Ballard Roadside Raingardens, Phase 1 – Lessons Learned

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Abstract

This paper covers the experience and lessons learned from the Ballard Roadside Raingarden, Phase 1 Project. This project involved installing bioretention facilities along eight blocks of City right-of-way for combined sewer overflow reduction goals in 2010. This paper details the design and construction experience and where Seattle Public Utilities (SPU) made missteps that resulted in the removal of 40% and retrofit of 50% of the constructed raingardens.

Background

A $1.4 million American Reinvestment and Recovery Act (ARRA) loan funded this project to build bioretention cells or "roadside raingardens" along eight blocks in the Ballard neighborhood, located in NPDES Basin 152. In 2010, 63 combined sewer overflows (CSOs) were observed in this basin, exceeding the regulatory standard of one overflow per outfall per year and discharging approximately 40 million gallons of combined sewage into Salmon Bay.

Seattle Public Utilities (SPU) has successfully constructed numerous bioretention systems in creek watersheds that control flows to urban creeks, called natural drainage systems (NDS), and mitigate 232 acres of drainage area to urban creeks. In contrast to NDS projects, BRR1 is SPU's first project constructing bioretention cells in the right-of-way (ROW) to reduce the volume of stormwater entering the combined sewer system, thereby reducing the control volume. It is also the first significant retrofit in a neighborhood that already had a curb and gutter drainage system, as compared to unimproved (gravel) roadway shoulders. Since SPU had only conceptual designs for a curb and gutter road configuration but had not worked with Seattle Transportation Department or the community for their implementation this project was identified as a pilot project.

This project began as a conceptual design in the spring of 2009 to pilot roadside raingardens for CSO control, which included developing and piloting several different design configuration templates with the community. SPU was told that it was likely to receive funds at the beginning of July 2009, and was formally awarded the ARRA loan on August 17, 2009. ARRA rules required that the 90 percent plans and specifications and Engineering Report be submitted to Ecology for approval by September 17, 2009, and that the project be under a construction contract by February 16, 2010. Although the project met the required ARRA deadlines, the start of construction was intentionally delayed until June 2010 to avoid working in the wet season and to reduce the number of constructed, unplanted cells during the summer since they could not be planted until the fall. Unfortunately, for a variety of reasons (e.g. early rains, insufficiently protected raingarden cells which flooded and had to be pumped out, and design changes that required more information and slowed down the work), the construction period was longer than originally estimated and construction was not completed until the end of December 2010.

Consistent with the nature of pilot engineering projects, the BRR1 project encountered challenges. Two major challenges included lower performance than anticipated (that is, drainage in a majority of the bioretention cells was inadequate or too slow due to the presence of low infiltrating soils) and poor public involvement and communication. The public outreach problem made the performance problem more difficult to address. Both of these challenges provided an opportunity for SPU to learn valuable lessons to be applied to future projects.

Design Process

Project Management. This project did not prepare a Project Management Plan (PMP), which outlines the project scope, budget, roles and responsibilities, performance requirements, schedule, and communication plan and is now required for all SPU projects. As a result, the roles and responsibilities were not clearly defined, in addition to the overall project goals and expectations.

Basis of Design. The bioretention cells in BRR1 were designed to infiltrate approximately 95 percent of the stormwater volume from the area draining to each cell, which is roughly equivalent to the one-year event. The one-year event is the control target because State and Federal law require the City to reduce the overflows from each CSO basin down to no more than one overflow per site per year. The bioretention cells were designed to meet this goal based on the pre-sized tables that SPU developed for the City of Seattle Stormwater Manual, Volume 3 (Stormwater Manual). The original design was anticipated to reduce the 4.07 million gallon control volume in NPDES Basin 152 by 59,000 gallons, or 1%.

Geotechnical. The geotechnical evaluation included 19 modified pilot infiltration tests (PIT) that were completed in early August 2009 throughout the larger project area, which included blocks that were not ultimately selected. Six soil borings and monitoring well installations were completed in late October 2009 as a result of community feedback suggesting the presence of a high groundwater table and their concerns about infiltrating where there is already a groundwater problem. Preliminary infiltration rates, determined from pilot infiltration tests (PITs) that measured saturated hydraulic conductivity, were presented to the team in early August 2009, with the draft and final geotechnical reports completed in early and late November 2009, respectively. These draft and final geotechnical reports were completed at essentially the same time as the final design.

