal of TSS from stormwater prior to direct discharge to a surface receiving water or to the groundwater without additional treatment and "presettling" is the removal of TSS from stormwater upstream of another water quality facility (e.g., bioretention) as part of a treatment train. The latter is the focus of this TM.

Bioretention is a green stormwater infrastructure (GSI) Best Management Practice (BMP) consisting of earthen depressions or walled boxes where stormwater runoff is stored as surface ponding before it infiltrates through the underlying bioretention soil media (BSM). Bioretention is typically installed with a top course of mulch for the purpose of trapping TSS and protecting the BSM from being clogged with TSS. The mulch in bioretention facilities can be removed along with the captured sediment and properly disposed of.

Current guidance on presettling has a tiered set of requirements to provide a dedicated presettling zone at the upstream ends of bioretention cells (Figure 1). However, due to constructability and maintainability concerns, KCWTD and SPU are re-evaluating their presettling guidance requirements for bioretention facilities constructed as part of capital improvement projects.

The purpose of this evaluation is to use best available science, design best practices, and a review of built bioretention projects to update the guidance to achieve the following goals:

1. Optimize the implementation of presettling practices for bioretention to support water quality treatment goals considering total cost of ownership (i.e., considering assumed initial capital cost and assumed ongoing operation and maintenance [O&M] costs)
2. Implement presettling to support efficient and effective maintenance to remove sediment.
3. Minimize the risk of constructing projects with inadequate presettling serving basins with much higher-than-expected sediment loading and O&M effort, such was experienced at the Capitol Hill Water Quality Treatment Facility (or "Swale on Yale")
4. Provide clarity to designers on capital projects for how and when to implement presettling practices.

Figure 1. Current Bioretention Presettling Guidance

Table 5.19. Presettling Requirements for Bioretention Facilities in Roadway Projects.

Longitudinal Length of Street (L) or Impervious Area[a] (A) Contributing Runoff to a Single Flow Entrance	Presettling Requirements
Residential Streets	
L ≤ 360 linear feet of gutter OR A ≤ 6,700 square feet of ROW impervious area AND Pollution Generating Impervious Surface < 5,000 square feet	No presettling is required.
360 < L ≤ 660 linear feet of gutter OR 6,700 < A ≤ 12,300 square feet of ROW impervious area OR Pollution Generating Impervious Surface ≥ 5,000 square feet	At a minimum, the bottom of the first 2 feet in length (for a total area of 2.5 square feet) of the upstream bioretention cell (at the flow entrance) shall be designated the presettling zone. This bottom area shall be constructed of a roughened concrete pad surrounded by cobbles per City of Seattle Standard Plan No. 299.
L > 660 linear feet of gutter OR A > 12,300 square feet of ROW impervious area	Presettling requirements are project specific, to be determined by designer and approved by the Director.
Arterial Streets	
L ≤ 360 linear feet of gutter OR A ≤ 9,000 square feet of ROW impervious area	At a minimum, the bottom of the first 2 feet in length (for a total area of 2.5 square feet) of the upstream bioretention cell (at the flow entrance) shall be designated the presettling zone. This bottom area shall be constructed of a roughened concrete pad surrounded by cobbles per City of Seattle Standard Plan No. 299.
360 < L ≤ 660 linear feet of gutter OR 9000 < A ≤ 16,500 square feet of ROW impervious area	The full length of the first cell (in a series), which should have a bottom length of 8–10 feet designated as the presettling zone. At a minimum, the bottom of the first 2 feet in length (for a total area of 5 square feet) of this presettling zone shall have a roughened concrete pad. This initial bottom area should be followed by a porous weir that allows water to be temporarily detained and slowed down, such as a row of boulders set low (a few inches above the bottom of bioretention cell).
L > 600 linear feet of gutter OR A > 16,500 square feet of ROW impervious area	Presettling requirements are project specific, to be determined by designer and approved by the Director.

[a] All ROW impervious area contributing runoff to the facility shall be included (e.g., roadway, sidewalk, driveways). Runoff from ROW pervious surfaces need not be included. Runoff from adjacent non-ROW impervious areas can be considered incidental and need not be included unless assessment of the site determines that the adjacent area that contributes runoff is greater than 10% of the total ROW impervious area.

Table 5.20. Presettling Requirements for Bioretention Facilities in Non-Roadway Projects.

Impervious Area (square feet) Contributing Runoff to a Single Flow Entrance	Presettling Requirements
<5,000	No presettling is required. Designer to determine if site specific presettling is needed based on upstream area conditions.
≥5,000 and <10,000	The bottom of the first 2 to 3 feet of the upstream bioretention cell (at the flow entrance) shall be designated the presettling zone. This bottom area of the cell shall be constructed of cobbles, concrete open celled paving grids, plastic lattices filled with gravel or groundcover vegetation, a roughened concrete pad, or similar material for collection of sediment for maintenance. Alternatively, a catch basin (such as City of Seattle Standard Plan No. 240 or 241) with a minimum 2-foot sump may be used as the presettling zone. Where the pipe (from the catch basin) daylights into the bioretention cell, provide energy dissipation within the cell.
≥10,000	Presettling requirements are project specific, to be determined by designer and approved by the Director.

This proposed guidance achieves these goals by:

- Eliminating the smaller and less effective practices (i.e., presettling pads).
  - This meets goal number 1 by eliminating a practice that is not effective in capturing sediment and is inefficient to maintain because the sediment is distributed in the cell versus held in a structure where it can be easily removed by hydroexcavation. This will reduce the capital costs of the projects and allow those funds to be invested in more effective practices.
- Increasing the size of the larger presettling BMP practices to make them more effective.
  - This supports both goals number 1 and number 2 by maximizing investments in properly sized and more effective presettling BMPs by trapping sediment in a concrete structure where it can be easily removed by hydroexcavation. This also addresses goal number 3 by reducing the risk of undersized presettling BMPs.
- Introducing new non-proprietary presettling practices (fat pipes and extended sumps).
  - This meets goal number 1 by introducing a low-cost and effective presettling practice.
- Discussing a promising emerging presettling technology (lamella plate clarifiers).
  - This meets goals number 1 and number 3 by introducing a new effective BMP that traps sediment well.

Development of Revised Guidance

The following steps describe the flow of the work performed to develop the guidance and achieve the goals listed above. A detailed description of each step is provided in subsequent sections:

1. Review current guidance.
2. Review built GSI projects.
3. Develop stormwater TSS loading and sediment capture design bases.
4. Review presettling BMPs, including Manufactured Treatment Devices (MTDs), lamella plate clarifiers, presettling vaults known as “fat pipes,” and extended sumps.
5. Propose revised design guidance.
6. Test the application of the new design guidance on example projects.

Review Current Guidance

Current guidance on presettling for bioretention from the City of Seattle (COS) Stormwater Manual can be found in Figure 1. The guidance consists of a tiered set of requirements that provide a dedicated presettling zone at the upstream ends of certain bioretention cells. The applicability of these presettling zones is dictated by land use (residential streets versus arterial streets) and contributing area (measured as gutter length or area of pollution generating impervious surface).

Review Built GSI Projects

On April 16, 2021, Chris Webb of Herrera met Masako Lo and Shasta McKinley of SPU in the field to visit six built GSI facilities of various ages and design configurations for the purpose of gaining insight into the need for presettling. Table 1 summarizes the systems visited, their contributing areas, the presettling practice provided. Detailed field notes, observations, and photographs from this site visit can be found in Appendix A of this TM.

Table 1. GSI Facilities observed on April 16, 2021.

Site	Contributing Area Description	Presettling Practice Provided
107th Cascade, meeting at Greenwood Avenue North and 107th Street	First cell receives treated water from east of Greenwood (residential 1.3-acre EIA) and the west half of Greenwood from North 110th to North 107th (0.6-acre EIA).	None
110th Cascade, meeting at Greenwood Avenue North and 110th South	First cell receives west half of Greenwood from North 112th Street to North 110th Street (0.6-acre EIA)	None
Venema NDS Site 1, meeting at North 122nd Street and Palatine Avenue North	One-third of the overall 80-acre contributing area (i.e., about 27 acres)	Presettling zone
Venema NDS Site 2, meeting at North 120th Street and First Avenue Northwest	9.5-acre contributing area	Presettling zone
SDOT 30th Avenue Northeast NDS, meeting at Northeast 135th Street and 30th Avenue Northeast	Contributing area is about 0.35 acre (EIA)	Presettling zone
T117, meeting at Dallas Avenue South and South Donovan Street	0.341 to 0.117 Total Impervious Area (TIA) contributing area to each cell	Presettling splash pad

NDS = Natural Drainage System

Based on these site visits, the team noted the following general observations regarding current presettling practices upstream of bioretention systems:

- There is less sediment accumulation than expected from smaller contributing drainage basins (even in areas of informal drainage).
- While there are some localized areas of sedimentation occurring around piped inflow from larger drainage basins, the overall sediment observed is minimal.

These observations seem to indicate that there is room for improvement in the current bioretention presettling guidance, for both smaller and larger drainage basins.

Develop Presettling Design Basis

Development of presettling design guidance requires an understanding of both the characteristics of the contributing area that affect the influent TSS loading and the TSS removal mechanisms taking place in the presettling BMPs being considered. These two factors will drive the need for, and type of, presettling practices, and are discussed below.

Anticipated Influent TSS Loading

Sediment production in watersheds has been thought to be driven by the following elements: 1) topography (i.e., slope), 2) basin size, 3) land use, 4) ground cover, 5) and channel density (SCS 1985). In this context, channel density is a measurement of the sum of the channel (i.e., the length of stormwater drainage conveyance pipes and ditches) per drainage basin area. Within the urban portions of the city, Herrera expects elements 3, 4 and 5 will be relatively similar between basins (Figure 2) and elements 1 and 2 will vary. Therefore, the revised evaluation criteria are built around basin size, slope, and imperviousness (also known as ground cover and represented by EIA) as the primary drivers of higher mass loading of TSS to stormwater facilities in Seattle.

Land use was considered at first because it is considered in the current guidance (arterial streets versus residential streets). Also, it is common practice in stormwater design to assume higher influent concentrations of a wide range of pollutants of concern in commercial and industrial land uses and from arterial roadways versus residential land use and roadways. However, in the case of presettling, the pollutant on concern is only TSS. Figure 2 below shows the expected TSS concentrations by land use. It is evident from Figure 2 that Residential, Commercial, Open Space, and Vacant land uses have demonstrated similar TSS concentrations. Therefore, land use was not carried forward into the revised guidance because the variability in anticipated concentrations shown was determined to not influence the mass loading of TSS significantly.

While Herrera does expect the TSS loading to be somewhat different for different land use categories, we expect the basin slope, size and imperviousness (EIA) will influence sediment production much more than land use category. Therefore, the basin slope, size and imperviousness are included in the proposed guidance (Table ES-1) as triggers for when presettling is required. Also, the sizing of presettling practices will be based on modeling to calculate water quality flow rate, which also considers EIA, and thus will meet the sediment runoff needs for different land uses. The presettling practices are expected to be implemented more frequently, and be larger, in basins with commercial and industrial land use due to the higher EIA typical in these basins.

Informal drainage (ditch and culvert) was considered next based on an assumption that unpaved alleys and parking strips would lead to more TSS in runoff. However, field observations conducted as part of this study of built SPU GSI facilities (Appendix A) did not show unusually high sedimentation in areas of informal drainage. For example, as shown in Figure 3, the unpaved alley at North 107th Street between First Avenue and Palatine Avenue North has a catch basin draining directly to the swale as part of the

107th Cascade and there is no observable sediment at the outlet into the swale despite it being 4 years since the swale was maintained[1].

Figure 2. Land Use Runoff Concentrations taken from Volume 3 of Seattle's Integrated Plan.

