Design Charrette Summary – November 1, 2016

Oakland, CA

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2/26/2016

Lotus Water
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Contents

1 INTRODUCTION AND FORMAT

1.1 Introduction

The Bay Area Stormwater Management Agencies Association (BASMAA) convened a Design Charrette on November 1, 2016, as part of the regional Urban Greening Bay Area Project, funded by a grant from the US Environmental Protection Agency. Urban Greening Bay Area is a large-scale, multi-agency effort, led by the San Francisco Estuary Partnership, to re-envision Bay Area urban landscapes to develop stormwater-friendly, urban green infrastructure that addresses challenges associated with climate change, infiltrates or captures stormwater and pollutants near their sources, and promotes improved water quality in San Francisco Bay. However, the high cost of retrofitting streets with green infrastructure to realize these goals has been an obstacle to its widespread implementation.

The purpose of the charrette was to develop cost-effective typical designs for integrating green infrastructure with bicycle and pedestrian improvements at roadway intersections. Therefore, this charrette was primarily focused on different types of bulbouts (also referred to as vegetated curb extensions). The typical design drawings developed through the charrette process will be used to support the design of demonstration projects at intersections in San Mateo and Sunnyvale that are representative of common intersections in Bay Area cities. These projects will help verify the cost-effectiveness of the typical designs and serve as demonstration projects for other agencies. These intersections also served as the subject of the charrette to provide tangible examples for the development of typical bioretention bulbout designs while also supporting the retrofit of these two locations.

1.2 Specific Goals and Objectives

The overall goal of developing standardized, transferable designs is to make progress in addressing the high cost of design and construction, operational issues, and maintenance challenges that often inhibit the widespread implementation of green infrastructure. The goal of the BASMAA Urban Greening Charrette was to create tools and guidance to facilitate the cost-effective implementation of green infrastructure (GI) in conjunction with bicycle and pedestrian related intersection/street improvements in the Bay Area to capitalize on the multiple synergies that exist between these two types of capital community investments.

Although there are many types of bicycle and pedestrian improvements that may benefit from green infrastructure, the Charrette set out to challenge a multidisciplinary group of professionals to think about the best and most economical ways of retrofitting typical Bay Area intersections with bioretention bulbout planters. The design sessions were organized around further developing preliminary designs for four types of bulbouts that could be implemented for the Sunnyvale and San Mateo subject intersections.

1.3 Anticipated Output

The charrette aspired to produce two different outputs for use by BASMAA and subsequently Bay Area municipalities. The first is a list of the industry's best thinking in the following focus areas: Cost, Constructability/Maintainability, Aesthetics/Functionality and Repeatability/ Synergy with bike and pedestrian infrastructure. The second output includes sketches, design drawings, and other supporting direction for the four types of bulbout configurations and their related sections that commonly occur within Bay Area streets.

1.4 Pre-Charrette Activities

Leading up to the Design Charrette, BASMAA with support from its project consultant team, led several coordination, site selection, preliminary design and outreach efforts to establish a clear set of goals and a structure that would yield tangible results from the charrette. The first pre-charrette activity was to convene an Advisory Committee of SFEP, BASMAA, USEPA, the San Francisco Bay Regional Water Quality Control Board (RWQCB), and representatives from Bay Area Cities. Early discussions with this advisory committee revealed that the top objective for the charrette was to produce typical GI designs that could cost-effectively be integrated into pedestrian and/or bicycle improvements at intersections. Due to the budget limitations, it was agreed that producing detailed designs for specific intersection improvement projects was infeasible within the charrette's current scope of work. The prioritization of typical GI designs for intersection retrofit projects was the basis for the format and the objectives of the charrette.

The next pre-charrette activity involved the selection of candidate sites within the cities of San Mateo and Sunnyvale. To assist these two cities in selecting suitable sites, consultant team member Lotus Water provided site selection criteria within a memorandum dated June 29, 2016 (see Appendix A). The memo provided recommended site selection criteria and a list of the favorable characteristics an example intersection should possess to serve as a typical Bay Area intersection for the purposes of the charrette and the eventual demonstration project. In addition to favorable physical characteristics such as the presence of on-street parallel parking, 90-degree corners, and an existing storm drain system, the memo also recommended looking for intersections in which other capital infrastructure improvements were planned to start construction by mid-2017, and/or there was an opportunity to obtain additional grant funding, such as the Safe Route to Schools Program. These types of capital project synergies would provide a more complete street project while also decreasing overall project costs and construction disturbance. The cities provided several intersection site location options to the project team for consideration before the final two intersection locations were agreed upon. The project team visited the two locations to do an initial study of the existing conditions to develop rough base maps and photo logs.

As part of the site identification task, consultant team member Geosyntec conducted a GIS analysis to assist in verifying that the selected intersections are as representative as possible of the common features that make up intersections found throughout the Bay Area. The GIS analysis indicated that approximately 15 percent of the intersection corners within the City of San Mateo can be expected to have all three of the following prioritized conditions: the corners are located adjacent to a drain inlet connected to a storm main, have an approximately 90-degree angle, and have on-street parallel parking on both legs of the intersection. A more in-depth summary of this GIS analysis and the overall site identification task can be found in the Design Charrette Site Identification Technical Memorandum provided by Horizon on August 31, 2016 (Appendix B).

To ensure that the charrette participant group was representative of various disciplines (landscape architecture, civil engineering, urban planning, construction management, city budget directors) and sectors (private, city, and regional agencies) involved in GI design and implementation, BASMAA and its project consultant team collaborated closely with the Advisory Committee to produce a participant invitation list. A maximum of 27 participants was set to assure that the break-out groups to be a manageable size. Within the previously mentioned memorandum (Appendix A), Lotus Water provided a list of suggested candidate types and some specific individuals.

1.5 Format

1.5.1 Design Exercise I

The objective of Design Exercise I was to provide a focused review/critique of a designated element/bulbout layout variation and its supporting details and sections. The conceptual bulbout layouts, sections, and details were developed by the project team prior to the charrette. Participants were assigned to one of four different groups based on how their individual background aligned with the following discipline/experience categories: Aethetic/Function, Cost, Constructability/Maintainability, and Repeatability/Synergy.

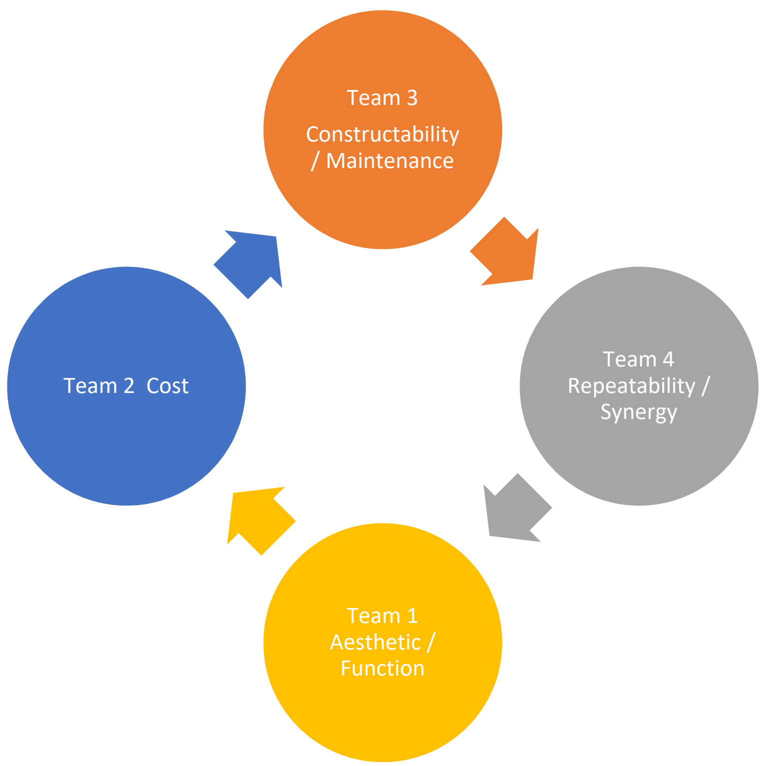

Figure 1: Design Exercise I Group Categories

During Design Exercise I, the breakout groups critiqued all four bulbout variations and sections for approximately 20 minutes each. Each group's comments were focused on their assigned category. For example, Group 2 focused their attention on potential ways to make each bulbout variation less expensive to implement. The groups produced lists, markups, ideas, etc. to accompany the bulbout design into the next exercise. The key comments and ideas were documented on a large board assigned to each bulbout variation (see Appendix C) and vocalized to the larger group at the end of Design Exercise I.

Figure 2: Participants Discuss Ideas in Design Exercise I

1.5.2 Design Exercise II

The objective of Design Exercise II was to create a revised design sketch and/or markup for each bulbout variation and associated section/detail. The groups for this second design exercise, in contrast to the Design Exercise I groups, were formed by mixing disciplines and private and public sector professionals. Each interdisciplinary group spent the duration of Design Session II improving the design of one bulbout variation and its associated section/detail(s). The groups referenced the feedback provided across all the focus categories during Design Exercise I and were provided additional background information, such as aerials, existing conditions maps, and opportunities and constraints maps, on the subject intersection corner. The groups discussed their proposed revisions and produced drawings/sketches of the revised bulbout variation and supporting sections/details. At the end of the exercise, they shared their consensus and reasons for proposed design changes with the greater group.