Design. This project was intended to pilot raingardens in the ROW for CSO control and to develop design templates for application of raingardens for different street configurations and infiltration rates. The cell design followed the standard design requirements for side slopes, setbacks, and bottom slope provided in the Stormwater Manual. The templates were important for detailing how to fit the cells into the available area given the site constraints and traffic control requirements, such as distance from end of curb and whether the curb could be moved out into the roadway and for what distance. A critical element in developing these templates was ensuring sufficient bottom area, the flat area in the bottom of the cell, because it provides the surface area through which most of the infiltration occurs, which is the primary mechanism for meeting our design goal. On many blocks that had a relatively narrow (< 9.5 feet) planting strip, this proved challenging and led to the development of the curb extension design which moves the curb up to five feet into the roadway for a short distance (Figure B, next page) and allows for a larger bottom area.

Due to the tight timeline, this project skipped preliminary engineering and moved directly into 30 percent design. In addition, in an effort to keep soft costs down and pilot the implementation of template designs, no survey was completed and the exact location of the cells had to be field directed, meaning that because there were no survey points to identify the specific cell locations, the design engineer had to work with the contractor to identify in the field where each cell should begin and end. This approach was identified when SPU thought that the project would only involve working in the planting strip (Figure A) or adding curb extensions (Figure B) along a small portion of the block length. However, it was not revisited for the design involving full block curb shifts (Figure C), which moves the curb out along the entire block.

The final design included one block with raingardens only within the planting strip, four blocks with both planting strip and curb extension raingardens, and three blocks with full block curb shifts. The full block curb shifts were possible only on 28th Avenue NW due to the overly wide roadway width (up to 44 feet in some places).

Project streets were selected based on a number of factors including:

- Street slope < 5%
- Planting strip width > 9.5 feet and/or ROW width > 58 feet
- Lack of established trees or landscapes
- Frequency of driveways not restricting the available length in planting strip

Figure A - Planting Strip Example **Figure B - Curb Extension Example**

Figure C - Full Block Curb Shift Example

- Native soil design infiltration rates > 0.25 inches per hour
- Located within an existing CSO Long Term Control Program (LTCP) flow monitoring basin and would already have data that was gathered for model development in support of the LTCP but could also be used as post-construction data for BRR1

The design went from 30 percent conceptual design to 90 percent in about two months. This required making quick decisions with short review times. As a result, the results and recommendations from the geotechnical report were not thoroughly incorporated into design. Based on past NDS designs, this project applied short-term infiltration rates instead of the corrected rates; however, on past projects the uncorrected rates were greater than 0.5 inches per hour so if the recommended correction factor of 2 had been applied, the raingardens still met the minimum requirements, which was not the case for this project. And in some cases on this project even the short term rates were below the minimum design standard. In addition, because of the short timeline and the quick selection of project streets, the infiltration data were based on only one test per block, and in some cases interpolated based on upper and lower block data. The uncorrected test pit rates ranged from 0.2 in/hr to 5 in/hr. Currently, the City's Stormwater Manual requires at least two tests per project block, but at the time of the geotechnical evaluation for this project, the revised geotechnical requirements were still in draft format and were not applied.

Construction. Construction began at the end of June 2010. Based on an estimate of 107 working days by the SPU Construction Management group, it was anticipated that construction would reach substantial completion by the end of September. This would allow the cells to be planted in October and allow the vegetation to establish during the winter months. However, the lack of survey data also resulted in project redesigns and delays. For example, the selected contractor felt that shaping of the cells, weir placement, and cell slopes required more refined elevation data than was provided. In addition, bad weather caused construction delays. The contractor's erosion and sediment control plan relied on placing sandbags in the curb cuts, which proved to be completely insufficient as the winter storms hit. The cells flooded every time it rained, creating further delays in construction. Substantial completion actually occurred in late December 2010.