Volume 3 Final Integrated Plan May 29, 2015
Appendix F: Pollutant Reduction Estimation Method—Candidate Stormwater Projects
Chapter 3: Model Input Parameters

Table 3-7. Land Use Runoff Concentrations: Selected Upper and Lower Bounds
(Assumed 95% Confidence Levels on Long-Term Averages)

RCOC	Units	Residential		Commercial		Industrial		Open space		Vacant	
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
BOD_5	mg/L	2.88	11.53	3.39	17.56	2.30	16.82	1.39	3.51	2.88	11.53
Fecal coliform	CFU/100 mL	1,184	30,106	4,068	32,323	2,965	66,589	658	24,406	1,184	30,106
TSS	mg/L	44.51	93.12	58.33	106.28	58.24	176.89	6.86	105.70	44.51	93.12
Oil and grease	mg/L	2.27	5.89	2.87	9.50	2.84	10.07	0.49	2.79	2.27	5.89
[H+]	mg/L	8.97E-05	3.32E-04	6.32E-05	4.62E-04	7.75E-05	1.33E-03	2.65E-05	1.65E-04	8.97E-05	3.32E-04
Total copper	µg/L	9.0	19	21	44	14	39	1.0	16	9.0	19
Dissolved copper	µg/L	3.0	7.0	7.0	16	3.0	10	1.0	5.0	3.0	7.0
Total zinc	µg/L	47	129	124	204	133	258	9.0	45	47	129
Dissolved zinc	µg/L	13	40	44	124	133	258	2.0	25	13	40
Ammonia-N	µg/L	83	151	127	311	184	297	123	229	83	151
TP	µg/L	97	343	93	330	114	383	28	202	97	343
Total PCBs	ng/L	4.226	28.982	4.226	28.982	4.226[a]	28.982[a]	4.226	28.982	4.226	28.982
Total PBDEs	ng/L	1.958	52.218	1.958	52.218	1.958	52.218	1.958	52.218	1.958	52.218
Bis(2-ethylhexyl)phthalate	µg/L	1.154	3.152	3.201	6.644	2.445	3.491	0.632	3.435	1.154	3.152
Dichlobenil	µg/L	0.0532	0.1123	0.0250	0.0581	0.0236	0.0390	0.0000	0.0000	0.0532	0.1123

a. The total PCB concentrations for the industrial areas draining to the Duwamish used higher LCL and UCL (25.63 and 97.56) as described above.

[1] Per email dated 5/18/21 from Masako Lo stating "… 110th Cascade structures were serviced 4 years ago. Vactor removal of sediments."

Figure 3. Photograph of 107th Cascade at Alley Between First Avenue and Palatine Avenue North.

In summary, basin size and slope were selected as the basis of the guidance because they are consistent with both the science of geomorphology and the conditions observed at built projects. This is supported by the higher-than-expected TSS loading at projects like Capitol Hill Water Quality Treatment Facility (or "Swale on Yale"), which have larger, steeper, contributing areas and lower-than-expected TSS loading on projects like 107th Cascade, which have flatter contributing areas with informal drainage and arterial roadways. EIA was included in the guidance because of its influence on the volume of water being managed and thus the mass loading of TSS.

TSS Removal Mechanisms and Development of Target Particle Size

The presettling practices evaluated as part of this effort include proprietary manufactured hydrodynamic treatment devices (e.g., Contech Vortechs and CDS Treatment System, Hydro International Downstream Defender), proprietary manufactured lamella plate treatment devices (e.g., Stormtrap Sitesaver, Terre Hill Terra Kleen) and non-proprietary techniques such as presettling vaults/tanks (sometimes referred to as “fat pipes”), catch basins with extended sumps, and “presettling pads.” Presettling pads are shown as part of the “Presettling Zone” on City of Seattle Standard Plan 299.

To evaluate and compare the performance of these proprietary and non-proprietary practices using a common metric, Herrera performed a literature review to determine a methodology and target particle size for the design of presettling practices. The Minnesota Stormwater Manual includes well-established guidance for sizing pretreatment practices, including filter strips (Minnesota Stormwater Manual 2023).

The guidance in the Minnesota Stormwater Manual is to “settle the larger particles (typically sand, which is greater than 80 µm [microns]) into an easily cleaned location to capture roughly one-half of the suspended solids.” The #200 US Standard Sieve is 75 microns, which is the division between sand and silt/clay in the AASHTO and Unified Soil Classification System (ASTM D 2487).

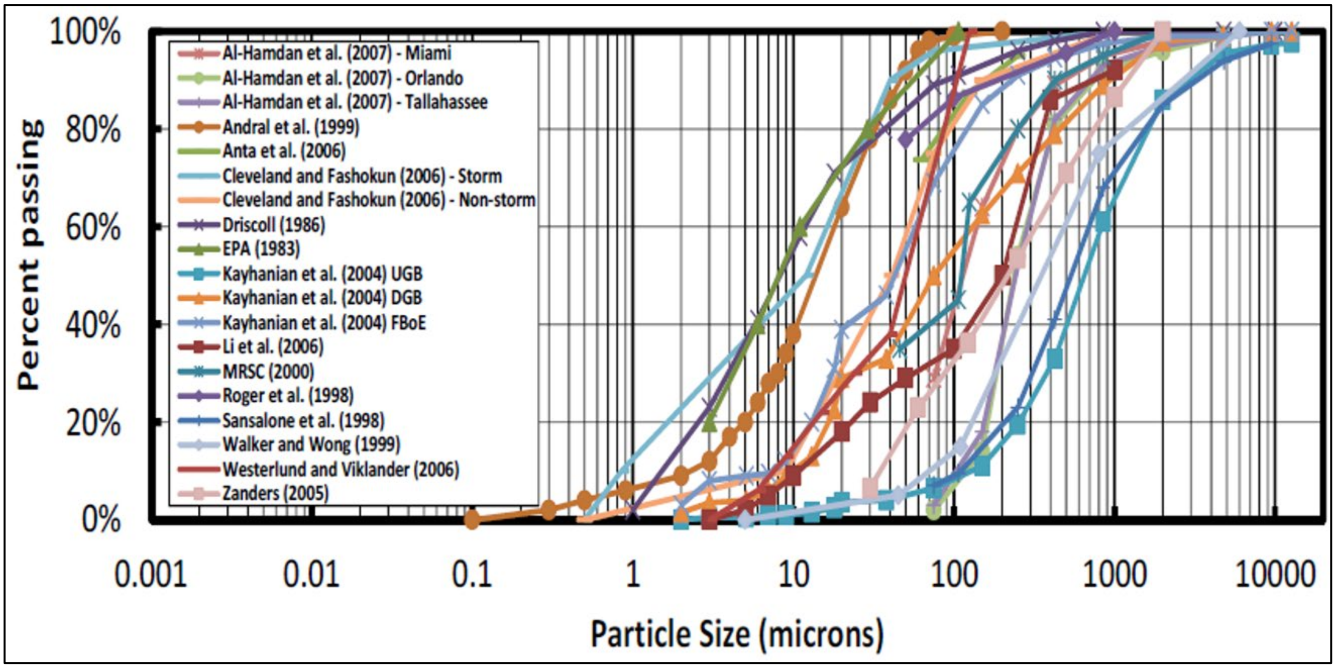
The Minnesota Stormwater Manual approach is based on Stokes Law and the approach and its applicability to stormwater settling was vetted by senior geomorphology staff at Herrera. Table 2 was extracted from the Minnesota Stormwater Manual guidance and shows the settling velocities of various spherical diameter sand and silt particles based on Stokes Law.

Table 2. Settling Velocity of Various Equivalent Spherical Diameter Sand and Silt Particles at 20°C.

Silt and Sand Diameter (µm)	Meters per Second (m/s)	Feet per Second (ft/s)
10	0.000089	0.00029
30	0.00078	0.0026
80	0.0051	0.017
100	0.0075	0.025
150	0.015	0.049
200	0.023	0.075
500	0.071	0.23
1,000	0.13	0.43

Figure 4 (also from the Minnesota Stormwater Manual 2023) shows the range of expected particle size distributions of roadway runoff suspended solids from multiple locations across the country.

Figure 4. Particle Size Distribution of Suspended Solids in Road Stormwater Runoff.
Source: Erickson 2012



Seattle is predominantly underlain by glacial till; consequently, the particle size distribution (PSD) in urban runoff in Seattle tends to be finer than the many locations across the country. For reference, when a treatment system is to be certified by the Department of Ecology through the Technology Assessment Protocol – Ecology (TAPE) process (Ecology 2018), the influent data must have an average particle size (represented by the "d_{50}") of 65 microns or finer to be considered "typical." Cross referencing this value of 65 microns with the 50 percent passing line in Figure 4, the Seattle stormwater PSD is, on average, finer than more than half of the other locations referenced.

It is important to not only consider the PSD in runoff but also the PSD that is settleable by typical means. As a point of reference, Figure 5 shows the range of expected particle size distributions of catch basin sediment from multiple locations in Seattle. The data is from samples collected monthly, from 2006 to 2007, from 70 catch basins located across Seattle as part of the 2012 City of Seattle Street Sweeping for Water Quality Program Effectiveness Report (SPU 2012). The d_{50} of 250 microns in Figure 5 (shown as a red dashed line) is much coarser than the typical d_{50} of the runoff (65 microns) because it is difficult to settle particles much finer than 250 microns in a catch basin, thus there is the need for more advanced pretreatment devices.

Figure 5. Particle Size Distribution of Suspended Solids in Catch Basins in Seattle.
Source: SPU 2012

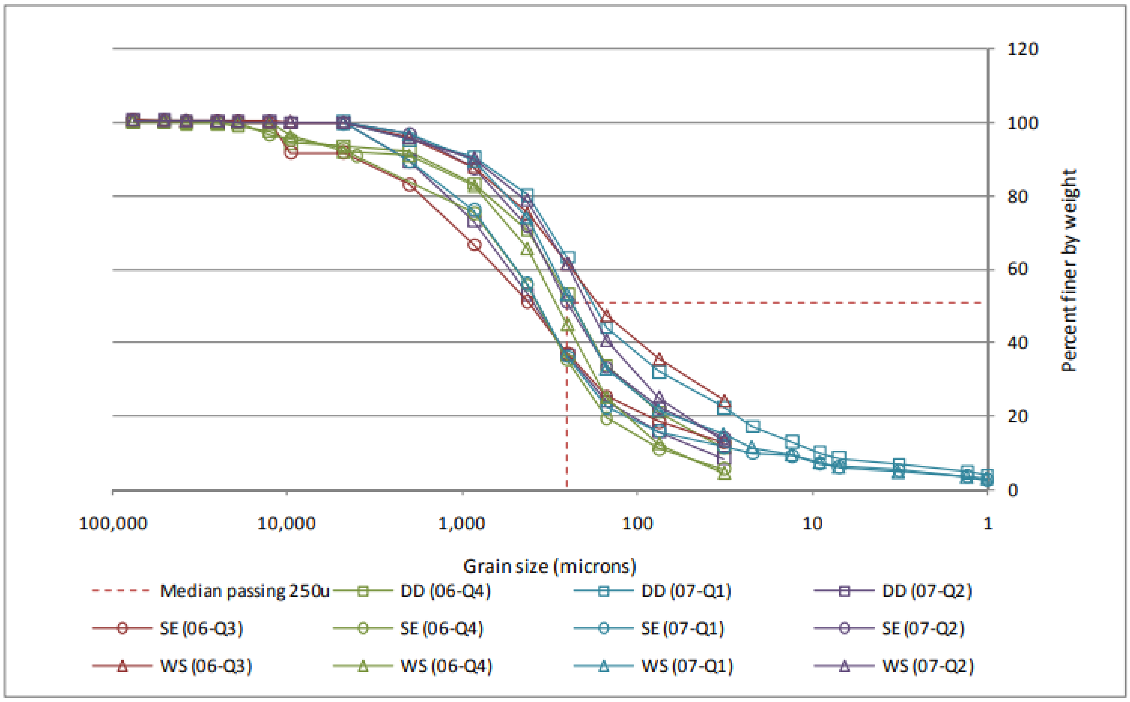


Figure 13. Cumulative particle size distribution for catch basin sediment showing median (51 percent) for percent finer than 250u (n=11).