2 BULBOUTS AND CHARRETTE OUTPUT

The charrette yielded a variety of useful output, most of which was expected, in the form of design critiques, design recommendations, material suggestions, implementation strategies, and prioritization of next steps. From Design Exercise I, the participants provided general feedback on the conceptual designs of the bulbout layouts and sections, but in many cases found it hard to provide detailed critiques of site-specific design elements without grading plans (topographic surveys were not provided by the cities prior to the charrette so proposed grading plans were not within this project's scope). In addition to the recommended design changes coming out of both design exercises, participants also suggested strategies, or at least options worth further consideration, that would allow GI to be implemented more thoughtfully and more frequently at a lower cost. Some of these suggestions were focused on the site selection process while others dealt with how GI projects were put out to bid. A summary of the feedback for each bulbout variation is provided in this section. The raw material from the charrette is provided in Appendices C and D. At the closing of the charrette, the larger group discussed the best way to utilize the day's output and provide the participating cities with the most useful tools in implementing bioretention bulbouts in their respective jurisdictions. This is discussed in detail within Section 5.

2.1 Bioretention Bulbout One

Bioretention Bulbout Variation One, located in San Mateo at the southwest corner of the intersection of 4th and Fremont Avenues, accepts runoff from one leg. The proposed bulbout footprint is within the existing parking lane only. The layout for Bulbout Variation One, provided by the project team in advance of the charrette, is shown below:

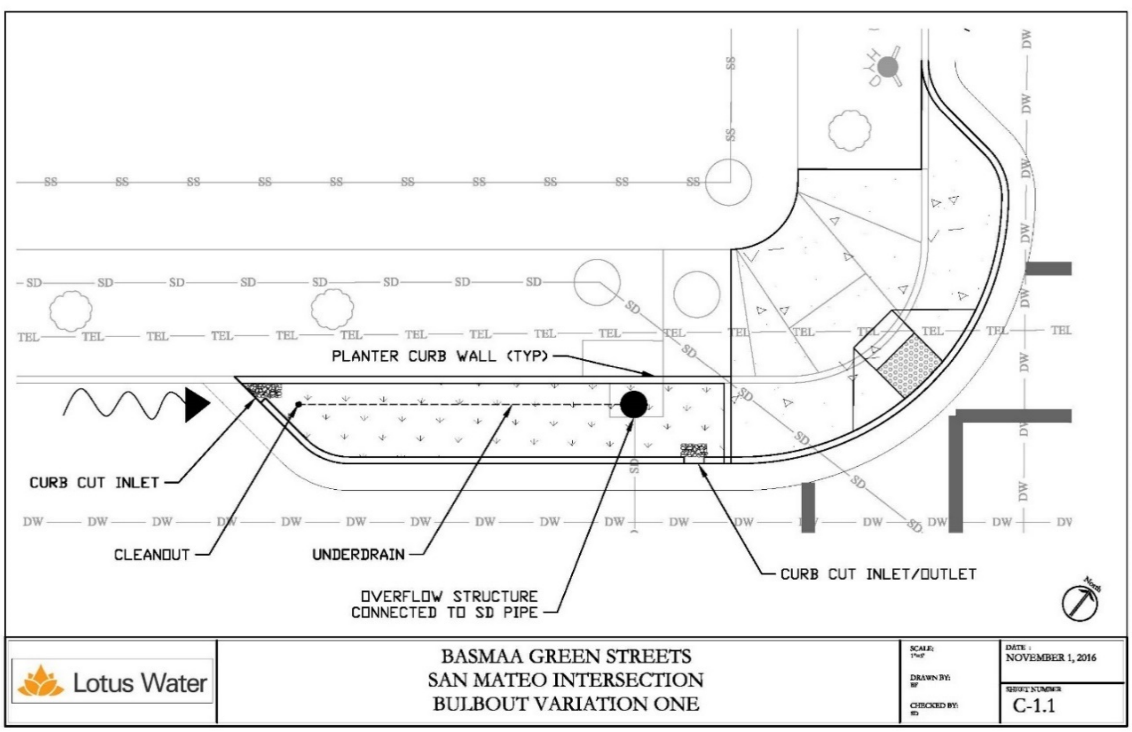

Figure 3: Conceptual Layout for Bioretention Bulbout Variation One

During Design Exercise I, participants provided the following comments, which have been consolidated for the purposes of this summary report, for each of the four design consideration categories for Bulbout Variation One:

2.1.1 Aesthetic/Function

- Expand bioretention area into existing planter strip to eliminate need for retaining wall
- Expand bioretention area to perform better from a stormwater perspective
- Design is too “cookie cutter”
- Don’t block the inlet with plants—provide clear path for water to enter facility
- Create forebay for pre-treatment
- Consider incorporating street trees in design[1]
- Consider the driver’s sight lines with plant selection—some plants listed exceed 5 feet in height
- Do not use filter fabric
- Create space for someone to sit and provide tree for shade
- Existing landscaping could serve as an upland zone and could potentially support trees

2.1.2 Cost

- Avoid retaining walls where feasible
- Use water barrier vs. deepened curb at roadway side
- Removing existing tree could provide opportunities to expand into planting strip and slope up to existing finish grade instead of installing concrete wall along this edge
- Consider economy of scale for bids – bundle projects to increase profitability for contractor and reduce unit costs
- Look for project synergies to reduce overall costs, i.e.split construction costs with ADA curb ramp improvement projects
- Use Tucson planting palette to remove need for permanent irrigation system

2.1.3 Construction/Maintenance

- Enhance forebay design for sediment/trash capture/maintenance purposes
- Enhance structural design of foundation/dowel curbs/cross bracing

2.1.4 Repeatability/Synergy

- Can underground tree root area be excavated? It costs more but provides better sustainability.
- Clarify the design criteria – Water quality sizing or compulsory GI?
- Make GI essential to meeting pedestrian safety goals
- Sites with existing catch basins are more readily repeatable
- Promote green infrastructure as a solution to constructability of bulbouts
- Mitigate grade breaks and elevation issues with smart design

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[1] The topic of incorporating trees within green street designs was tabled during this charrette per the direction of BASMAA, because of parallel efforts regarding this specific issue by a different working group.

2.1.5 Design Images from Charrette Board

The image below is one of several that were produced during Design Exercise II: see Appendix D for all the sketches and markups generated.

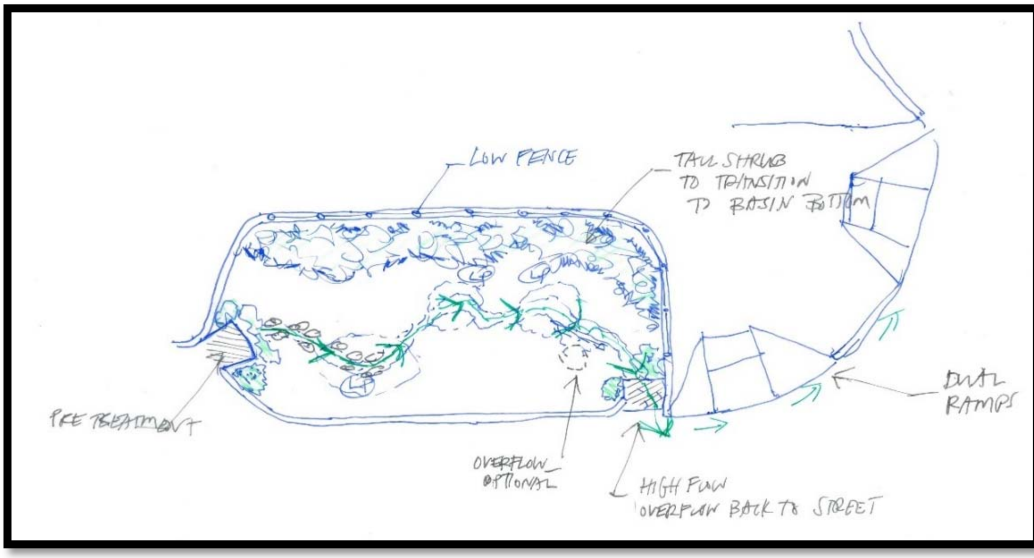

Figure 4: Proposed Design Changes for Bulbout Variation One

2.2 Bioretention Bulbout Two

Bioretention Bulbout Variation Two, located in San Mateo, at the southeast corner of the 4th and Fremont Avenues intersection accepts runoff from both legs and the footprint is within the existing parking lanes only. The layout provided by the team in advance of the charrette for Bioretention Bulbout Two is shown below:

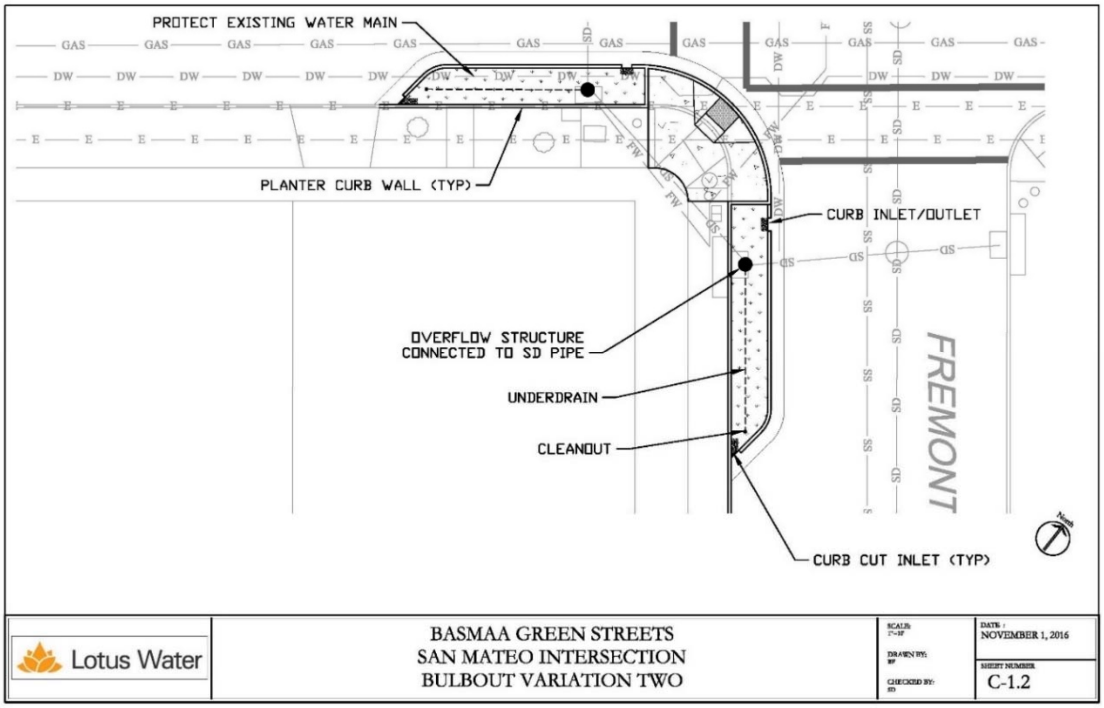

Figure 5: Conceptual Layout for Bioretention Bulbout Variation Two

During Design Exercise I, participants determined that the following criteria were important for each of the four design consideration categories for Bulbout Variation Two:

2.2.1 Aesthetic/Function

- Create a hydraulic connection between the two corner bulbouts using a subdrain or trench drain
- Expand and integrate bioretention area into adjacent planting areas if no existing trees (or trees need replacement)
- Add a concrete/rip-rap pretreatment forebay
- Keep trees on upland area and remove existing curb
- Use organic mulch to provide additional soil nourishment
- Provide low-growing grasses near the inlet and low-flow path
- Provide a meandering low-flow path to get water all the way into facility
- Consider offline condition
- Don't need both overflow and outflows in all situations
- Remove sidewalk-side curb walls where adjacent to existing trees to be saved
- Curb extension nose shouldbe landscaped (too small to provide effective treatment)

2.2.2 Cost

- Keep one bidirectional ADA ramp at corners (San Mateo prefers having two ramps) if existing traffic light poles impede using two ramps (conflicts with path of travel). Moving traffic light is cost prohibitive.
- Complicated concrete forms cost more
- More storm drain structures equates to more money

- Study ADA code to see if raised portion of planter wall on sidewalk side could be flush since it’s not immediately adjacent to sidewalk
- Consider extra costs of reducing street crowns, where necessary
- Seek opportunities for additional funding, e.g. Safe Routes to Schools Funds
- If bulbout project is combined with a Safe Routes to School project, consider extra costs and design coordination associated with new crosswalks, signage, and curb ramps

2.2.3 Construction/Maintenance

- Split bulbout costs with curb ramp improvement project
- Increase width of splash pad and mortar cobbles for energy dissipaters (improves ease of maintenance)
- Provide an enhanced forebay design to capture sediments and trash

2.2.4 Repeatability/Synergy

- Provide bi-directional ADA curb ramps everywhere
- Use LIDAR/reroute data sets to screen potential bulbout sites (technical support needed)
- Create decision support system (parameters), i.e. “kit of parts” for intersection retrofit projects
- Produce one-page report with constraints to do field reviews

2.2.5 Design Images from Charrette Board

The image below is one of several that were produced during Design Exercise II: see Appendix D for all the sketches and markups generated.

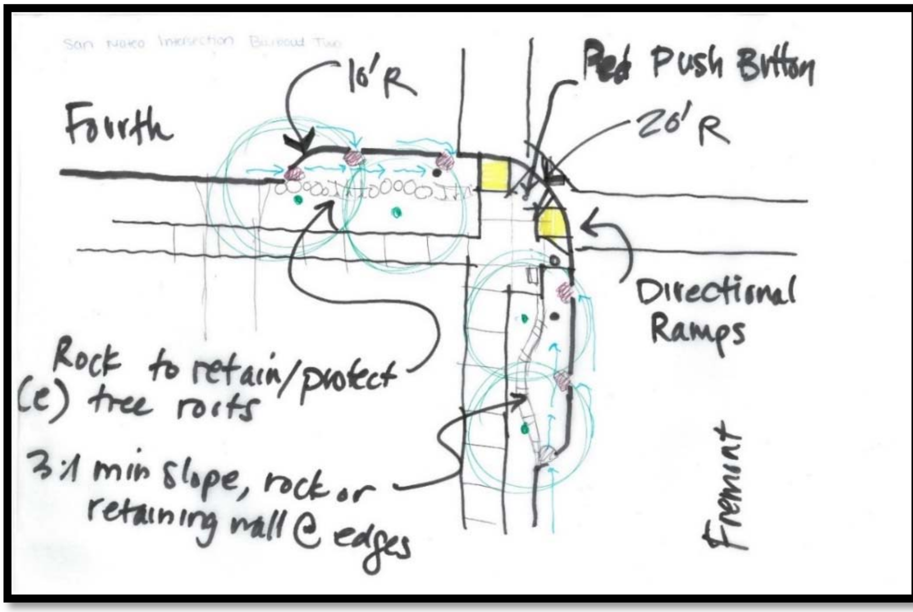

Figure 6: Proposed Design Changes for Bulbout Variation Two

2.3 *Bioretention Bulbout Three*

Bioretention Bulbout Variation Three, located in Sunnyvale, at the northwest corner of the East Duane and San Miguel Avenue intersection, accepts runoff from one leg and the footprint encroaches into the planter strip and parking lane. The provided layout for Bulbout Variation Three is shown below:

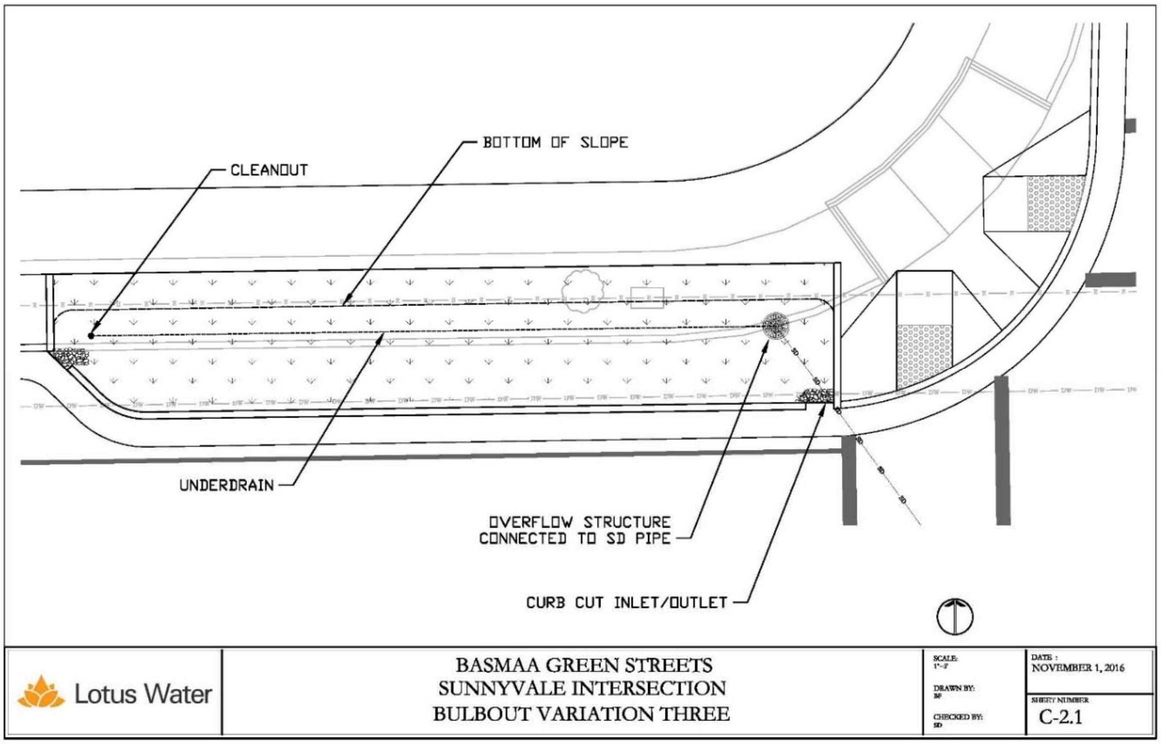

Figure 7: Conceptual Layout of Bioretention Bulbout Variation Three

During Design Exercise I, participants determined that the following criteria were important for each of the four design consideration categories for Bulbout Three:

2.3.1 Aesthetic/Function

- Need to make sure water spreads evenly throughout facility
- Consider variability of planting for intersection character
- Taper depth of bioretention soil to minimize or eliminate deep curb
- The 2.5:1 slope is too steep for bioretention soil

- Add more curb cuts
- Don't need both overflow and outlet curb cut
- Be careful of creating tripping hazards with raised curbs on sidewalk side
- Too many layers in planting plan – simplify design
- Consider incorporating small trees within bioretention

2.3.2 Cost

- Using planter strip reduces transition height – reduced wall height results in reduced cost
- Modifying bioretention area into more of a square shape yields more bioretention area per unit perimeter which is more cost effective
- Include protection BMPs in project costs
- Consider using precast curb strips for retaining to lessen slopeor just reduce cross-section with less biotreatment soil at slope edges.
- Develop utility compatible designs
- Leave utilities in place if feasible

2.3.3 Construction/Maintenance

- Utilize a "false" curb, where feasible
- Round corner with curb
- Address soil settlement during and after construction
- Design may not provide enough structural support
- Limb up trees within sight lines

2.3.4 Repeatability/Synergy

- Pay attention to bulb radii to support existing/desired uses (bike lane, trucks/buses, street sweepers, etc.)
- Develop standard agreements, MOU's and utility protection measures that meet the approval of all local agencies and utility providers

2.3.5 Design Images from Charrette Board

The image below is one of several that were produced during Design Exercise II: see Appendix D for all the sketches and markups generated.