Finally, three critical steps did not occur during construction on BRR1 that occurred on previous NDS projects:

1. Review of project goals and objectives with construction management staff, including critical design elements
2. Geotechnical engineer evaluation of excavated cells to verify soils
3. Thorough and timely communication with community

Community Outreach. While the BRR1 pilot project was in the design stage, educational materials that explain the broader CSO program context were being developed to describe the overall CSO problem that SPU needs to solve and the appropriate tools (e.g., bioretention, permeable pavement, storage tank, weir retrofits). Because this material was not yet available, the BRR1 project team tried to cover this CSO program context information during the project community meetings. During the course of design, SPU held two community meetings in Ballard (July 29, 2009 and October 13, 2009). The first meeting introduced the problem, the proposed project, pictures of the finished result of similar projects, and the potential project streets. The second meeting again presented the problem and project, pictures, and the chosen project streets. A final pre-construction community meeting was held on May 12, 2010 to introduce the contractor and review the schedule for construction and anticipated impacts. These meetings were the primary outreach to the Ballard community. Attendance at the first meeting, when SPU introduced the problem and project, had the lowest attendance, only 24 residents, and there was no follow up with a more aggressive outreach at this point.

Although SPU did not provide adequate outreach to the specific project community, SPU did host a walking tour on November 6, 2010. This tour included BRR1 Roadside Raingardens, in addition to Residential Rainwise raingardens (private property), and a test green alley (permeable pavement). The feedback was mixed, but was generally positive and people were interested in what SPU was doing.

Performance Results

The winter of 2010 was a very wet winter with the cumulative rainfall depth for the period October 2010 through March 2011 being 7 inches (27%) above the

Long Term Average for Seattle. As construction was nearing completion in November and December, a significant number of the cells were not draining properly or even at all. When construction was finally completed and an accurate assessment of the cells' performance was made, SPU determined that approximately 33% of the cells were not draining, 33% were draining too slowly, and 33% were working as designed. Field observations by SPU and our geotechnical consultant determined that the non-draining and slow draining cells were a result of poor soils and a perched or mounded groundwater condition, which can often occur over glacial till soils. It became obvious that the design had not fully taken into account or understood the implications of low infiltrating soils and insufficient information.

The Ballard community was unhappy about the drainage performance and resulting standing water. Community leaders were vocal in demanding that the cells either needed to be fixed or removed. Community frustration and opposition to the project was covered in the media by two community blogs, newspapers, radio, and television. On February 2, 2011 SPU hosted a community meeting to present the problem and ask for the community's help and patience in finding a workable solution. The community expressed varied opinions about the raingardens, with some residents willing to keep the raingardens if they could be retrofitted to work properly, but the majority just wanting them to be removed.

A Task Force was formed with twelve community members and five SPU staff, including SPU's Deputy Director, to discuss the problem and possible solutions. The community was primarily concerned about the following issues:

- Long-term (>24 hours) ponded water
    - Drowning hazard for young children and the elderly
    - Mosquito breeding
    - Aesthetics
    - Smell
- Cell design
    - Side slopes too steep
    - Depth of allowable ponding
    - Depth of cell
- The presence of object marker signage on the curb extensions (the size, 12" wide by 36" tall, and look)
- Lack of communication and community input
- Loss of parking spaces

Figure G illustrates some of the non-functioning cells and the community concerns, such as long-term ponded water, the large black and yellow striped object marker signs, the parking restrictions, cell depth, and general aesthetics.

The Task Force met formally five times during March and April of 2011, with a few smaller informal discussions during that period, and came to a compromise on the design and presence of the raingardens. Because of the wide spread community dissatisfaction with the project SPU's communication, and the significant number of raingardens that were not draining, SPU found itself in a bad position to negotiate and ended up having to remove or retrofit (fill in to remove any visible ponding) many of the performing raingardens in order to gain community acceptance.

Figure G - Examples of Nonperforming Cells and Community Concerns

SPU Improvements

Based on the outcome of the Task Force meetings, the raingardens on 29th Ave NW and NW 77th St. will be completely removed, with the curb replaced back to its original location. Most of the raingardens on 31st Ave NW, along the east and west side of 28th Ave NW between NW 71st St and NW 72nd St, and along the east side of 28th Ave NW between NW 65th St and NW 67th St were retrofitted to be more shallow and remove any visible ponding, with several being completely removed.