Herrera also reviewed BMP T6.10 in the 2019 *Stormwater Management Manual for Western Washington* (SWMMWW), which provides design guidance for pre-treatment upstream of a subsurface infiltration BMP. This guidance directs the designer to size presettling basins at 30 percent of the total volume of runoff from the 6-month, 24-hour event, with a 4-foot minimum depth and a 3:1 length-to-width ratio. Berms or baffles may be used to lengthen the flowpath, and inlets and outlets shall be designed to minimize velocity and reduce turbulence, to maximize particle settling opportunities.

The SWMMWW does not provide a target particle size as the basis for its guidance; however, the target particle size can be approximated by applying BMP T6.10 sizing guidance to a prototypical basin and comparing the resulting hydraulic residence time to the predicted settled particle size per Stokes law. For example, a basin consisting of 10,000 square feet (sf) of impervious surface area in Seattle was modeled using an approved continuous simulation hydrologic model. The results were a water quality volume of 1,075 cubic feet (cf) (1.29 inch precipitation depth) and water quality flow rates of 0.032 cubic feet per second (cfs) (online) and 0.018 cfs (offline). Sizing a simple rectangular settling vault per BMP T6.10 results in a vault that is 4 feet (ft) deep x 5.54 ft wide x 16.63 ft long. When the water quality flow rate of 0.032 cfs is applied to this vault, the resulting hydraulic residence time is approximately 3.21 hours, which based on the settling velocity in Table 2 equates to a settled particle size of 10 microns at the water quality flow rate.

However, BMP T6.10 is intended to be implemented primarily as the treatment element of a water quality treatment train, protecting downstream subsurface infiltration facilities for example. Since these below-grade infiltration facilities cannot be easily inspected or maintained, this BMP is likely targeting a higher level of performance than necessary for a presettling practice—particularly those upstream of bioretention, where the primary goal of the presettling practice is to reduce the maintenance burden within the bioretention facility.

Through discussions with SPU GSI program staff based on these data and references, a target particle size of 80 microns was selected for sizing and evaluating presettling practices. The consultant team and SPU GSI program staff felt that this target was supported by some of the only published design guidance on the topic (Minnesota Stormwater Manual 2023), was usefully correlated to the #200 sieve, and appeared to balance the size and cost of the presettling practice with the desired performance. Additionally, the test sediment used in the NJDEP/NJCAT certification process for hydrodynamic separators has a particle size distribution of gradation of 1 to 1,000 microns and a d_{50} of 75 microns, further validating the target particle size here as reasonable.

Review Presettling BMPs

As part of the review of existing presetting BMPs, the following were considered and are described below: Manufactured Treatment Devices (MTDs), lamella plate clarifiers, “fat pipes,” and extended sumps.

Manufactured Treatment Devices

In 2021 Herrera reviewed the manufactured treatment devices (MTD) with TAPE approval for Pretreatment and then developed a short list of selected MTDs for analysis that are relatively low maintenance. This list was based on the technologies available at that time. The completeness of this analysis will evolve as the market continues to evolve. The devices selected for analysis are listed in Table 3 at the end of this subsection. For this analysis Herrera did not evaluate the lamella plate clarifiers because they operate on a different principle. The lamella plate clarifiers are discussed in a subsequent section of this TM.

The MTDs included on the TAPE Pretreatment GULD list include systems that remove sediment using screening and/or settling of particles. A typical Pretreatment MTD provides residence time to allow particles to settle along with enhanced features to optimize settling and/or prevent resuspension during higher flows.

The design flow rates for MTDs are provided in the manufacturers’ literature and are often based on testing of one selected size and design flow rate of each system as part of a regulatory certification process (i.e., New Jersey Corporation for Advanced Technology (NJCAT) and Washington State Technology Assessment Protocol – Ecology (TAPE)). The design flow rates for the other sizes of each system appear to be determined using an extrapolation/estimation process performed by the manufacturers and then endorsed by regulatory agency, typically based on a hydraulic loading rate (gallons per minute per square foot [gpm/sf] of presettling area).

To normalize the performance of these selected MTDs so they can be compared to each other, Herrera reviewed the dimensions and design flow rates for the selected presettling MTDs. To better compare them to other types of BMPs, we evaluated them solely on the settling volume provided (as measured from overflow to top of dedicated sediment storage zone). From the design flow rate and the volume provided, a hydraulic residence time was derived. From the hydraulic residence time and the available settling depth, a particle size that would fully settle was derived. This particle size is reported below as "Particle Size Captured by MTD (micron)" in Table 3.

Next, Herrera derived the hydraulic residence time that would equate to a capture of the 80-micron particle size given the settling depth available. The flow rate that corresponds to this residence time was then derived based on the volume provided in the device. This particle size is reported below as "Design Flow Rate Normalized to 80 microns (cfs)" in Table 3. This design concept is supported using the Peclet Number to assess the performance of standard sumps as BMPs for stormwater treatment (McIntire et al. 2012). In this study, the researchers established that settling of particles in stormwater sumps can be estimated by scaling using the Peclet Number: Pe = (d*h*Vs)/Q where d = horizontal flow dimension in feet, h = vertical flow dimension in feet, Vs = particle settling velocity in ft/s, and Q = flow rate in cfs. For similar performance, the flow rate Q can be scaled based on the relationship between settling velocities for different particle sizes.

As seen in the results in Table 3, the relationship between the design flow rate and the target particle size is highly variable between MTDs and between different models of the same MTD. Additionally, none of the MTDs capture a particle size of 80 microns at their design flow rates; the captured particle size ranges from 122 percent to over 700 percent of the target 80-micron particle size.

Table 3. Adjusted Target Particles and Design Flow Rates for Selected Approved Pretreatment Manufactured Treatment Devices.

Device Name (manufacturer)	Model	Published Design Flow Rate (cfs)	Particle Size Captured by MTD (micron)	Design Flow Rate Normalized to 80 Microns (cfs)
Vortechs System (Contech)	1000	0.55	111	0.31
	2000	1.00	126	0.45
	3000	1.50	136	0.60
	4000	2.20	147	0.79
	5000	3.00	157	0.97
	7000	3.90	162	1.20
	9000	5.00	168	1.46
	11000	6.10	170	1.75
	16000	8.80	173	2.45

Table 3 (continued). Adjusted Target Particles and Design Flow Rates for Selected Approved Pretreatment Manufactured Treatment Devices.

Device Name (manufacturer)	Model	Published Design Flow Rate (cfs)	Particle Size Captured by MTD (micron)	Design Flow Rate Normalized to 80 Microns (cfs)
Downstream Defender (Hydro International)	4 foot	1.30	192	0.31
	6 foot	4.10	259	0.66
	8 foot	9.40	311	1.21
	10 foot	17.70	357	1.93
Stormceptor (Imbrium Systems)	STC 450i	0.32	114	0.17
	STC 900	0.63	108	0.38
	STC 1200	0.63	104	0.40
	STC 1800	0.63	101	0.43
	STC 2400	1.06	98	0.75
	STC 3600	1.06	95	0.78
	STC 4800	1.77	100	1.21
	STC 6000	1.77	99	1.23
	STC 7200	2.47	98	1.75
	STC 11000	3.53	151	1.21
	STC 13000	3.53	150	1.23
	STC 16000	4.95	148	1.75
CDS Stormwater Treatment Systems (Contech)	CDS 2015-4	0.70	127	0.31
	CDS 2015-5	0.70	101	0.47
	CDS 2020-5	1.10	133	0.46
	CDS2025-5	1.60	172	0.45
	CDS3020-6	2.00	155	0.66
	CDS 3030-6	3.00	210	0.64
	CDS 3035-6	3.80	256	0.62
	CDS 4030-8	4.50	207	0.97
	CDS 4040-8	6.00	261	0.96
	CDS 4045-8	7.50	314	0.95
	CDS 5640-10	9.00	219	1.80
	CDS 5653-10	14.00	319	1.74
	CDS 5668-10	19.00	427	1.68
	CDS 5678-10	25.00	567	1.65

Table 3 (continued). Adjusted Target Particles and Design Flow Rates for Selected Approved Pretreatment Manufactured Treatment Devices.

Device Name (manufacturer)	Model	Published Design Flow Rate (cfs)	Particle Size Captured by MTD (micron)	Design Flow Rate Normalized to 80 Microns (cfs)
Nutrient Separating Baffle Box (Oldcastle Infrastructure, Inc.)	NSBB-48	4.60	180	1.22
	NSBB-510	8.03	201	1.80
	NSBB-612	12.70	231	2.37
	NSBB-816	26.00	263	4.11
	NSBB-1020	45.40	274	6.82
	NSBB-1224	71.70	300	9.62

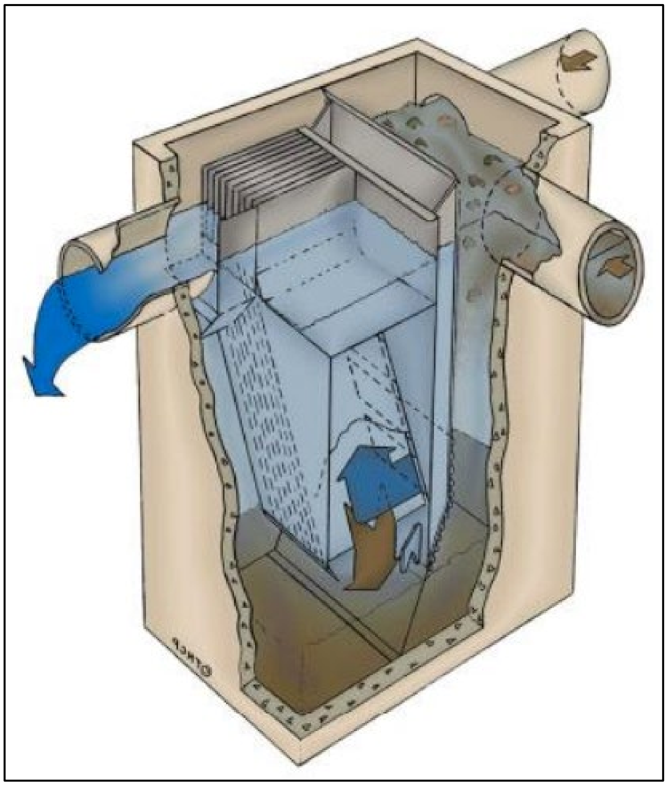
Lamella Plate Clarifiers

Lamella plate clarifiers (also called inclined plate settling devices) consist of a vessel containing a series of inclined plates with the flow passing through the gaps between the plates. The multiple plates effectively create a set of stacked shallow and wide settling chambers. The relatively shallow settling depth allows particles to settle and contact the plate faster than if the plates were not present and the particles had to settle all the way to the bottom of the vessel. Lamella plate clarifiers, therefore, have a relatively high settling surface area within a given footprint. Once the settled solids contact the plates they slough off and are collected in the sediment storage area until they are removed via hydroexcavation for disposal.