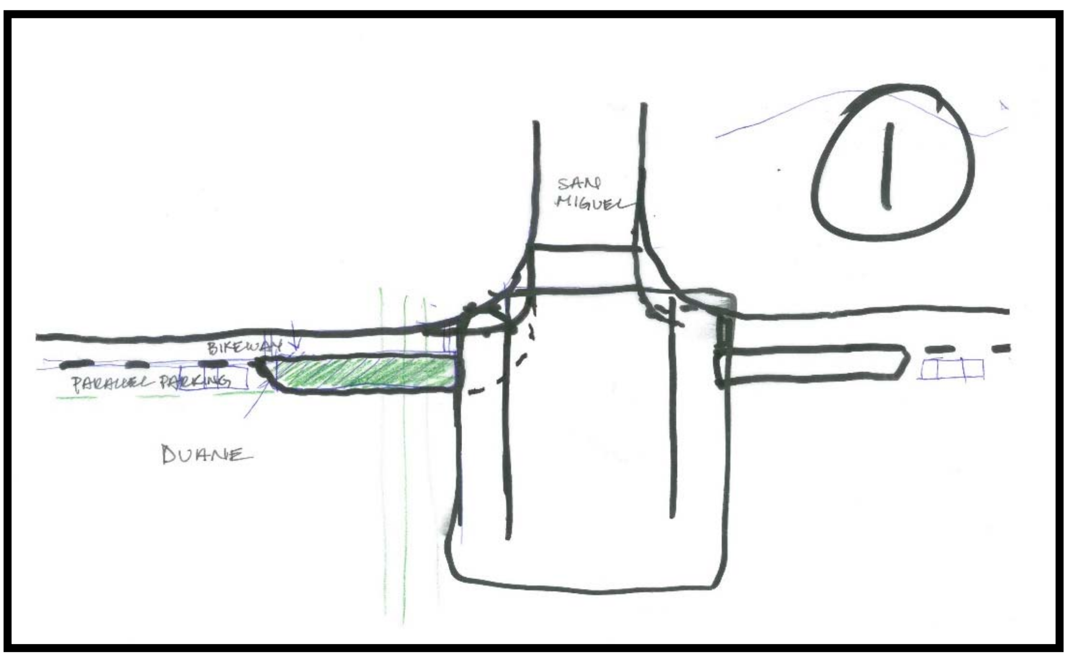

Figure 8: Proposed Island Bulbout for Bulbout Variation Three

2.4 Bioretention Bulbout Four

Bioretention Bulbout Variation Four, located in Sunnyvale at the south side of the Duane and San Miguel Avenues intersection, is a midblock bulbout design at a T-intersection with an integrated raised bike lane. The provided conceptual layout for Bulbout Variation Four is shown below:

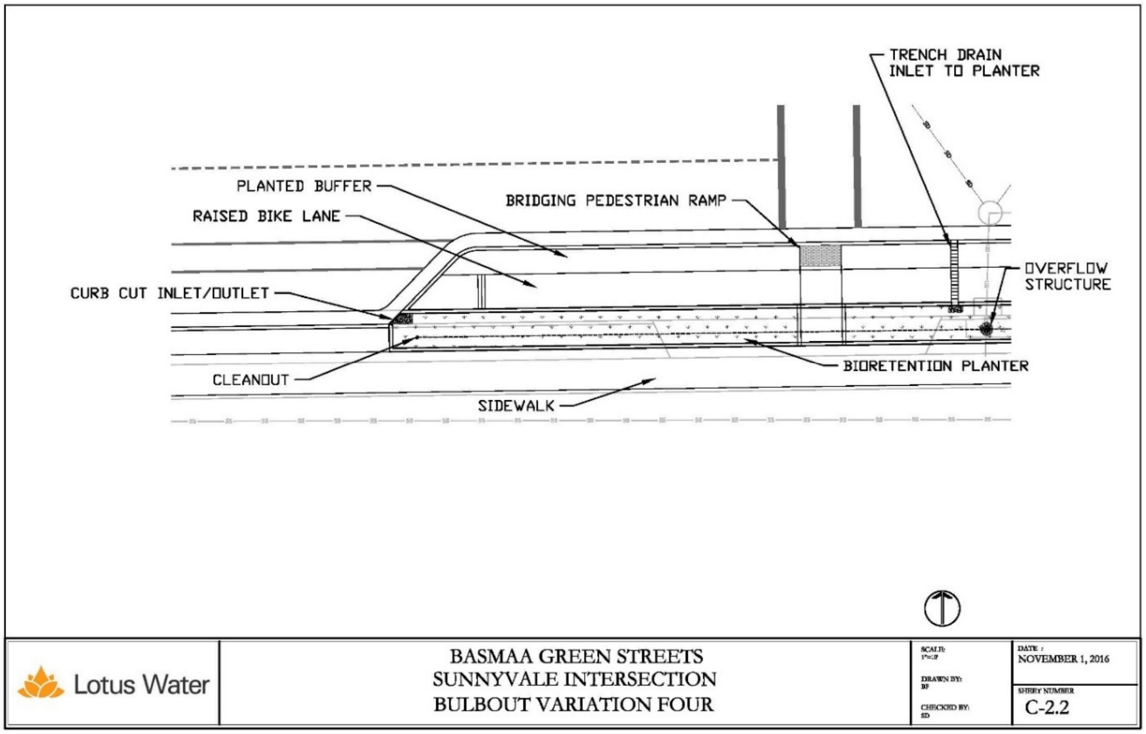

Figure 9: Conceptual Layout of Bioretention Bulbout Variation Four

During Design Exercise I, participants determined that the following criteria were important for each of the four design consideration categories for Bulbout Variation Four:

2.4.1 Aesthetic/Function

- Shift bike lane farther from cars
- Wide sidewalk to make it more inviting
- Revise to 9-foot wide bioretention area
- Make bioretention slope more gentle
- Create low flow channel feature that meanders through bioretention area
- Keep plants away from bike path to minimize hazards
- Move inlet to angle point of curb
- Provide concrete slab for splash pad for easy maintenance
- Planting may overhang edge of slab for aesthetics
- Hard to irrigate and maintain traditional planting strip portion
- Use prefabricated fiberglass reinforced bridge for pedestrian ramp crossing
- Combine planting areas
- Create bioretention zones

- Flip-flop bioretention and standard planting zones to create interest
- Include check dams and terracing
- Consider raised crosswalks
- The 30-inch maximum drop from sidewalk down to planter finish grade is too deep

2.4.2 Cost

- Remove one crosswalk across Duane Avenue
- Consider long term maintenance cost
- Use sleeves through solid curb ramp to connect bioretention areas
- Get community support for project, i.e. Adopt a Biofilter program
- Move bike lane south
- Cheaper to irrigate one larger strip vs. two long, skinny strips

2.4.3 Construction/Maintenance

- Remove trench drain
- Provide check dams
- Include trash capture/curb cut pad at inlet

2.4.4 Repeatability/Synergy

- Consider using/developing precast bulbout components
- Consider situations in which road diet strategies conflict with bulbout designs

2.4.5 Design Images from Charrette Board

The image below is one of several that were produced during Design Exercise II: see Appendix D for all the sketches and markups generated.

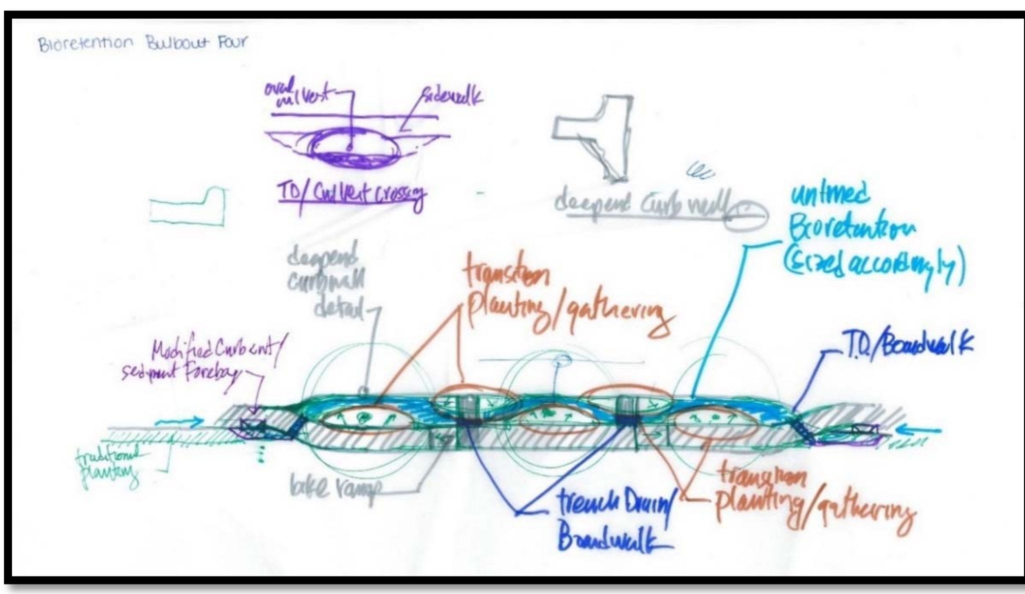

Figure 10: Proposed Design Changes for Bulbout Variation Four

3 DISCUSSION AND FEEDBACK FROM PARTICIPANTS

To wrap up the charrette, the project team posed several questions to the participants and led a discussion regarding the best ways to use the ideas and findings from the charrette in developing typical design drawings.