The cells that were retrofitted to be more shallow have varying levels of infiltration due to the native soils conditions, but generally do not provide anything close to the intended performance and are classified as low performing or low infiltrating raingardens. Along the west side of 28th Ave NW, many of the raingardens are being redesigned as a detention system with an orifice-controlled underdrain. This design will capture the stormwater in the cell and temporarily store it in the bioretention soil (there is no surface ponding) while it waits to be slowly metered out to the combined sewer system by moving through the soil into the underdrain fitted with an orifice, which controls the rate of flow. A detention system helps with reducing CSOs by only allowing a little of the stormwater into the system when it is at capacity. Raingardens along 30st Ave NW work as designed and do not have any long term ponded water issues or community concerns, so no additional work or redesign is required.

The orifice controlled underdrain design along the west side of 28th Ave NW may become a prototype design for other areas of the city where the soils do not allow adequate infiltration, but the provided detention (or live storage within the soil) can be beneficial to the basin's overall CSO control requirements. The basic design includes a trench down the center of the cell with a slotted underdrain pipe surrounded by a filtering soil. An orifice at the downstream end of the underdrain pipe regulates the release rate of water into the combined sewer system. Several feet of bioretention soil are placed above the underdrain pipe to provide voids for water storage and good soil for plant growth. The appropriate depth and orifice size required to meet the basin's control volume requirements was determined by extensive SWMM5 modeling using the parameters of each block along 28th Ave NW.

The initial design was estimated to reduce the control volume in Basin 152 by 59,000 gallons. With the retrofits on all the streets in place, the new estimate is a 38,000 gallon control volume reduction, which represents 64 percent of the original goal.

Lessons Learned

Community Engagement.

- Get out into the community early, ideally a minimum of two years before project design meetings begin, and often. Introduce the problem you are trying to solve, before you present the solution.
- Don't rely on community meetings to educate the community about the project and to get their feedback, issues, and concerns. Develop several different strategies for communicating with the community and making sure they feel heard, such as one-on-one or small group meetings with residents, especially those that haven't attended the community meetings.
- Be clear with the community on:
    - How the raingardens work and why short-term ponding is important.
    - What the community could expect to see during early and late stages of construction.
    - What they can expect to see over the next few years as the raingardens mature, including ponding and changes in the vegetation look and size.
    - If there are going to be signs associated with the raingardens, be very clear with the community on what they will look like.
- Be clear on the "pilot" element of the project and how the community can help with the evaluation of its success.
- Understand the community "look" regarding street character and what's important.

Planning.

- Develop a Project Management Plan (PMP) that outlines roles and responsibilities, schedule, budget, and risks and is approved by management.
- Hold regular team meetings to review project status and design.

- Clearly articulate the risks of accelerating a schedule to accept a grant or loan or meet some other deadline and communicate those risks to management and political staff. Be ready to proceed before accepting a grant or loan.
- If accepting a grant or loan, be sure to have clearly defined and allocated support from Grants and Contracts and Finance for filling out the forms and financial statements, the PM can't do it on their own.
- Develop and communicate to the community the context of the problem and the toolkit of possible solutions before moving forward with implementing a project.
- When implementing a pilot project that sets the stage for future projects within a short timeframe, think through the goals and associated risks. For this project, given this well established community, it may have been better to pilot a single, lower impact design such as only constructing raingardens in the existing planting strip. Also consider the risks associated with consolidating many raingardens in one area for monitoring measurable performance.
- Be clear and get management support on the project policies, acceptable level of community impact (i.e., parking loss), and community acceptance threshold related to site selection criteria to avoid continual adjustments to the design and site locations during the design phase.

Geotechnical.

- Read the geotechnical report carefully and follow its recommendations, specifically using the corrected infiltration rates (not the short term rates) to determine site feasibility. Also, work more closely with the geotechnical engineers as project streets are selected and designed. Discuss whether, given the particular site conditions, more geotechnical data are required to increase the confidence in design.
- If the initial short term infiltration rate is less than 0.75 inches per hour for the sites that are applying that value, conduct in-depth subsurface evaluation per the 2009 City of Seattle Stormwater Manual, including wet season analysis. If the corrected infiltration rate is less than 0.25 inches per hour, anticipate that the geotechnical engineer will recommend a design that does not rely on infiltration. If the corrected infiltration rate is between 0.25 and 0.5 inches per hour, build a redundant system into the design, such as an underdrain.
- Follow the requirements for geotechnical evaluation in the 2009 Stormwater Manual, including ensuring adequate PITs along each project block, designing with corrected infiltration rates, testing for seasonal high groundwater level (not just the regional groundwater levels), and characterizing the infiltration receptor, which includes depth to groundwater and impermeable layers, seasonal variation in groundwater table, volumetric water holding capacity of the infiltration receptor soils, horizontal hydraulic conductivity, and the impact of the infiltration rate and proposed added volume from the project on local groundwater mounding, flow direction, and water table. Although the Stormwater Manual was not finalized at the time of the geotechnical evaluation for this project, if the requirements in the Stormwater Manual had been completed, it is likely that the project would have performed as anticipated because raingardens would only have been located in areas with soils that are appropriate for infiltration.