Lamella plate clarifiers are common in the industrial wastewater industry and their application in stormwater management is emerging. Herrera reviewed the national stormwater manufactured treatment device market and identified two lamella plate clarifiers currently on the market that are designed specifically for stormwater pretreatment (Terre Kleen and Site Saver). A third lamella plate clarifier was identified, the Ultra Urban Street Inlet (UUSI), which is a lamella plate clarifier manufactured by AEGIS Systems that is specifically designed to be installed upstream of bioretention facilities. There are no known lamella plate clarifiers with a TAPE GULD certification for pre-treatment. Lamella plate clarifiers are summarized here. Additional detail about specific systems can be found in Appendix B.

Lamella plate clarifiers are typically contained within a precast concrete vault. Each stacked overlapping plate is inclined at a specific angle, creating a collection of shallow, wide settling plates. The concrete structure typically has two chambers. The primary chamber captures oil, grease, trash and debris, and coarse sediment. Then the stormwater exits through a screen and enters the inclined plate chamber. The sediment slides on the inclined surfaces to a collection area located below the plates. Often, high flows are bypassed around the inclined surfaces. An example system is shown in Figure 6.

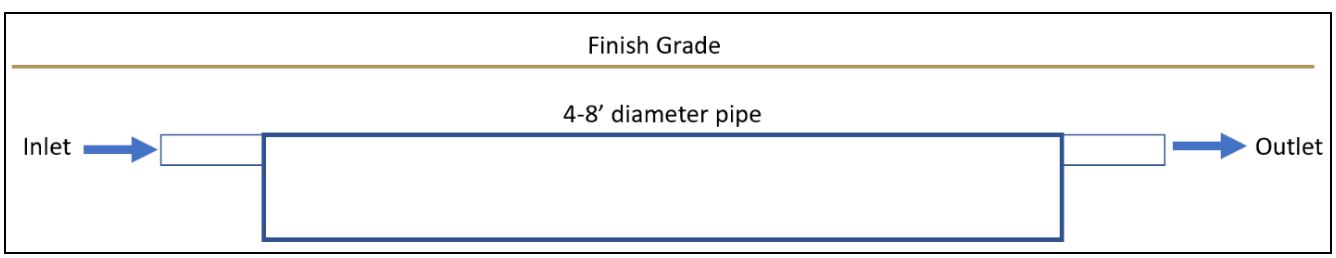
Figure 6. Lamella Plate Clarifier.
Source: Terre Kleen



Presettling Vault/"Fat Pipe"

A presettling vault is a below-grade vault or tank located in-line as part of the upstream conveyance system. The volume provided slows down the water quality flow rate and allows settling to occur. The vaults can be constructed of precast or cast-in-place concrete or can be constructed as a length of oversized pipe with smaller diameter inlet and outlet pipe connections that match at the crowns. This configuration is commonly called a "fat pipe" and is recognized as being a simple and cost-efficient type of presettling vault because the facility utilizes standard materials, and its cylindrical shape is very material efficient. A simplified profile of a fat pipe presettling vault is shown in Figure 7.

Figure 7. Simplified Profile of a "Fat Pipe" Presettling Vault.



BMP T6.10 of the 2019 *Stormwater Management Manual for Western Washington* provides design guidance for presettling vaults and recommends that they have a 3:1 (minimum) length-to-width ratio and a minimum depth of 4 feet. When designing a presettling vault, increasing either the diameter or the length of the fat pipe (while maintaining the minimum length-to-width ratio) improves the settling capability.

To compare the performance of different fat pipe configurations, several small-diameter pipe options were evaluated, each with the lower 12 inches reserved for sediment storage. The resulting cross-sectional areas and volumes were determined and the settling velocities of particles per modified Stokes' Law (Ferguson and Church 2004) were considered.

First, fat pipes of various diameters and a constant length of 10 feet were evaluated for settling 80-micron particles; the results are shown in Table 4. Next, fat pipes of varying lengths and a constant diameter of 4 feet were evaluated for settling 80-micron particles; the results are shown in Table 5. Note that several of the configurations presented in the tables below do not meet the recommended minimum length to diameter ratio but have been included to illustrate how settling performance changes as pipe length and diameter change.

The analysis in Table 4 and Table 5 focuses on smaller-diameter storage pipes. Although larger diameter pipe (such as 6-foot diameter) could provide similar performance, a longer pipe would be recommended to maintain the minimum length to diameter ratio.

Table 4. 10-Foot-Long Fat Pipe Sizing for Various WQ Flow Rates to Settle 80-Micron Particles.

Fat Pipe Diameter (feet)	Design WQ Flow Rate (cfs)
3	0.489
4[a]	0.636
5[a]	0.779

[a] Configuration does not meet the recommended minimum length to width ratio (3:1).

Table 5. 4-Foot-Diameter Fat Pipe Sizing for Various WQ Flow Rates to Settle 80-Micron Particles.

Fat Pipe Length (feet)	Design WQ Flow Rate (cfs)
5[a,b]	0.318
10[a]	0.636
15	0.954
20	1.272
25	1.590

[a] Configuration does not meet the recommended minimum length to width ratio (3:1).

[b] A 5-foot-long fat pipe is shown for informational purposes only; the minimum recommended fat pipe length is 10 feet.

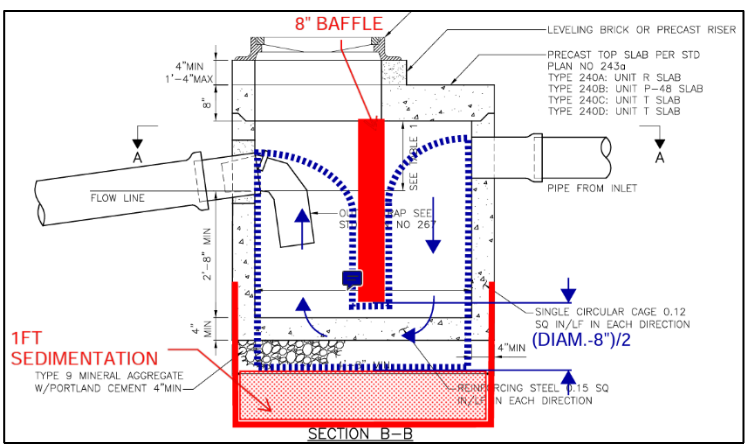
To illustrate the expected sizing of a fat pipe for a 6-acre residential basin, consisting of 25 percent impervious cover, with generally flat topography and underlain by till soils, MGSFlood[2] was used to estimate the water quality flow rate for the subject basin. The resulting online water quality flow rate is 0.2200 cfs. Per the sizing in Table 4 and Table 5, presettling requirements could be satisfied using a 3-foot-diameter, 10-foot-long fat pipe.

Extended Sump with Baffle Presettling BMP

Extended sumps help improve the effectiveness of sediment capture in catch basins or maintenance holes by providing additional volume and residence time by deepening the sump. Given the geometry of these structures, they inherently do not provide the recommended 3:1 length-to-width ratio and therefore are susceptible to short circuiting. To partially mitigate this issue and increase the flow path length from inlet to outlet, Herrera investigated adding a baffle to the structure, as shown conceptually in Figure 8. A proprietary catch basin baffle was also identified as part of the work on this task. More information on the "SAFL Baffle" can be found here: <https://upstreamtechnologies.us/products/safl.shtml>. No further analysis was completed on this technology as to its appropriateness or effectiveness.

Baffles will necessarily inhibit the conveyance capacity of the structure and introduce additional head loss. These losses should be considered during design to verify sufficient conveyance capacity of the proposed drainage system.

Figure 8. Conceptual Section of a Catch Basin/Maintenance Hole with an Extended Sump and a Baffle.



Extended sump manholes with various diameters and an extended sump of 4 feet were evaluated for settling 80-micron particles; the results are shown in Table 6. Note that the configurations presented in the tables below do not meet the recommended minimum length to diameter ratio.

[2] Modeling of subject basin conducted in MGSFlood v 4.58, using the Seattle 38-in MAP precipitation series, a 15-minute time step, and the default IMPLND parameters.

Table 6 shows the water quality design flow rate that would settle an 80-micron particle considering the geometry shown in Figure 8. Due to the small design water quality flow rate capacity of Extended Sumps, these are only expected to be applicable for smaller basins. This analysis assumed a 4-foot extended sump, but project applications may require other configurations.

Table 6. Particle Settling Effectiveness for 4-Foot Extended Sumps to Settle 80-Micron Particles.

Catch Basin Diameter (feet)	Design WQ Flow Rate (cfs)
4	0.2871
5	0.3872
6	0.4986
7	0.6214
8	0.7555

To illustrate the expected sizing of an extended sump for a 6-acre residential basin, consisting of 25 percent impervious cover, with generally flat topography and underlain by till soils, MGSFlood[3] was used to estimate the water quality flow rate for the subject basin. The resulting online water quality flow rate is 0.2200 cfs. Per the sizing in Table 6, presettling requirements could be satisfied using a 4-foot-diameter, 4-foot-deep extended sump.

Revised Guidance Recommendations

The purpose of this effort is to re-evaluate and update design guidance for the use of presettling upstream of bioretention facilities on capital projects. Based on the evaluation of current guidance and the review of built GSI projects, Herrera recommends a tiered set of presettling requirements (Table 7). These requirements are based on the size, land use (via estimates of EIA), and average slope of the basin. As explained above, these characteristics are understood to provide the greatest impact on the amount of stormwater sediment that can be removed by presettling.

With the goal of prioritizing presettling and consolidating maintenance activities, the requirements have been separated into three tiers. The first tier includes small (<1.5 acres) basins (regardless of topography and imperviousness); moderately sized (1.5 to 3 acres), less-impervious basins; and large (3 to 6 acres), less-impervious, flatter basins and recommends no presettling. For these basins, the expected sediment load relative to presettling system size is low. The cost of inclusion and maintenance are not expected to be balanced by the removal of sediment. The second tier includes moderately sized (1.5 to 3 acres), more-impervious basins, and large (3 to 6 acres) basins that are less impervious, but steeper. These basins could benefit from some presettling, such as an extended sump, but are also not expected to have

[3] Modeling of subject basin conducted in MGSFlood v 4.58, using the Seattle 38-in MAP precipitation series, a 15-minute time step, and the default IMPLND parameters.

a significant sediment load. Finally, the third tier includes very large (>6 acres) sites that would most benefit from larger, easily maintained presettling devices.

Table 7. Proposed Presettling Requirements for Bioretention Facilities on Capital Improvement Projects.

Contributing Basin Size and Slope	Presettling Requirement for Bioretention Facilities
Total Basin Size[a] <1.5 acre **OR** Total Basin Size[a] 1.5–3 acres ***and*** <50% EIA **OR** Total Basin Size[a] 3–6 acres ***and*** <50% EIA ***and*** average basin slope[b] <5 percent	No presettling required.
Total Basin Size[a] 1.5–3 acres ***and*** >50% EIA **OR** Total Basin Size[a] 3–6 acres ***and*** average basin slope[b] >5 percent (***and either*** <=50% EIA or >50% EIA)	Extended Sump required.
Total Basin Size[a] >6 acres	MTD, Extended Sump, or "fat pipe" required.

[a] Total basin size: the total area (pervious and impervious) contributing runoff to a single cell or series of connected cells from both piped inflow and sheet flow from adjacent surfaces. The size of the basin producing the runoff is considered irrespective of any flow splitters that may be in use.

[b] Basin slope: overall slope estimated across an entire city block.

To optimize maintenance and longevity of presettling practices, Herrera recommends designing for the removal of a typical 80-micron sand particle by settling during the residence time available for the appropriate (online or offline) water quality flow rate.

This proposed guidance should result in presettling practices that increase water quality performance and reduce overall O&M effort, both by reducing the number of presettling practices installed and by implementing presettling practices that effectively capture sediment.