3.1 Charrette Wrap-up Questions

Figure 11: Discussion of Charrette Findings

1. **Knowing what you know now about this work what is the best way/format to deliver it to BASMAA/Municipalities?**
   - Go/No-Go checklist for site selection

2. **As a public-sector professional, what is the most useful format to receive this information so that you can take it to the next level?**
   - Municipalities lack guidance on best locations to implement GI
   - Give guidance on how to select location/intersection
   - Give guidance on how designs can be modified for different conditions
   - Utilize tools to find intersections (i.e. GIS) rather than manual/visual
   - Typical standard details are challenging with small budgets because there are so many different paths that can be taken to produce these
   - A good example is the Los Angeles County Model Street Design Manual for Living Streets
   - Three design approach categories:
     1. Bulbout Concept
     2. Island Concept
     3. Stormwater treatment within sidewalk

3. **As a consultant or private sector design professional inheriting the next phase of this work, how would you like to receive it?**
   - Have flexibility in design, no standard details
   - Details/specs do not capture rationale, but guidance documents can
   - 1-page summary guidance document for each category
   - Guidance that takes maintenance into consideration
   - Develop methodology to very quickly identify site and feasibility using Google Earth and field assessment
   - Provide guidance on utilizing these tools to assess feasibility before design

4. **Is guidance or details/specifications more useful?**
   - Need a checklist from multiple perspectives to encompass varying conflicts
   - Allow people to consider all components

- Standardized details do not make sense, but a standard component checklist could be a useful tool

3.2 City Input from Design Charrette

As the conclusion of the charrette, the following city representatives and BASMAA members reported back on their key takeaways from the charrette:

- Elaine Marshall (City of Sunnyvale)
- David Swartz (City of Fremont)
- Leo Chow and Otis Chan (City of San Mateo)
- Shari Carlet (City of Palo Alto)
- Matt Fabry (BASMAA)

This group related some of the charrette findings to specific lessons learned from their jurisdictions but there was a consensus that there was a need for design guidelines and site selection criteria, and cost-effective strategies for incorporating bioretention bulbouts with transportation and other capital improvement projects. Their comments can be found in Appendix E.

4 CONCLUSIONS AND NEXT STEPS

4.1 Summary

Site Selection/Feasibility Guideline Documents

Based upon the Charrette materials produced during the two design exercises and the succeeding discussion session, guidance documents, rather than standard details, appear to be the best way to assist municipalities with GI implementation. The public sector is lacking guidance on how to select good locations to implement GI, as well as how to modify typical designs for varying conditions. Site variability is a key factor in determining that typical standard details would not be a useful tool for municipalities. Standard details are difficult to produce with small budgets and they do not provide flexibility in design. Guidance documents can capture rationale in a way that standard details and specifications cannot, and they also provide flexibility and allow creativity in design. A one-to two-page document that provides guidance on the methodology used to quickly evaluate site feasibility using Google Earth, City GIS data (if available) and a rapid field assessment would be a very useful tool for municipalities.

Project Integration Identification

After site feasibility is confirmed, municipalities should identify opportunities for project integration to minimize overall project costs and disturbance to residents and local businesses. Integration of GI into complete streets projects would result in more competitive bids and will reduce the costs of GI implementation when compared to stand-alone GI streetscape projects. Other potential project synergies that could reduce GI implementation costs include Bay Area Grant Programs (i.e. Safe Routes to School), utility repair/replacement, ADA curb ramp upgrades, and paving restoration. Economy of scale should also be considered because bundling projects can be used to reduce unit costs of GI facilities.

Technical Design Guidelines

Once the site is selected by the municipality, it would be beneficial to provide technical design guidelines for GI implementation. A one-to two-page summary document would be a useful tool in providing guidance for each of the four categories identified in the Charrette: Aesthetic/Function, Constructability/Maintenance, Costs, and Repeatability/Synergy. The key components identified in the charrette for each of the four categories should be used as the foundation for the guidelines. The key design considerations for each category are listed below

- ***Aesthetic/Function***
    - Remove curb walls on sidewalk side, if feasible, and take advantage of existing planting strips, if any
    - Do not use overhanging plants near bike lane/sidewalk for safety reasons
    - Side-slopes of 2.5:1 or steeper within the bioretention planter can result in erosion – recommend flatter slope or terraces
    - Don’t block bioretention planter inlets with vegetation
    - Address ADA requirements

  - Consider effective turning radii that provides traffic calming while also providing enough clearance for fire trucks, buses, garbage trucks, and other large vehicles that are served by this intersection.
- ***Constructability/Maintenance***
  - Curbs may need foundation or brackets/cross-bracing to provide adequate structural support
    - Check dams can be used as brackets/cross-bracing while also functioning as grade control
  - Protect existing utilities within and adjacent to the bioretention planter
  - A maximum vertical drop from sidewalk to finish grade of planter of 30 inches is too deep
- ***Costs***
  - Perimeter walls increase costs – minimize where feasible
  - Long, linear features cost more, so make bioretention wider and more square in shape
  - Take advantage of gutter low point in grading design and "bridge" bioretention planter over this low point by pushing it into existing planting strip, if feasible.
  - Difficult to get contractors to bid on small projects, so "bundle projects" to attract more bids.
  - Incorporate into large multi-use project (Example: Safe Routes to Schools)
  - Need for multi-agency approved standards for utility protection to reduce costs associated with moving/relocating utilities
  - Connect multiple bioretention facilities hydraulically to avoid requiring more than one overflow structure
  - Consider long-term maintenance costs in design
  - Use low water/no irrigation plant palettes
- ***Repeatability/Synergy***
  - Prepare a simple checklist to see the extent to which desired stormwater/pedestrian safety/bike improvements/ADA improvements/streetscape beautification/utility benefits are met
  - Create opportunities for pre-fabricated components
  - Identify locations where GI can be used to lower incremental costs of drainage or sidewalk improvements

In summary, it is important that these new technical design guidelines consider all the key components for GI implementation while also providing design flexibility for the user.

4.2 Next Steps

Based on the final summary discussion during the charrette and pre-charrette planning process, the charrette output will be used to develop the following documents to best provide typical design drawings, which will be utilized by the cities of San Mateo and Sunnyvale to develop demonstration bulbout projects:

1. Advance the conceptual design drawings provided in advance of the charrette, to incorporate input from the charrette participants. After reviewing the different options

for bioretention designs developed at the charrette, the following options were identified for inclusion in the final conceptual typical design drawings:

a. Bioretention Bulbout Variation 1: Bioretention Area Extended into Planting Strip with 3:1 Maximum Slope from Sidewalk to Curb. Where existing trees and/or utilities do not prohibit grading within the planting strip, this option is preferred over the flat bioretention area with a retaining wall option, based on the retaining wall cost and concerns regarding the appearance of a drop-off next to the sidewalk. The following are some other suggested features that may be included in the final conceptual typical designs:
    i. Additional roadside curb cut inlets
    ii. Two curb ramps at the corner if feasible
    iii. 12-inch minimum wide bench adjacent to sidewalk and taller plants in upland zone to discourage pedestrian traffic within bioretention area
    iv. Enhanced splash pad/forebay design

b. Bioretention Bulbout Variation 2: Bioretention Areas on Both Legs Hydraulically Connected and Extended into Planting Strips. This option maximizes the performance of the facility while reducing the number of connections to the storm drain main, thus improving its cost effectiveness. Careful consideration of site-specific intersection grading will be required to ensure that a proper hydraulic connection (via underdrains and surface flow) can be achieved and flooding concerns addressed without excessive maintenance requirements. The final conceptual typical designs may also include the following suggestions from the charrette, many of which are like those listed under Bulbout Variation 1:
    i. Transition grade down to bioretention area using slope in lieu of concrete retaining wall where feasible. Use stacked stone or precast retaining elements around existing trees and/or utility vaults to be kept in place.
    ii. Additional roadside curb cut inlets
    iii. Two curb ramps at the corner if feasible
    iv. Enhanced splash pad/forebay design

c. Bioretention Bulbout Variation 3: Bioretention Area Incorporating Compacted Native Soil Perimeters. The use of compacted native soil benches around the edges of the bioretention planter would eliminate the need for costly retaining wall and water barrier features. It is noted that the Design Exercise II Group suggested a major configuration change to the conceptual bulbout design to provide a protected bike lane. The suggested change would create an island containing bioretention and reverse the locations of the bike and parking lanes, which would cause a ripple of road design changes for Duane Avenue, and other streets in which this typical design was applied. By locating the bioretention area away from the existing low point, this design would likely require significant intersection grading changes. Considering the goals of these typical concept bulbout design drawings, the project team recommends that the bioretention island idea be studied further under a different scope or be considered an individual landscape element without the stormwater management elements, and that the following suggestions be included in the revised Bulbout Variation 3 design:

i. Revise bulbout shape to be more square
ii. Protect utilities in place to avoid relocation costs
iii. Simplify plant layout using ground cover in low-flow channel areas and taller plants in upland zone; do not place plants at inlets
iv. Add more curb cut inlets and ensure sidewalk can drain freely into bioretention planter

d. <u>Bioretention Bulbout Variation 4:</u> Combined Bioretention and Planting Area Adjacent to Raised Bike Lane at Midblock Crossing. Per the suggestion of charrette participants, the dedicated raised bike lane is shifted immediately adjacent to the sidewalk and the planting strip and bioretention areas are combined into a multifunctional green space which allows for a more flexible and creative landscape design. The wider footprint provides more space for sloped sides and varied topography and plant types. Additional suggestions that may be incorporated into the final typical conceptual design include:
   i. Remove one crosswalk across Duane Avenue
   ii. Use solid curb ramp crossing with culverts/pipes to hydraulically connect bioretention areas in lieu of more expensive boardwalk-style pedestrian crossings.
   iii. Add more curb cut inlets
   iv. Provide raised pavement markers or something similar to safely delineate the bike lane from the sidewalk
   v. Ensure pedestrian/bike crossings are safe and meet all applicable code
   vi. Create meandering low-flow channel
   vii. Consider sight lines at pedestrian crossings
   viii. Create forebay to capture trash and sediment at first inlets

2. Under a separate project contract, develop the following guidance documents:
   a. Site selection guidance for the integration of bioretention bulbouts with pedestrian and/or bike improvement projects, and
   b. Key planning and design considerations for bioretention bulbouts.