- When conducting PITs, consider conducting them during the winter, especially in glacial till soils, and consider the ratio of sidewall to bottom area during the test and try to limit horizontal flow.
- Integrate the geotechnical engineers in all phases of the project, including construction. Empower them to speak up if they think infiltration is unlikely or high risk.
- Walk the site during the late wet season with an eye toward things that might suggest seasonal high groundwater – seeps, wet pavement along cracks or seams when the surrounding pavement is dry, saturated planting strips.
- Ask and listen to the community for clues to areas that might be problematic and require more investigation.

Design.

- Always complete preliminary engineering.
- Include a formal geotechnical review during the 30% circulation.
- Include a backup design in your plans, such as an underdrain, especially when the design infiltration rate is less than 0.5 in/hr.
- If a detailed survey is not desired, complete a "light" survey that focuses on critical elevations for streets and sidewalks and other critical points.
- When doing more than just working in the existing planting strip or adding a curb extension (< 40 feet in length), survey should be performed.
- If anticipating including a number of "field directed" elements in the design, work closely with the construction management group to evaluate this option against the proposed contracting approach and discuss how to make it feasible.
- Allow for a constructability review by Construction Management prior to finalizing design to produce a buildable contract plan (e.g., the specified payment method for the bioretention soil became problematic).
- Provide the design for the flow control/bypass plan and erosion and sediment control plan; don't leave it to the contractor. Also make sure it is enforceable and allows for additional measures as necessary to achieve the desired level of protection.
- Deliberately decide when the facility will be "turned on" to accept runoff.
- Review the project design, how it functions, and the critical project components with Construction Management ahead of time. All bioretention systems will require some level of field design; therefore, it is critical for the design team to articulate the design intent, the rigid requirements, and where there is flexibility.
- Don't be cheap with the plants – weigh cost of planting bigger stock initially to get better initial look for community.
- Identify lay-down areas on plans; try to avoid staging in front of homes.
- Consider raingarden payment by lump sum; if estimated quantities must be used, survey necessary to identify pre-construction grades/elevations for measurement/payment.
- If shallow utilities cross cells – avoid, relocate, or place sidewalks in those locations.
- Concrete removal limits – cut as rectangle, don't show curvy/diagonal saw cut, make long, straight cuts.

Construction.

- Balance funding sources with the ability to course correct during construction and the documentation requirements.
- Involve the geotechnical engineers during construction to field verify that the excavated or exposed soils look as anticipated.
- Prior to construction, develop internal response strategy for dealing with soils with lower permeability than anticipated within cells.
- Only assign staff to these types of projects if they are comfortable with projects that are very community intensive and not completely rigid.
- Maintain an open dialogue between the Contractor, Construction Management, Project Manager, designer, and geotechnical engineer.
- Review flow control and erosion and sediment control requirements and expectations with Construction Management staff to ensure raingardens cell receive adequate protection from siltation during construction.
- Clarify role of Street Inspector.

Looking Forward

SPU originally imagined a much different outcome for the Ballard Roadside Raingarden project. SPU still believes strongly in the value of bioretention as one of the tools for reducing CSO volumes, in addition to providing flow control in creek basins, and expects to continue to construct roadside raingardens into the future for both purposes. The number of very successful bioretention projects that we have implemented over the last 12 years, emphasizes that bioretention is an effective technology for reducing flows when applied where the conditions are appropriate. This project has highlighted the need to outreach and engage the community early and often, not try to rush things, and to continue to go back and review the technical assumptions and data with the project team. As SPU moves forward we will take the lessons learned from BRR1 and have greater success in the future.