Applying the Guidance

Table 8 illustrates how and when the new presettling guidance applies to bioretention capital projects and provides some example presettling approaches for different project scales. For various basin sizes and EIA values (assuming 25 percent impervious area), the online water quality flow rate was calculated and presettling options were sized according to the guidance in Table 7. These examples are summarized in Table 8.

The approaches shown are not intended to be recommendations but rather to represent some of the available options. MTDs were sized according to Table 3. In addition to those listed in Table 3, any of the approved (TAPE GULD for Pretreatment) MTDs may be used if feasible and sized appropriately.

"Fat Pipe" options were sized according to Table 4 and Table 5. Extended Sumps were sized according to Table 6. If your site constraints make these infeasible, then re-evaluate.

For reference, a "typical" residential block within the City of Seattle is 5 acres (measured from right-of-way centerline to right-of-way centerline of adjacent streets (i.e., 660 ft by 330 ft rectangular block). Based on past SPU Natural Drainage System (NDS) projects, EIA in this residential setting is typically 15 to 25 percent of the total basin area. According to Table 7, no presettling would be required for this scenario. However, as basin area and imperviousness increases, presettling needs change.

SPU requested that Herrera test the implications of the new guidance by applying it to two current SPU Natural Drainage Systems (NDS) projects: Broadview NDS and Thornton South NDS. See Appendix C for this analysis.

Table 8. Examples of Applying Guidance.

Total Basin Size (acres)	EIA[a] (acres)	Water Quality Flow Rate (cfs)	Example Presettling Approach	Example Presettling Sizing
6	1.5	0.22	No Presettling Required	N/A
12	3	0.44	Presettling Vault/"Fat Pipe"	4-foot-diameter pipe, 10 LF (minimum size, 7 LF required)
			Extended Sumps	Two 4-foot-diameter structures with 3-foot sump (one per block) OR One 6-foot diameter structure with 4-foot sump for larger single basin
			MTD	Vortechs 2000
			MTD	6-foot Downstream Defender
			MTD	CDS 2015-5
			MTD	STC 2400
18	4.5	0.66	Presettling Vault/"Fat Pipe"	4-foot-diameter pipe, 10.5 LF
			MTD	Vortechs 2000
			MTD	6-foot Downstream Defender
			MTD	CDS 2015-5
			MTD	STC 2400
24	6	0.88	Presettling Vault/"Fat Pipe"	4-foot-diameter pipe, 14 LF
			MTD	Vortechs 2000
			MTD	6-foot Downstream Defender
			MTD	CDS 2015-5
			MTD	STC 2400

Table 8 (continued). Examples of Applying Guidance.

Total Basin Size (acres)	EIA[a] (acres)	Water Quality Flow Rate (cfs)	Presettling Practice Options	Recommended Size
30	7.5	1.10	Presettling Vault/"Fat Pipe"	4-foot-diameter pipe, 17.5 LF
			MTD	Vortechs 7000
			MTD	Vortechs 2000
			MTD	6-foot Downstream Defender
			MTD	CDS 2015-5
			MTD	STC 2400
36	9	1.32	Presettling Vault/"Fat Pipe"	4-foot-diameter pipe, 21 LF
			MTD	Vortechs 9000
			MTD	10-foot Downstream Defender
			MTD	CDS 5640-10
			MTD	STC 7200
			MTD	Terre Kleen TK45
42	10.5	1.54	Presettling Vault/"Fat Pipe"	4-foot-diameter pipe, 24.5 LF
			MTD	Vortechs 11000
			MTD	10-foot Downstream Defender
			MTD	CDS 5640-10
			MTD	STC 7200
			MTD	Terre Kleen TK45
48	12	1.76	Presettling Vault/"Fat Pipe"	4-foot-diameter pipe, 28 LF
			MTD	Nutrient Separating Baffle Box NSBB-510
			MTD	Vortechs 11000
			MTD	10-foot Downstream Defender
			MTD	CDS 5640-10
			MTD	Terre Kleen TK54
			MTD	Nutrient Separating Baffle Box NSBB-510
54	13.5	1.98	Presettling Vault/"Fat Pipe"	4-foot-diameter pipe, 31.5 LF 5-foot-diameter pipe, 25.5 LF
			MTD	Vortechs 16000
60	15	2.20	Presettling Vault/"Fat Pipe"	4-foot-diameter pipe, 35 LF 5-foot-diameter pipe, 28.5 LF
			MTD	Nutrient Separating Baffle Box NSBB-612

LF = linear feet

[a] This table assumes 25 percent EIA factor based on NDS projects.

Additional Considerations

Each basin and site are unique and require consideration of many factors to select an appropriate presettling practice for a project. This complexity defies a simplified selection approach. Some of the factors that should be considered include:

1. Proper sizing of presettling practices should be based on accurate basin delineations and modeling efforts. For larger systems, model calibration via flow monitoring should be considered to improve the accuracy of predicted flows. For Manufactured Treatment Devices, the sizing should also be based on the Peclet number of the unit (which considers depth) and not necessarily based on the manufacturer's stated design flows, which are typically based on the application of a hydraulic loading rate on the horizontal surface area of the unit.
2. The geometry of the site and the flowline of the drainage network will drive the selection of the presettling practice. In the urban environment, the site grades, flowline of the upstream and downstream drainage network, available space at the surface, and available space among other below-grade utilities will drive the feasibility, geometry, and size of presettling practices.
3. Design should consider the operations and maintenance requirements and effort of selected presettling practices. The practice needs to be accessible for maintenance, including:
    a. Providing access for maintenance equipment and personnel without excessive obstacles requiring removal or navigation,
    b. Limiting/not requiring specialized tools or non-standard maintenance procedures,
    c. Considerations for maintenance equipment reach length (i.e., hydroexcavation vehicle), and
    d. Traffic control requirements (i.e., design so not burdensome to accommodate the maintenance).

    The sediment storage volume in the unit should be sufficient to limit the maintenance frequency to once-yearly visits.
4. The "total cost of ownership" should be considered by balancing the capital costs with maintenance effort. One of the purposes of adding a presettling practice is to transfer the location of capture for stormwater sediment from the bioretention facility to an upstream structure. The intent of that is that it more efficient to remove sediment via hydroexcavation from a structure than to replace mulch by hand in a bioretention cell. Thus, the cost of the selected practice should consider the avoided maintenance effort in the cells versus the effort of maintaining the presettling practice.

Each class of presettling practice has benefits and drawbacks that should be considered in the project planning phase to inform selection of an appropriate presettling practice. Table 9 summarizes the benefits and drawbacks for each class of practice.

Table 9. Practice Benefits and Drawbacks

Practice	Benefits	Drawbacks
Manufactured Treatment Devices (MTDs)	Small footprint; internal baffles, and other components to accelerate settling effectiveness within the volume provided; sediment storage zone less prone to scour and resuspension	Cost; "standard" design flow rates may target larger particles
Lamella Plate Clarifiers	Small footprint	Cost; little performance data available; not commonly used in stormwater settings
"Fat Pipes"	Cost; many shapes and sizes available in concrete vaults or pipes; L:W aspect ratio can be favorable	Needs to be placed flat; if it is a typical fat pipe, it can have a large footprint and utility conflicts
Extended Sumps	Cost; small footprint	Without a baffle prone to short circuiting, shape of the settling zone has a poor L:W aspect ratio; sediment storage is more prone to scour and resuspension

Next Steps

The following next steps have been identified to further advance this work:

1. Develop a standard detail for the fat pipe and extended sumps including a simple sizing table for each.
2. Refine the guidance for the sizing of MTDs and finalize a sizing approach, which could be based on the Peclet number.
3. Pilot the use of an extended sump with and without a baffle on an NDS project.
4. Monitor installed presettling BMPs including fat pipes and extended sumps for TSS removal effectiveness, maintenance needs, and sedimentation of the downstream BMP.
5. Additional research and analysis to support possible inclusion of this guidance in the GSI manual or the Stormwater Code (more broadly applying this guidance to non-capital projects).
6. Additional analysis on flow-splitting methods and how the use of flow splitters should be considered in the trigger for and design of presettling practices.

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Appendix A:
Site Visit Field Notes

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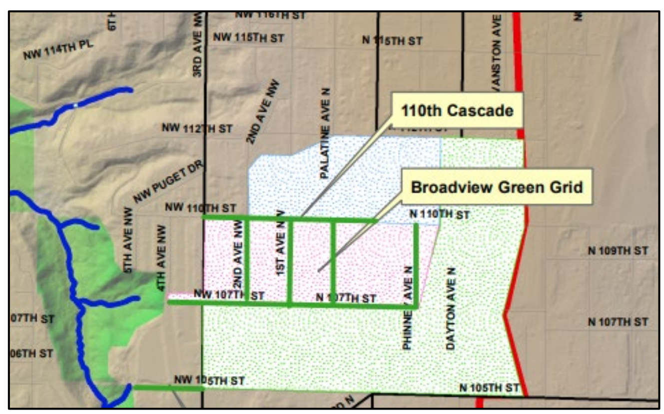
Presettling Site Visit Field Notes and Observations

On April 16, 2021, Chris Webb, PE, of Herrera (consultant to GSI program) met Masako Lo, PE (Design Engineer) and Shasta McKinley, PE (Line of Business Representative from GSI Program) of SPU in the field to visit six built GSI facilities of various ages and design configurations for the purpose of gaining insight into the need for presettling/pre-treatment. This insight will be used to further develop the guidance that is being developed for SPU on presettling/pre-treatment.

The following table summarizes the systems evaluated, their Contributing areas, and how they would be considered in the current and future guidance.

Site	Basin Information	Guidance
107th Cascade	1.3 acres EIA Residential plus 0.6 EIA of arterial ROW enter the first cell. Unpaved alleys with informal drainage and paved streets with infiltrating bioretention contribute along.	Tier 2
110th Cascade	First cell receives west half of Greenwood from North 112th Street to North 110th Street (0.6-acre EIA)	Tier 2
Venema Site 1 122nd	One-third of 80-acre catchment	Tier 4
Venema Site 2 120th	9.5-acre catchment gets here	Tier 3
SDOT 30th Avenue NDS	Catchment area EIA is about 0.35 acre.	Tier 1c
T117	0.341 to 0.117 TIA to each cell	Tier 1b and 1c

Site 1: 107th Cascade



- Walked the Cascades on North 107th Street from Greenwood Avenue North down to second avenue Northwest.
- This project was constructed around 2003 as part of the Broadview Green Grid Project and reconstructed four north/south streets (Phinney, Palatine, First, and Second) for one block north of 107th with bioretention. The project replaced a ditch and culvert system that was prone to local flooding.
- The cells were built with aggregate mulch, bioretention soil consisting of 2/3 native soil and 1/3 compost and do not have underdrains. The cells were designed with flat bottoms, 2:1 side slopes, and 6 inches of ponding below the bottom of the weir notch.
- The first cell below/west of Greenwood Avenue North receives treated flows 1.3 acres of EIA from the residential area east of Greenwood Avenue North and the west half of Greenwood Avenue North between 107th and 100th, which is another 0.6 acre of EIA.

- It is unknown when these facilities were last maintained by SPU. A conservation crew was working in the area and reported that they had visited some of these facilities and placed newly observed mulch. They were actively working at the Venema facility.

Observations

- In general, the cells are sparsely vegetated on the cell bottoms and intermittently heavily vegetated on the sides with 6- to 10-foot tall woody plants.
- The first cell below/west of Greenwood Avenue North appears to have a lot of energy entering the cell and sediment is present. Geomorphic processes appear to be at play; the cell bottom no longer appears flat; and the upper cells no longer have the full 6 inches of ponding in the design.

Figure A-1. Entrance to First Cell Below Greenwood Avenue North on 107th Cascade.