5 ACKNOWLEDGEMENTS

Special thanks to the Charrette Advisory Committee:

- Elaine Marshall, City of Sunnyvale
- Geoff Brosseau, BASMAA
- Josh Bradt, SFEP
- Keith Litchen, RWQCB
- Ken Kortkamp, SFPUC
- Kristin Hathaway, City of Oakland
- Leo Chow, City of San Mateo
- Luisa Valiela, USEPA
- Matt Fabry, BASMAA

And the Charrette Participants:

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Daniel Apt
Lisa Austin
Lisa Beyer
Jill Bicknell
Dale Bowyer
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Leo Chow
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Sarah Sutton
David Swartz
Joe Tootle
Melody Tovar
Christy Villa
Jason Wright
Eric Zickler

APPENDIX A

Site Selection Criteria Technical Memorandum dated June 29, 2016

Lotus Water
engineering solutions for a better environment

215 Kearny Street, Suite B, San Francisco, CA 94108
(415) 800-6805 www.lotuswater.com

From: Lotus Water

For: Horizon-BASMAA staff

Date: June 29, 2016

Project: BASMAA Urban Greening Bay Area

RE: Charrette Action Items from June 21 Kickoff Meeting

This memo provides information required by the following two action items from the June 21 kickoff meeting for the Urban Greening Bay Area Project:

- Prepare site selection criteria for the Cities of San Mateo and Sunnyvale to consider with cost, performance, and transferability of designs in mind.
- Provide a list of potential Charrette participants for consideration by BASMAA

Criteria to Assist Cities with Site Selection (preliminary)The following preliminary site selection criteria are provided for consideration. Please note that this is not a list of requirements, but recommendations. Any particular site is unlikely to meet all of these criteria. In general, sites that meet a larger number of these criteria are anticipated to be more suitable than sites that meet a lower number of criteria. However, there may be site-specific mitigating factors, and sites that meet a larger number of the criteria may not be most suitable if, for example, hazardous conditions exist at the site.

- Physical Configuration:
  - Standard Block/Intersection, street width, sidewalk width, and block length
  - Four-way intersections with the most common dimensions and parking lanes
  - Significant distance between curb radius and nearest driveway/access
  - No potential conflicts with ADA parking spaces and/or loading zones
- Drainage Infrastructure: End of block catch basins
- Utilities: No known major utility conflicts within the parking lane zones near the intersection corners
- Topography/Elevation: Suitable drainage management areas/intersections at low points, low to moderate slope and typical street crowns
- Soils: Infiltrative or sandy soils (Type A or B to eliminate the need for underdrains and additional infrastructure); no known presence of contaminated soils; groundwater below 10'; no shallow bedrock
- Land Use:
  - Lower density (with cost in-mind)
  - Lower number of parcels per block in higher density areas
  - Non-Mass Transit Streets
  - Non-major arterial streets with heavy-truck traffic

- Capital Project Coordination: Known street, pedestrian, or bicycle project scheduled in same location in an early design phase
- Miscellaneous: highly visible, adjacent, or nearby, to existing feature that requires landscape maintenance, no potential security risks (such as a known drug-use area)

Draft Charrette Participants

The number of participants should be between 18 and 27 to keep the groups manageable and costs reasonable. Ideally an even distribution of disciplines would be included in each group. For example: If we had three sites, with three different groups, then we would want to have an engineer in each one, a landscape architect in each one, and so on.

Types of Participants and suggested candidates:

- Engineer or water quality professional from San Mateo and Sunnyvale
- Capital budget-minded representative from San Mateo and Sunnyvale
- Civil Engineers with direct streetscape and green infrastructure experience (built work)
- Landscape architects with Bay Area green infrastructure experience and knowledge of native plant species (Kevin Robert Perry)
- Construction Management/Inspectors from Bay Area Municipalities (Michael Adamow, SFPUC, GI Construction Management Specialist)
- Contractors who have recently won a bid or constructed a green infrastructure project on Peninsula
- Pedestrian and/or Bicycle planner with Peninsula experience (Horizon staff has worked with and would recommend John Ciccarelli, who has done work for San Mateo County Health System)

APPENDIX B

Design Charrette Site Identification Technical Memorandum dated August 31, 2016

Office:
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(510) 986-1851
www.horizonh2o.com

Technical Memorandum

To: Geoff Brosseau, BASMAA

From: Laura Prickett, AICP, CPESC, QSD

Date: August 31, 2016

Re: Urban Greening Bay Area - Design Charrette Site Identification

1. Purpose and Organization of this Memorandum

This memorandum documents the task to assist the cities of San Mateo and Sunnyvale in identifying intersections within their respective jurisdictions for green infrastructure improvements, and the process to confirm that selected intersections are as representative as possible of applicable common features of road segments that make up intersections found throughout Bay Area cities.

The memo begins with an introduction to the Design Charrette as part of the larger Urban Greening Bay Area project, followed by a description of the analytic approach used identify applicable common features of intersections in Bay Area cities, a summary of the findings of the intersection analysis, and a discussion of the candidate sites identified by the cities of San Mateo and Sunnyvale.

2. Introduction

The Design Charrette task is part of the Urban Greening Bay Area grant project, which is funded by Region IX of the US Environmental Protection Agency (USEPA) Water Quality Improvement Funds, awarded to the Association of Bay Area Governments (ABAG), a joint powers agency acting on behalf of the San Francisco Estuary Partnership (SFEP), a program of ABAG.

The Bay Area Stormwater Management Agencies Association (BASMAA) is a member of the team headed by SFEP that was awarded the grant. BASMAA is leading the development and implementation of a Design Charrette, to develop cost-effective and innovative “typical” designs for integrating green infrastructure with bicycle and pedestrian improvements at roadway intersections. The overall goal in developing standardized, transferable designs is to make progress in addressing the high cost of design, implementation, operations, and maintenance that inhibits the widespread use of green infrastructure and LID features. The Design Charrette will utilize actual intersection locations in San Mateo and Sunnyvale that are as representative as possible of the common features of road segments that make up intersections found throughout Bay Area cities. The development of the Design Charrette is guided by the Roundtable Task Team, which consists of representatives of USEPA, SFEP, the San Francisco Bay Regional Water Quality Control Board (Regional Water Board), BASMAA, the San Francisco Public Utilities Commission (SFPUC), and the cities of San Mateo, Sunnyvale, and Oakland. Horizon Water and

Environment (Horizon) is leading a team of consultants to support the development and implementation of the Design Charrette.

As part of the site identification phase of the Design Charrette, the Horizon team coordinated with the cities of San Mateo and Sunnyvale, and other members of the Charrette Advisory Committee, to identify candidate intersections. Horizon's team member Lotus Water prepared a memorandum providing site selection criteria to assist the cities in the site selection process, which is included as Attachment A. Team member Geosyntec conducted a GIS analysis to assist in verifying that selected intersections are as representative as possible of the common features of road segments that make up intersections found throughout Bay Area cities. Geosyntec's analysis is documented in a memorandum included as Attachment B.

3. Analytic Approach to Identify Common Intersection Features

The approach to identifying applicable, common roadway intersection features utilized GIS technology to identify the frequency of the occurrence of intersections, and corners within intersections, that have common roadway features that are applicable to the implementation of green infrastructure. Due to the complexity of the analysis, it was necessary to limit the GIS roadway feature analysis to four parameters, and to limit the study area to one city, as described below.

Roadway Features Analyzed

Based on the experience of the Charrette Advisory Committee and the Horizon team in designing and implementing green infrastructure projects, and the anticipated needs for the development of typical design drawings, the following intersection features were prioritized for analysis:

- Intersection corners with a 90 degree angle,
- The presence of a storm drain inlet that connects to a storm drain main,
- Configuration of on-street parking, and
- Underlying soil type.

Applicability of the GIS Study Area to Bay Area Cities

The GIS analysis was conducted within the City of San Mateo, identifying the frequency of occurrence of the four roadway features described above throughout the City of San Mateo. These results may be considered reasonably representative of common roadway intersection conditions in other Bay Area cities, based on the following considerations.

Prevalence of Intersections with 90-Degree Corners. Historic maps indicate that a dominant rectilinear street grid was established in the City of San Mateo early in its development (City of San Mateo 2012), as is typical of cities in the American West (Knight 2012). Later development in San Mateo, particularly during the extensive build-out of the city during the post-World War II era, expanded upon the street grid, and also introduced some curvilinear roadways. Patterns of development within San Mateo's downtown area can be expected to be similar to pre-World War II downtown street grids in other cities. Patterns of development in other parts of the city can be expected to be similar to areas of other cities that were developed during the major development expansion that occurred in the Bay Area in the postwar era.

Storm Drain Inlets at Intersections. Section 837.3 of the Caltrans Highway Design Manual (Caltrans 2016) identifies intersections a one of the locations at which a storm drain inlet is nearly always required. However, the Manual indicates that, under certain conditions (where the gutter flow is small and vehicular, bicycle, and pedestrian traffic are not important considerations) stormwater flows may be carried across the intersection in a valley gutter and intercepted by an inlet downstream. It is reasonable to expect that storm drain inlets will frequently be present at intersections in Bay Area cities, except for cities in which stormwater is frequently conveyed through intersections. For example, within the City of San Mateo there are some drain inlets that do not connect to the storm drain main, and, instead, allow stormwater to flow in a pipe to the other side of an intersection, where it “bubbles up” and continues to flow downstream in the gutter. The GIS analysis controlled for this occurrence, by including in the analysis only the storm drain inlets that connect to a storm main.

Configuration of On-Street Parking. A survey of Public Works and Traffic Engineering Departments of 56 California cities and 19 cities nationwide found that the average standard roadway width for residential streets was 36 to 40 feet, a width that was preferred by transportation officials because it allows for on-street parking on both sides of a street. Additionally, most cities were found to rely on standards for right-of-way width that were established by the Institute of Transportation Engineers in 1967 (Ben Josef, 1995). Based on the prevalence and longevity of street design standards that allow for on-street parking, it is anticipated that on-street parking would be prevalent in most Bay Area cities.

Soil Type. The Low Impact Development Feasibility Report prepared by BASMAA (2011) included mapping of hydrologic soil groups for Alameda, Contra Costa, San Mateo, Santa Clara counties, and portions of Solano County. In general, low-lying portions of these counties have substantial areas of poorly-drained soils (hydrologic soil group D), with well-drained soils occurring primarily in hillside areas. Urbanization has occurred primarily within low-lying areas, and it is reasonable to expect that many Bay Area cities include substantial areas of poorly drained soils, similar to findings for the City of San Mateo, described in Section 4, below.

4. Summary of Findings of the Intersection Analysis

The GIS analysis used individual street corners as the unit of analysis. As shown in Table 1, a total of 1,560 intersections were identified in the City of San Mateo, consisting of a total 4,010 corners. The GIS analysis indicated that approximately 15 percent of the corners can be expected to have all three of the following conditions: the corners are located adjacent to a drain inlet connected to a storm main, have an approximately 90-degree angle, and have on-street parallel parking on both legs of the intersection.

Of the three conditions, the chief limiting condition may be proximity to a drain inlet connected to a storm main. Only 28 percent of all corners in the city have this condition. The angle analysis was conducted only for the universe of corners that are adjacent to a drain inlet connected to a storm main. As shown in Table 2, the angle analysis found that there was an approximately 90-degree angle at 66 percent of the corners that are adjacent to a drain inlet connected to a storm main.

The parking analysis was conducted for a random sample of the intersections that met the first two conditions (corners located adjacent to a drain inlet connected to a storm main, and with an approximately 90-degree angle). The parking analysis found that 85 percent of corners that met the first two conditions had parallel parking on both legs of the corner. More detail regarding the GIS analysis is provided in Attachment B.

Table 1:
Summary of Findings from the GIS Analysis

Feature	Number of Occurrences	Percentage of Occurrences
Total intersections	1,560	100%
Total corners	4,010	100%
Corners adjacent to inlet connected to storm main	1,116	28%
Corners approximately 90 degrees, adjacent to inlet connected to storm main	737	18%
Percentage of corners approximately 90 degrees, adjacent to inlet connected to storm main, and are estimated to have parallel parking on both legs of the intersection[1]	626 (estimated)	15% (estimated)

Source: Geosyntec Consultants 2016

[1] The parking analysis was based on a random sample of the 737 corners that are approximately 90 degrees, and are adjacent to inlet connected to storm main. Eighty-five percent of the sampled intersections had parallel parking on both legs of the intersection. It may be estimated that 85 percent of the 737 corners have parallel parking on both legs, which would amount to 626 corners, or 15 percent of all corners.

Table 2:
Results of the Angle Analysis of Corners Adjacent to Inlet Connected to Storm Main

Feature	Number of Occurrences	Percentage of Occurrences
Total corners adjacent to inlet connected to storm main	1,116	100%
Corners approximately 90 degrees, adjacent to inlet connected to storm main	737	66%

Source: Geosyntec Consultants 2016

5. Candidate Sites for the Design Charrette Task

In order to maximize cost efficiencies in project implementation, the cities of San Mateo and Sunnyvale sought to incorporate green infrastructure improvements in capital projects that have been scheduled, or could potentially be scheduled, to begin construction in mid-2017. From that group of projects, the cities prioritized projects that include at least two 90-degree corners, have a storm drain line to which an underdrain may be connected, have on-street parking, and do not have any constraints that would preclude construction of bulb-outs at the intersection corners. An example of a condition that would preclude construction of bulb-outs is a dedicated right-turn lane. The cities also considered additional criteria that were identified in the Site Selection Criteria memo prepared by consultant team member Lotus Water (Attachment A).

The consultant team assisted city staff in reviewing a number of candidate intersections. The status of the site reviews is shown in Table 3. The City of San Mateo has verified that the sites that are currently under consideration in San Mateo (4th Avenue/Fremont Street and 29th Avenue/Juniper Street) each have at least two 90-degree corners, have a storm drain line to which an underdrain may be connected, and have on-street parallel parking, and do not have dedicated right-turn lanes. The City of San Mateo is currently reviewing these intersections to consider conditions such as roadway width, recent construction that may have occurred at these intersections, and opportunities to improve Americans with Disabilities Act (ADA) access. The City of Sunnyvale is currently reviewing an intersection on North Sunnyvale Avenue, near Bishop Elementary School, for potential installation of pedestrian bulb-outs that could include green infrastructure facilities.

Table 3:
Sites Reviewed for Potential to Develop Green Infrastructure

	Intersection	City	Status/Considerations
1	9th Avenue/ Claremont Street	San Mateo	Removed from further consideration/ a corner lacks 90 degree angle
2	9th Avenue/ El Dorado Street	San Mateo	Removed from further consideration/ lacks adequate storm drain
3	10th Avenue/El Dorado Street	San Mateo	Removed from further consideration/ lacks adequate storm drain
4	4th Avenue/El Dorado Street	San Mateo	Removed from further consideration/ lacks adequate storm drain
5	4th Avenue/Fremont Street	San Mateo	Currently under consideration
6	29th Avenue/Juniper Street	San Mateo	Currently under consideration
7	Mathilda Avenue – pedestrian safety improvements at channeled right turn lanes	Sunnyvale	Removed from further consideration/ lacks corners with 90 degree angles
8	North Sunnyvale Ave and East Taylor Avenue	Sunnyvale	Currently under consideration

6. References

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DRAFT Memorandum

Date: 25 August 2016

To: Matt Fabry, San Mateo County and Geoff Brosseau, BASMAA

Copies to: Laura Prickett, Horizon Environmental

From: Kelly Havens, Geosyntec Consultants

Subject: Urban Greening Bay Area Project – Design Charrette GIS Intersection Frequency Analysis

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INTRODUCTION AND GOAL

The Urban Greening Bay Area Project includes a Design Charrette to develop cost-effective green infrastructure designs for typical roadway intersections. The Charrette includes the development of conceptual designs for BMPs that could be implemented in these intersections, as well as an assessment of how frequently typical roadway intersections occur in the Bay Area region.

Geosyntec conducted a GIS analysis to identify the frequency that intersections characterized as typical roadway intersections occur in the Bay Area region. This memorandum serves to summarize the analysis conducted and the frequency results.

METHODOLOGY

Overview

The GIS methodology employed for this analysis entailed screening and analysis of shapefiles provided by the City of San Mateo to identify typical roadway intersections where generic BMP designs could be implemented. As BMPs would typically be implemented at one or more corners in any given intersection, corners were identified as the unit which would be analyzed for frequency of occurrence.

Based on discussions with the BASMAA team and the Project team, the characteristics associated with corners located in typical roadway intersections that would be feasible for BMP implementation include the following:

1. Corner angle is approximately 90 degrees
2. Inlet that is connected to the storm main is present at corner

Parking configuration and underlying soil type were two other factors brought up by the team that were considered relevant to suitability of implementation of a generic BMP.

Analysis Steps

Data received for the analysis included the City of San Mateo street layer (a line layer) and the City of San Mateo storm drain layer (consisting of points and storm drain lines). A summary of the analysis steps are included below:

1. Using the street layer, all intersections and corners in the City were identified. To identify the "total corners", the following steps were conducted:
    a. Corners associated with highways or bridges were removed using visual assessment.
    b. Angles of corners were calculated based on the street layer linework.
    c. Corners with angles greater than 175 degrees were removed (these were found to represent street ends through visual assessment).
2. Once the total corners were estimated, those corners adjacent to an inlet connected to a storm main were identified using the following steps:
    a. Storm main lines were extracted from the storm drain layer.
    b. Inlet points connected to the storm main lines were identified.
    c. Corners within 30 feet of an inlet connected to a storm main were identified using a buffer analysis.
3. Corners adjacent to an inlet connected to a storm main that were approximately 90 degrees were then identified.
    a. Corners with angles ranging from 87.5 degrees to 92.5 degrees were assumed to be approximately 90 degrees. This range was found to adequately represent an average of 90 degree corners based on a visual assessment of the corners in different angle ranges (85 to 95, 87.5 to 92.5, 89.5 to 90.5, and 89.95 to 90.05).
4. These corners were analyzed for underlying soil type using the NRCS SSURGO dataset available through Web Soil Survey (http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm).

To examine parking configuration for the identified corners, a visual assessment was conducted on half of the corners identified. These corners were identified using a random selection tool available in ArcGIS. The first 100 feet of curb of the corners were examined in Google Earth to characterize parking on both parking legs.