- As we approached the end of the first block the cells appeared visibly cleaner with less obvious sediment present.
- The lower cells appear to provide more of the design ponding depth though it appears to be less than the full 6 inches.
- As we walked down the cascades, evidence of geomorphic processes and high energy flows were present including scour holes at the base of the weirs.
- The character of the soil present on the cell bottom was inconclusive as to its origin; however, a few inches of it appeared to be covering some of the original rock mulch variously throughout the cells.
- The alleys that drain to the 107th Cascade are unpaved and have informal drainage.

Figure A-2. Last Cell of First Block Below Greenwood Avenue North on 107th Cascade.

Figure A-3. Unpaved Alleys along 107th Cascade.

Figure A-4. Scour Hole Below Weir Exposing Aggregate Mulch on 107th Cascade.

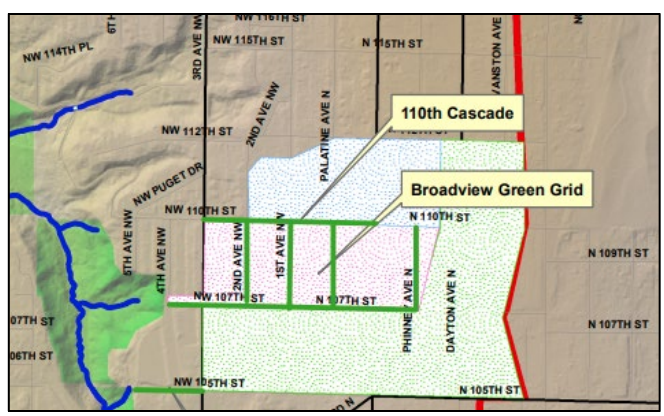
Significant sediment deposition was not typically observed in the first cell below the unpaved alley suggesting it is not being introduced or its being flushed during higher flow events.

- The team walked north up Second Avenue and observed the cells to be very clean and in good condition. O&M staff stated that they have never observed water in these swales.

Figure A-5. Cell Along Second Avenue.

Site 2: 110th Cascade

- Walked the 110th Cascade up from Second Avenue back up to Greenwood Avenue North.
- The project was completed around 2003 and was limited to 110th between Third Avenue and Greenwood Avenue North.



- The cells were built with approximately 3 inches of ponding from the bottom of the swale to the invert of the low flow orifice and another 9 inches to the high flow notch.
- The original design includes 96-inch structures with concrete bases throughout for sediment capture. The retaining walls consist of "soil bags" wrapped with a nonwoven geosynthetic mat and geogrid forming the of the retaining wall. These walls are mostly free of vegetation.

- The construction of these cells did not include any improvements to the north/south streets or alleys. The alleys are unpaved and have informal drainage and the north/south streets are paved but have informal drainage.
- The cells were constructed with 3 inches of aggregate mulch over 12 inches of swale soil mix consisting of 2/3 native soil and 1/3 compost and do not have underdrains.
- It is unknown when these facilities were last maintained by SPU. A conservation crew was working in the area and reported that they had visited some of these facilities and placed newly observed mulch.

Observations

- In general, the cells are sparsely vegetated on the cell bottoms and intermittently heavily vegetated on the sides with 6- to 10-foot tall woody plants.
- Some scour holes were observed near the outlets of some of the 96-inch sedimentation structures. The scour holes exposed the cobbles and other aggregate placed below the outlet. The scouring appears to be occurring in some accumulated sediment.
- Other 96-inch sedimentation structures are relatively free of any accumulated sediment and evidence of scouring.
- Flow monitoring equipment installed as part of the original design in the first cell below Greenwood Avenue North appeared still to be in place. This cell was also the site where the team discussed some testing for the presence of accumulated sediment and assessing any impact that may be having on the infiltration rate of the swale soil.

Figure A-6. Some Accumulated Sediment and Scouring near an Inlet on 110th Cascade.

Figure A-7. Relatively Clean Inlet Area on 110th Cascade.

Figure A-8. Remnant Monitoring Equipment Enclosure Between Greenwood Avenue North and Palatine Avenue North Along 110th Cascade.

Sites 3 and 4: Venema NDS Sites at North 120th and North 122nd Avenues

Figure A-9. Typical Venema Cell.

- Plans were not provided for these sites.
- SPU staff stated the system at North 120th Street is preceded by a grassy pre-sedimentation basin that was originally designed as an early bioretention cell in collaboration with Dr. Richard Horner of the University of Washington in the mid/late 1990s.
- SPU staff states that more flows appear to be developing at the North 120th Street facilities.
- SPU staff stated that these facilities may be oversized as they do not believe the receive the designed flows due to a disconnected upstream conveyance system.
- The cells receive piped inflow, have vegetated sloped sides, perpendicular concrete weir walls, and some parallel vertical walls near the inlet.
- The inlets have energy dissipating cobbles and small boulders.
- The cell outlets were via catch basin structures with domed beehive type grates with high open area to allow high flows to pass. Each structure had a +/- 1-inch notch weir cut through the frame, grate, and part of the exposed structure.

Observations

- In general, the cells were thickly vegetated with low growing ground covers and small shrubs on both the sidewalls and the cell bottoms.
- In general, the cells were free of observable sediment except at just a few of the inlets.
- The inlet with the most sediment is shown below, and the captured sediment appears to be primarily sand.
- Evidence of higher velocity flows were observed near the inlets.

Figure A-10. Typical Overflow Structure and Notch.

Figure A-11. Typical Inlet with Relatively Little Accumulated Sediment.

Figure A-12. Inlet with the Most Accumulated Sediment (sediment appears to be primarily sand).

Site 5: SDOT 30th Avenue Northeast NDS near Northeast 135th Street and 30th Avenue Northeast

- These cells were built as part of a safe route to school project.
- Only the first cell triggered presettling with a catchment area of about 0.35 acre of EIA.
- The cells receive some piped flow at the north end receive sheet flow from one-half of 30th Avenue Northeast.

Observations

- In general, the cells were thickly vegetated with low-growing ground covers and small shrubs on both the sidewalls.
- The only observable sediment was at the termination of the curb at the north at the Northeast 135th and 10th Avenue Northeast intersection at the road edge. There was no observable sediment at the pipe outlet.

Figure A-13. Cell Inlet at Northeast 135th and 30th Avenue Northeast.

Figure A-14. Observable Sediment at Road Edge.

Site 6: Terminal 117

- These cells were designed in 2015 and built in 2017 as part of a larger cleanup of contaminated soils in and around Terminal 117.
- There are some instances of piped inflow, but most of the inflow is via a curb drain opening and concrete spillway. The concrete spillway is located at the cell bottom and is designed for presettling. Each presettling pad is also provided with 2-inch weep holes so they can drain out. O&M staff stated that these weep holes clogged quickly. The O&M staff will try and rod them out when they can, and they appear to remain partially functional even when appearing clogged.
- The cells are unlined and are provided with an underdrain.

Observations

- In general, the cells were sparse to moderately vegetated with low growing ground covers and small shrubs on both the sidewalls.
- The only observable sediment was in the gutter line outside of the cell and a trace amount in the concrete presettling cell.

Figure A-15. Typical T117 Presettling Cell with Trace Sediment.

Figure A-16. Typical T117 Bioretention Cell.

Figure A-17. Typical T117 Presettling Cell.

Figure A-18. T117 Inlet with Sediment via Google Street View (August 2019).

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Appendix B:
Lamella Plate Clarifier Details

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Lamella Plate Clarifier Details

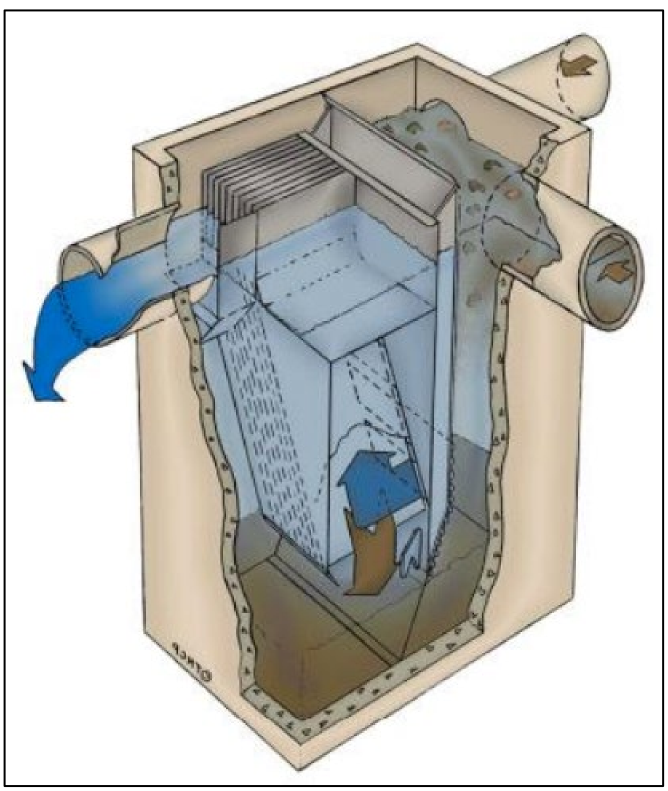
Three lamella plate clarifiers were evaluated and are summarized below.

Terre Kleen (not yet available in Washington as of 2022)

Herrera contacted the manufacturer of Terre Kleen and was told that all the current installations are in the New Jersey and Pennsylvania areas and that the device is not available in Washington State. It is being included herein for completeness and in case it becomes available in the future.

The Terre Kleen™ is a NJCAT verified stacked inclined plate hydrodynamic separator used for treatment or pre-treatment of stormwater runoff <https://www.terrehill.com/stormwater/terre-kleen> (see Figure B-1). The Terre Kleen™ separator is contained within a HS-25 precast concrete structure. Each stacked overlapping plate is inclined 55 degrees, creating a settling cell containing 6.4 SF of horizontally projected sedimentation surface area. The precast concrete structure has two chambers. The primary chamber captures oil, grease, trash and debris, and coarse sediment. The stormwater exits through a screen and enters the inclined plate chamber. The sediment slides on the inclined surfaces to a collection area located below the plates. The Terre Kleen is installed on-line with flows greater than the water quality flow rate bypassed. The unit is available in seven sizes with design flow rates from 9.4 cfs to 66.4 cfs.

Figure B-1. Terre Kleen Lamella Plate Clarifier.

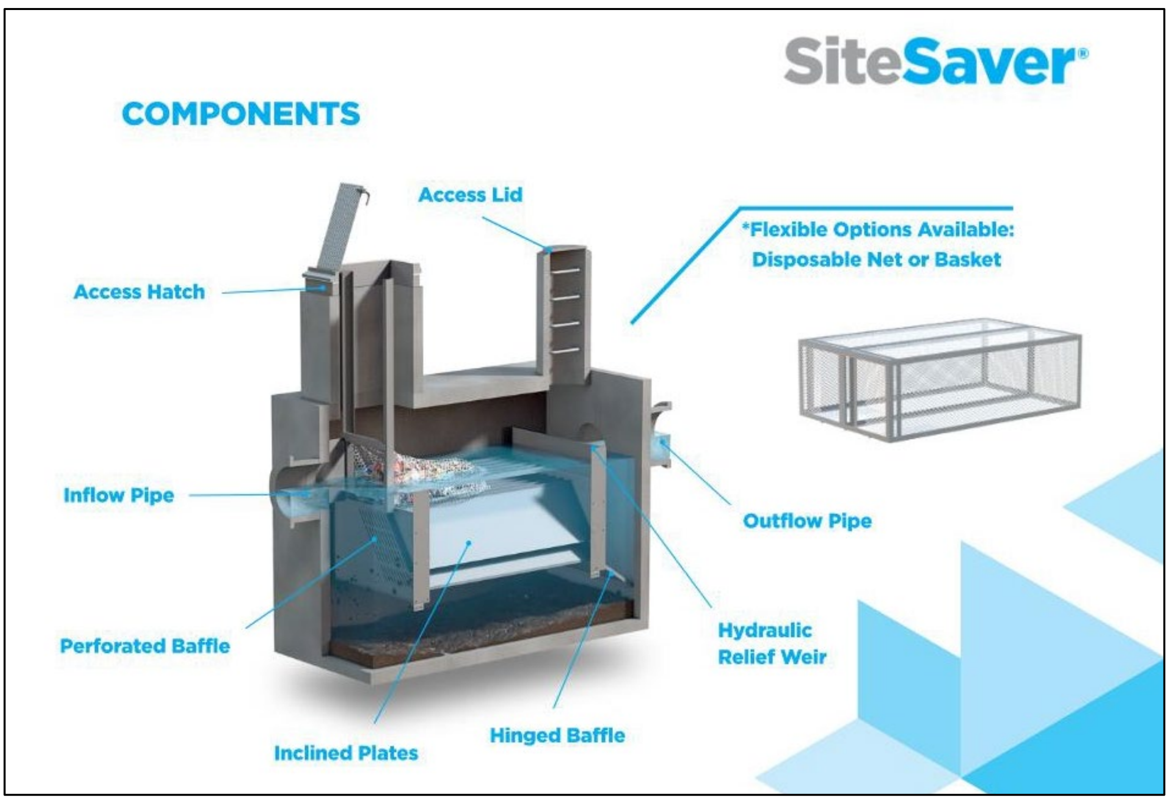


SiteSaver

The SiteSaver is a NJCAT verified lamella plate clarifier with piped inflow and outflow; see Figure B-2 and the product website: <https://stormtrap.com/products/sitesaver/> and the NJCAT report: <http://www.njcat.org/uploads/newDocs/SiteSaverSS8TerchnologyVerificationFinal.pdf>. When water first enters the device, any floating debris is trapped in a net/basket and floating oils are trapped on the inlet side of the hydraulic relief weir. Stormwater is then conveyed through the lamella plate assembly where sediment is settled and sloughs into the sediment storage area. Finally, the water travels through a perforated baffle to the outlet pipe. During peak events the hydraulic relief weir acts as a high flow bypass. To reduce resuspension of settled solids, the sediment storage zone is covered with a hinged baffle below the hydraulic relief weir.

According to email correspondence with the manufacturer, this unit comes in one size of vault that is 14 feet 8.5 inches long and 6 feet 10 inches wide. The overall depth of this vault is typically 11 feet 2 inches; however, he stated the depth can be variable if the trash netting system is removed. He further stated that the depth of the vault is determined as 7 feet 2 inches for the base section plus an inlet pipe diameter height (OD) plus 8 inches (minimum) to accommodate the top slab. The minimum or maximum flow rates for the unit were not provided but it was understood that additional flow rates are accommodated by adding more plates internally to the standard vault.

Figure B-2. SiteSaver Lamella Plate Clarifier.



Ultra Urban Street Inlet

The Ultra Urban Street Inlet (UUSI) is lamella plate clarifier manufactured by AEGIS Systems that is specifically designed to be installed upstream of bioretention facilities receiving flows from the gutter line and discharging to the bioretention cell via sheet flow. The UUSI provides a screening area to remove floatable debris larger than 5 mm, followed by a hydrocarbon capture area with oil absorbent socks, followed by a lamella plate assembly with overall configuration designed to target the 50-micron particle.

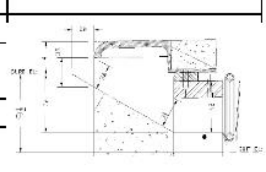
AEGIS systems is currently in the start-up phase and as such there is no website for the product or the company and just a few of the devices have been installed in the New Jersey and Pennsylvania areas. The company is run by Gregory Duncan who is a licensed engineer and can be emailed at greg@aegis-ep.com or via telephone at 484-268-2687.

Figure B-3 below is a data table provided by the manufacturer with information about the UUSI unit and Figure B-4 is a rendering of the UUSI unit.

Figure B-3. Ultra Urban Stormwater Inlet Data Table.

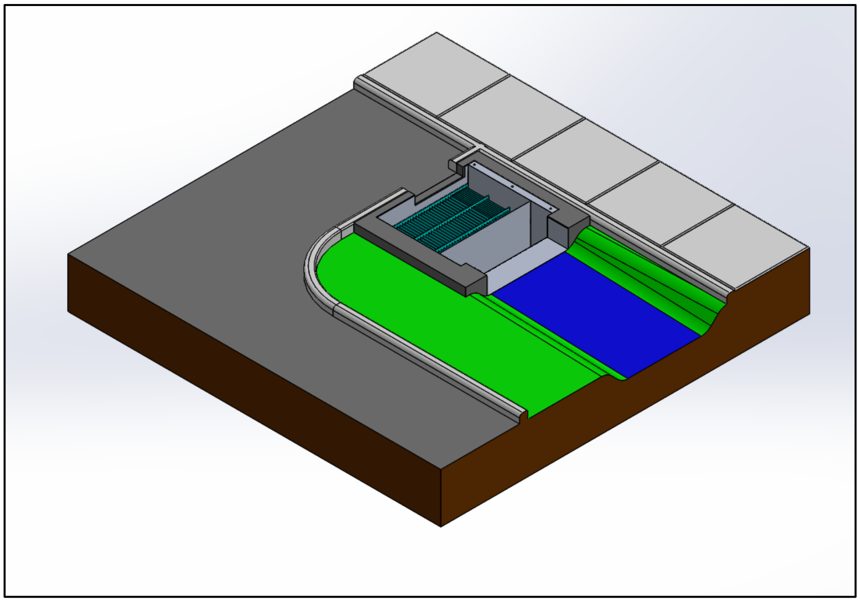
October 6, 2017

Item	Description (UUSI-DBS-FL, FR, LR, RL) *	Value	Foot print
1	Interior dimensions concrete: Vertical Height (Aluminum) Width (Aluminum) Depth (Aluminum)	42" x 48" 68 ⅜" 46 ¾" 44 ⅞ (box is 41 ⅞)	14 Ft^2
2	Material	Aluminum Alloy 5052	
3	Weld technique	TIG	
4	Material thickness	⅛"	
5	Weight without water	400 lbs.	
6	Passive water volume to overflow height	206 gallons	
7	Sediment storage volume	10.45 Ft^3 = 78 gallons	
8	Passive oil bulk storage (Requires spill response to remove)	16 gallons	
9	Effective Self-cleaning Sedimentation Area	43.35 Ft^2	300% of footprint
10	Effective netting area	19.27 Ft^2	1900% of inflow opening
11	Opening size of net orifices	5 mm or 3/16"	
12	Net frame opening	24" by 6"	1 Ft^2
13	Net volume	4.46 Ft^3 or 33 gallons	
14	Estimated weight of filled net	150 lbs. or less.	
15	Number of oil sorption socks	2	
16	Sorption capacity of oil sheen for each sock	¼ gallon	
17	Internal dimension of cleanout tube	6 inches.	
18	Depth from cleanout tube to bottom	68"	
19	Capacity at SOR 11 gpm/ft^2	1 cfs	
20	Net flow capacity (Theoretical)	5 cfs	
21	Serial number: Year-number-Front Left flow-net opening in mm-2 soaker socks.	17-000001-FL-5-2.	
22	Vertical drop from curb line to exit elevation	9.5 Inches.	



*FL= Front Left; FR=Front Right; LR=Left Right; RL=Right left.
UUSI= Ultra Urban Street Inlet. Patented product.
DBS= Diversion Bypass Structure

Figure B-4. Ultra Urban Stormwater Inlet Rendering.



Appendix C:
Test Applications of New Guidance

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Test Applications of Revised Guidance

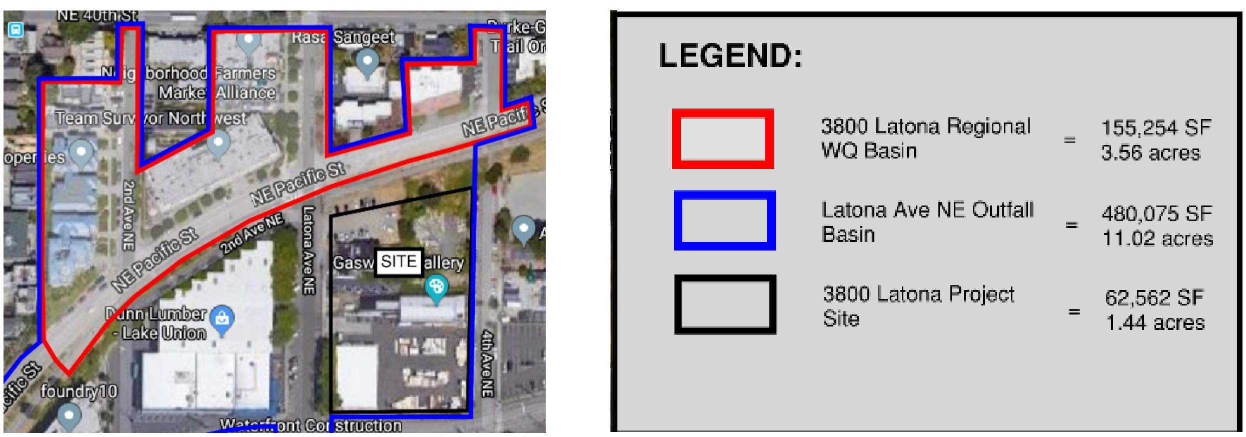
SPU requested that Herrera test the implications of the new guidance by applying it to two current SPU Natural Drainage Systems (NDS) projects: Broadview NDS and Thornton South NDS. Additionally, presettling requirements were evaluated for the 3800 Latona Avenue Northeast partnering/beyond code project.

3800 Latona Avenue Northeast

Site Summary

The 3800 Latona Avenue Northeast project (SDCI# 3034466-EG) is a development within the drainage basin for the Latona Avenue Northeast outfall, which includes both private property and public SDOT right-of-way. The project proposed a regional water quality stormwater facility in lieu of the onsite stormwater management (OSM) requirements, as this approach was determined to provide greater environmental benefits to Seattle waterways than OSM BMPs. Figure C-1 shows the project's drainage basin map and contributing areas.

Figure C-1. 3800 Latona Drainage Basin Map.



The proposed regional water quality facility consists of an offline biofiltration swale that treats runoff from arterial roads north of the project site. The project currently proposes to install the Vortechs System 1000 by Contech for pretreatment upstream of the biofiltration swale and downstream of a flow splitter. Figure C-2 provides a rendering of the proposed site development with a schematic of the water quality system.

Figure C-2. Graphic of the Proposed Regional Stormwater Facility for 3800 Latona.

Apply Proposed Thresholds for Presettling

Under both the proposed and existing presettling guidance, the bioretention facility would require a presettling BMP. See Table C-1 for the contributing area characteristics and relevant presettling thresholds met by the project.

Table C-1. Current and Proposed Presettling Triggers for 3800 Latona's Regional Bioretention Facility.	
Contributing Area Characteristics	
Road Classification	Arterial
Total Basin Size (acre)	3.56
EIA (acre)	3.03
EIA (square feet [SF])	131,987
EIA in ROW (SF)	53,000
Basin Slope	3.92 percent
Presettling Requirements	
Current Guidance	Yes – Arterial ROW impervious area is >16,500 SF
Proposed Guidance	Yes – Contributing area is >3 acres

Size Presettling BMP Under Proposed Guidance

Both a presettling vault and a pretreatment MTD were sized for comparison under the existing and proposed presettling guidance for the regional biofiltration swale. Table C-2 summarizes the runoff data for the contributing basin and the resulting design for each of the presettling devices.

Table C-2. Presettling Device Sizing for 3800 Latona Under Current and Proposed Presettling Guidance.

Contributing Area Runoff Characteristics	
Contributing Basin (acre)	3.56
Total Volume of Runoff from the 6-month, 24-hour Storm Event (acre-ft)	0.386
WQ Offline Flow Rate (cfs)	0.2751
Presettling BMP Sizing	
Current Guidance	• Presettling Vault – WSDOE's Vault: 16 ft x 47 ft x 6 ft (~4,425 cubic feet) • Vortechs: Model 1000 (design Water Quality flow rate of 0.55 cfs)
Proposed Guidance	• Presettling Vault – Fat Pipe Configuration: 4.8 linear feet of 6-foot-diameter pipe • Vortechs: Model 1000 (design Water Quality flow rate of 0.31 cfs)

ft = feet

Presettling Manufactured Treatment Device (MTD): Vortechs System by Contech

The 3800 Latona Project had originally selected the Vortechs System by Contech to provide the required presettling upstream of the biofiltration swale. The treatment system is downstream of a flow-splitter, so the presettling device and the swale must handle the offline water quality design flow rate of 0.2751 cfs. Based on the manufacturer's provided data, the Vortechs 1000 hydrodynamic separator can handle up to 0.55 cfs, nearly double the required flow rate needed for the project.

However, based on the adjusted design flow rates for selected approved MTDs (see Table 3[4]), the Vortechs 1000 should be installed for flow rates at or below 0.31 cfs in order to settle particles as small as 80 microns. The proposed Vortechs model still has sufficient capacity to handle the offline flow rate for the regional biofiltration swale, but under the proposed presettling guidance the device is significantly less oversized than originally assumed per the manufacturer's data.

Presettling Vault

The design for a presettling vault following the presettling basin design criteria per from Washington State Department of Ecology's *Stormwater Management Manual for Western Washington* (SMMWW) BMP T6.10. Per BMP T6.10, the presettling basin volume must be at least 30 percent of the total volume of runoff from the 6-month, 24-hour storm event. Additionally, the length-to-width ratio must be at least 3:1, and the depth must be between 4 feet and 6 feet. Therefore, the vault for the 3800 Latona regional

[4] Located in the *Manufactured Treatment Devices* subsection of this TM.

biofiltration swale per BMP T6.10 is 4,425 cubic feet (CF) and would likely settle particles as small as 10 to 20 microns in diameter.

In contrast, the proposed guidance recommends designing the presettling device to settle particles around 80 microns in diameter. A fat pipe configuration targeting 80-micron particles would only require approximately 5 linear feet of 6-foot-diameter pipe, approximately 150 CF of storage.

Conclusions for 3800 Latona

The proposed presettling guidance would not modify the current presettling design for the regional biofiltration swale system at 3800 Latona. However, the adjusted recommended flow rates for approved MTDs did highlight that the proposed proprietary presettling device is near its limit to meet the design flow rate if targeting 80-micron particles. A vault option was not developed for this project when the MTD met the target particle size at the design flow rate.

Broadview NDS

Site Summary

The Broadview NDS project, located in the Pipers Creek Basin, is being delivered under SPU's NDS Partnering Program, which aims to provide water quality treatment of urban stormwater runoff through construction of bioretention facilities in City ROW. The project includes a retrofit of approximately five blocks of City ROW with conveyance improvements and bioretention facilities to capture and treat stormwater runoff prior to discharge into Pipers Creek, and ultimately, the Puget Sound.

Figure C-3 shows the project's drainage basin map and contributing areas to each of the six bioretention series during the 60 percent design stage.

Figure C-3. Broadview NDS Drainage Basin Map.

127th	Contributing Area			EIA		
	Parcel (ac)	ROW C&G (ac)	ROW Curbless (ac)	Parcel (ac)	ROW (ac)	TOTAL (ac)
Series 1	0.000	0	0.230	0.000	0.084	0.084
Series 2	8.199	0	3.275	0.984	1.199	2.183
TOTAL	8.199	0	3.505	0.984	1.283	2.267

130th	Contributing Area			EIA		
	Parcel (ac)	ROW C&G (ac)	ROW Curbless (ac)	Parcel (ac)	ROW (ac)	TOTAL (ac)
Series 3	0.072	0.412	0.000	0.009	0.235	0.244
Series 4	0.722	0.201	0.337	0.087	0.238	0.324
Series 5	4.436	0.158	1.270	0.532	0.555	1.087
TOTAL	5.229	0.771	1.607	0.628	1.028	1.655

Apply Proposed Thresholds for Presettling

The six bioretention facilities, labeled Series 1 through Series 6 per Figure C-3, were reviewed under both the existing and proposed presettling guidance. See Table C-3 for the contributing basin characteristics for each of the bioretention series and the respective presettling thresholds met by each series.

Under the existing guidance, four of the six series would require a presettling BMP. However, under the proposed presettling guidance, only two of the six bioretention facilities would require presettling.

Table C-3. Current and Proposed Presettling Guidance for Broadview's Bioretention Facilities.

	Series 1	Series 2	Series 3	Series 4	Series 5	Series 6
Contributing Area Characteristics						
Road Classification	Residential	Residential	Arterial	Arterial	Arterial	Arterial
Contributing Basin (acre)	0.23	11.47	0.48	1.26	3.07	2.73
EIA (acre)	0.084	2.183	0.244	0.324	1.253	0.809
EIA (SF)	3,659	95,091	10,629	14,113	54,587	35,249
EIA in ROW (SF)	3,659	52,228	10,237	10,367	16,747	4,986
Basin Slope	4.0 percent	3.5 percent	1.2 percent	1.5 percent	1.7 percent	1.7 percent
Presettling Requirements						
Current Guidance	No–EIA<5,000 SF	Yes–ROW Impervious >12,300 SF	Yes–ROW Impervious between 9,000 SF and 16,500 SF	Yes–ROW Impervious between 9,000 SF and 16,500 SF	Yes–ROW Impervious >16,500 SF	No–ROW Impervious <9,000 SF
Proposed Guidance	No–Basin <1 acre	Yes–Basin >3 acres	No–Basin <1 acre	No–Basin <3 acres and Slope <5 percent	Yes–Basin >3 acres	No–Basin <3 acres and Slope <5 percent

Size Presettling Under Proposed Guidance

Both a presettling vault and a pretreatment MTD were evaluated for comparison under the existing and proposed presettling BMP sizing guidance for the Broadview NDS project. Table C-4 summarizes the runoff data for the contributing basin and the resulting design for the presettling devices under both the existing and proposed guidance.

Table C-4. Presettling Device Sizing for Broadview NDS Under Current and Proposed Presettling Guidance.

	Series 2	Series 5
Contributing Area Runoff Characteristics		
Contributing Area (acre)	11.47	3.07
Total Volume of Runoff from the 6-month, 24-hour Storm Event (acre-ft)	0.5233	0.1746
WQ Online Flow Rate (cfs)	0.3672	0.169
Presettling BMP Sizing		
Current Guidance	• Presettling Vault – WSDOE's Vault: 19 ft x 58 ft x 6 ft (~6,838 CF) • Vortechs: Model 1000 (design WQ flow rate of 0.55 cfs)	• Presettling Vault – WSDOE's Vault: 11 ft x 34 ft x 6 ft (~2282 CF) • Vortechs: Model 1000 (design WQ flow rate of 0.55 cfs)
Proposed Guidance	• Presettling Vault – Fat Pipe Configuration: 6.5 linear feet of 6-foot-diameter pipe • Vortechs: Model 2000 (design WQ flow rate of 0.45 cfs)	• Presettling Vault – Fat Pipe Configuration: 3.0 linear feet of 6-foot-diameter pipe • Vortechs: Model 1000 (design WQ flow rate of 0.31 cfs)

ft = feet

Pretreatment MTD: Vortechs System by Contech

For Series 5, the proposed guidance would ultimately recommend the same Vortechs System model. However, the Vortechs 1000 hydrodynamic separator is more than 200 percent oversized based on the manufacturer's specifications, while the adjusted design flow rates (Table 3[4]) would consider the Vortechs 1000 to be more appropriately sized for the project, only around 85 percent oversized.

For Series 2, based on the adjusted design flow rates for selected approved MTDs (see Table 3[4]) the proposed sizing guidance would require upsizing to a larger Vortechs System model than the manufacturer's specifications would recommend.

Presettling Vault

The design for the presettling vault under the existing guidance followed the presettling basin design criteria from Washington State Department of Ecology's *Stormwater Management Manual for Western Washington* (SMMWW) BMP T6.10. Per BMP T6.10, the presettling basin volume must be at least 30 percent of the total volume of runoff from the 6-month, 24-hour storm event. Additionally, the length-to-width ratio must be at least 3:1, and the depth must be between 4 feet and 6 feet. The presettling basin per BMP T6.10 criteria would likely settle particles as small as 10 to 20 microns in diameter.

The vault for Series 2 under the existing guidance would have been approximately 6,838 CF, and the vault for Series 5 bioretention facility would be approximately 2,282 CF.

In contrast, the proposed presettling guidance recommends designing the presettling device to settle particles around 80 microns in diameter. A fat pipe configuration targeting 80-micron particles would only require approximately 6.5 linear feet of 6-foot-diameter pipe for Series 2, approximately 220 CF, and only around 3 linear feet of 6-foot-diameter pipe for Series 5, approximately 85 CF. Other configurations could be developed and optimized for constructability and effectiveness.

Conclusions for Broadview NDS

The proposed guidance reduces the number of bioretention facilities requiring a presettling BMP by half. The proposed guidance eliminates presettling wherever the current guidance would require the standard concrete splash pad. Where the current guidance would require modeling to size the presettling BMP, the proposed guidance would match.

For sizing an approved MFD where the water quality design flow rate approached the manufacturer's specifications, the proposed guidance would require the designer to upsize to a larger model.

South Thornton

Site Summary

Under this project, SPU will construct NDS at four sites in the south Thornton Creek basin. Herrera was asked to support the consideration of presettling on this project by reviewing the application of the revised thresholds and assistance in sizing and designing a "fat pipe" presettling vault (see Figure C-4 below).

Size Presettling BMP Under Proposed Guidance

Herrera supported the design team in their development of a conceptual "fat pipe" presettling vault concept design, shown below as Figure C-4, and supported conversations with SPU asset management staff on design to support O&M. Herrera also provided sizing guidance for this BMP in four sites within the project. Herrera provided sizes for the water quality flow rates provided by the design team. Some flow rates provided were offline and some were online.

Site 1 is at the intersection of Northeast 107th Street and 23rd Avenue Northeast. This location has a basin area of 4.2 acres with about 1 acre of EIA and an online water quality flow rate of 0.432 cfs. Using a 15-foot-long, 4-foot-diameter fat pipe vault would result in capturing the 48-micron particle.

Site 2 is at the intersection of Northeast 105th Street and 23rd Avenue Northeast. This location has a basin area of 1.7 acres with about 0.5 acre of EIA and an online water quality flow rate of 0.18 cfs. Using a 27-foot-long, 4-foot-diameter fat pipe vault would result in capturing the 27-micron particle.

Site 3 is at 41st Place Northeast, and the design team reported an offline water quality flow rate of 0.18 cfs. Using just a 15-foot-long, 4-foot-diameter fat pipe vault would result in capturing the 54-micron particle.

Site 4 is at North 117th Street and the design team reported an online water quality flow rate of 0.13 cfs. Using just a 5-foot-long, 4-foot-diameter fat pipe vault would result in capturing the 45-micron particle. However, a 10-foot-long fat pipe should be used as this is the minimum length recommended

All these configurations are higher performing than the benchmark standard of 80 microns.

Figure C-4. “Fat Pipe” Presettling Conceptual Vault Detail.