RESULTS

The analysis yielded a total of 1,560 intersections in the city, and a total of 4,010 corners with less than a 175 degree angle. Twenty-eight percent of those corners were within 30 feet of an inlet connected to a storm main. Of those, approximately 65% (18% of total corners) were found to be approximately 90 degrees (i.e. with an angle within the 87.5 to 92.5 degree range). When examining how many total intersections contained at least one of these corners, it was found that approximately one quarter of City intersections contained a corner with the identified characteristics. A summary of the corner analysis is provided in Table X below:

Table 1: Summary of Intersections and Corners

Feature	Number	Percent of Total
Total Intersections[1]	1,560	100%
Total Corners[1,2]	4,010	100%
Corners Adjacent to Inlet Connected to Storm Main[1,2]	1,116	28%
Corners Approximately 90 degrees, Adjacent to Inlet Connected to Storm Main[1,3]	737	18%
Intersections with at least one Corner Approximately 90 degrees, Adjacent to Inlet Connected to Storm Main[1,3]	399	26%

1 Does not include highway or bridge adjacent intersections or corners.
2 Includes corners with angle of 175 degrees or less.
3 Includes corners with angle between 87.5 and 92.5 degrees.

Of the 737 identified corners that are approximately 90 degrees, and are adjacent to an inlet connected to a storm main, one half of the corners (rounded to 369 corners) were randomly selected and were visually assessed for parking configuration (Angled, Parallel, or No Parking Allowed). The findings of that assessment are presented in Table 2. In addition to the three parking configurations examined, four (about 1%) of the 369 corners visually assessed consisted either of points that were not actually corners (i.e. a driveway or alleyway was represented instead of a street) or the parking configuration was not able to be determined.

The majority of corners assessed include parallel parking on both parking legs (85%). Only about 2 percent (9 total corners) included parallel parking on one leg and angled parking on the other leg.

Table 2: Summary of Visual Assessment of Parking Configuration

Parking Leg I	Parking Leg II	Number of Corners Assessed	Percent of Corners Assessed[1]
Angled	Angled	1	0.3%
Angled	Parallel	9	2%
Angled	No Parking Allowed	4	1%
Parallel	Parallel	312	85%
Parallel	No Parking Allowed	32	9%
No Parking Allowed	No Parking Allowed	7	2%
N/A or Unable to Determine	N/A or Unable to Determine	4	1%
Total		369	100%

[1] Does not sum to 100% due to rounding.

The vast majority of soil underlying the identified corners was identified by NRCS as cut and fill or urban land. No hydrologic soil group is identified by NRCS for these soil types, but they are typically assumed to be poorly drained soils. Less than one percent of these corners (5 corners) were underlain by hydrologic soil group C soils.

Figure 1 displays the results of this analysis graphically.

Application to Greater Bay Area

A detailed analysis was not conducted to examine the representativeness of San Mateo as compared to the greater Bay Area. Land use was approximately identified during the visual assessment conducted to examine parking configuration for the identified corners. Based on that assessment, approximately 85% of the corners were located in residential land use areas. The majority of the remaining corners were located in commercial land use areas, with very few located in industrial, mixed use, and open space land use areas. Whether the high proportion of residential land use is representative of City of San Mateo or if this is a function of the identified corner characteristics (or both) was not examined as part of the scope of this work.

Land use does appear to affect parking configuration based on the visual assessment conducted. Per the assessment, no angled parking was observed in residential areas, whereas at least one leg of angled parking was observed for approximately 25% of corners located in commercial land use areas.

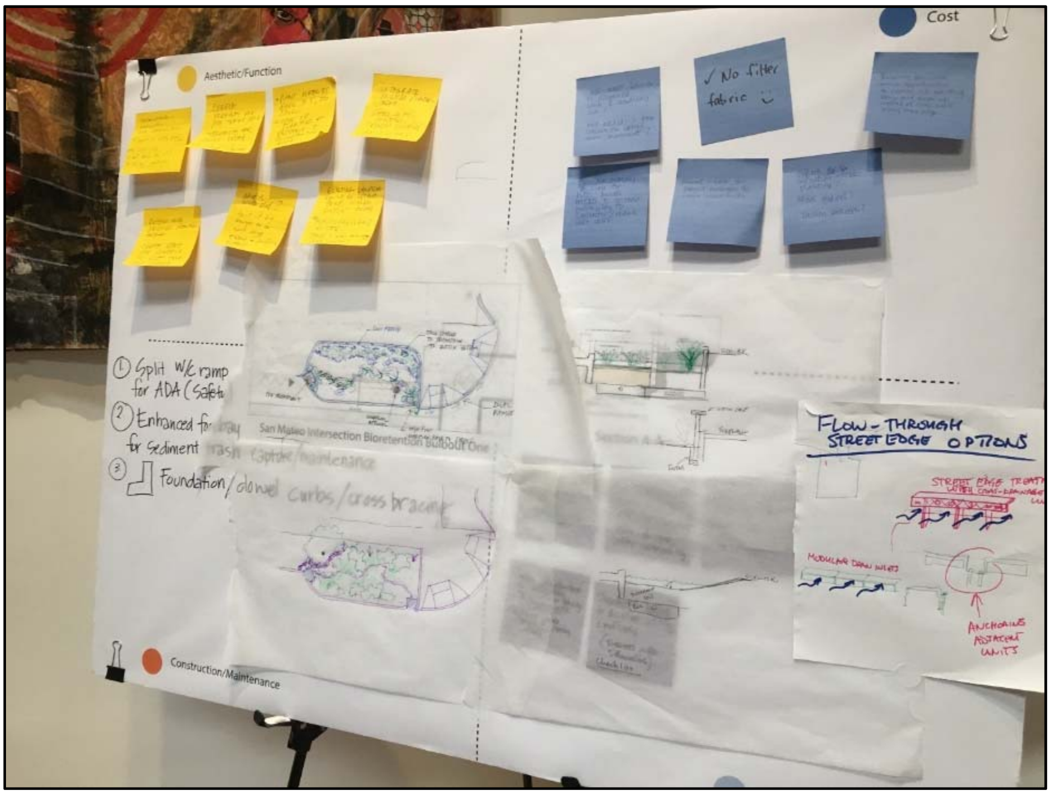
* * * * *

APPENDIX C

Design Exercise I Boards and Notes

Bulbout Variation One

Photo of Charrette Board:



Participant Feedback:

Aesthetic/Function

- Functional Elements:
  - Curb and gutter
  - DMA contribution varies
  - Expand into existing planter strip
  - Too cookie cutter
  - Don’t block the inlet
  - Forebay consideration
- Create forebay for pre-treatment
- Opportunity for street trees
- Plant materials grow to 5’, too tall
- Open planting at entrance to bioretention area
- Integrate existing planting area
- Avoid walls

- Extend into existing planting area
- Create space for someone to sit, tree for shade
- What is watershed? Is it big enough to be worth doing?
- Expand to perform better
- Existing landscaping could be upland zone, maybe support trees
- Add functional curb and gutter
- There is non-functioning curb/existing

Cost

- Use water barrier vs. deepened curb at roadway side? Not needed, is there concern for lateral water movement?
- No filter fabric
- Removing tree could provide opportunities to expand into planting strip and slope up instead of conc. Wall along this edge
- Consider economy of scale for bids – bundle projects to increase profitability for contractor/reduce unit costs
- General – look for project synergies to reduce overall costs
- Removing tree could provide opportunities to expand into planting strip and slope up instead of conc. Wall along this edge.
- Explore irrigation – tree planting
- More gravel?
- Tucson palette?

Construction/Maintenance

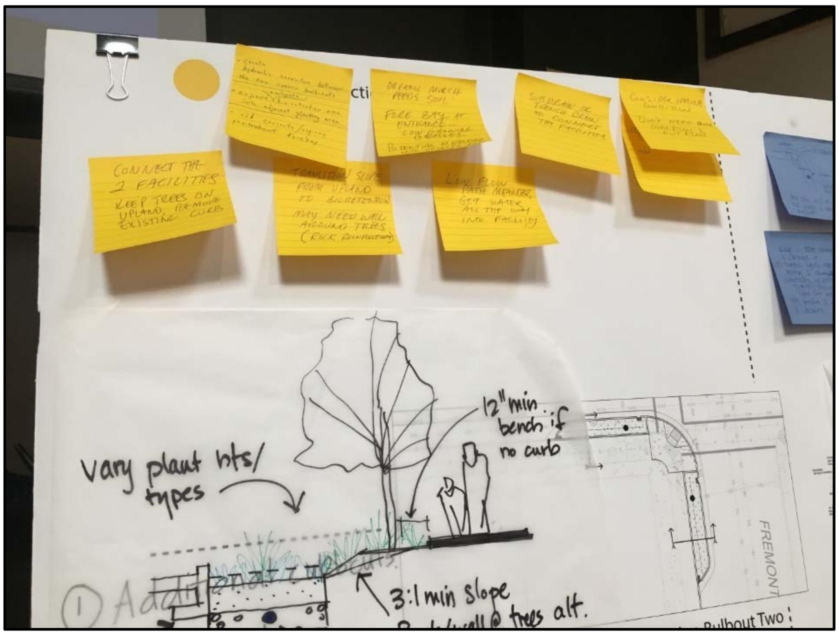
- Split with curb ramp for ADA (safety)
- Enhanced forebay for sediment/trash capture/maintenance
- Foundation/dowel curbs/cross bracing

Repeatability/Synergy

- Standard Detail – to resolve conflicts (sleeves under sidewalks)
- Can underground tree root area be excavated? More money but better sustainability
- Design criteria – WQ sizing or Compulsory GI
- Make GI essential to meeting pedestrian safety
- Sites w/ catch basins more readily repeatable
- Green infrastructure as a solution to constructability of bulb-outs
- Mitigate grade breaks and elevation issues

Bulbout Variation Two

Photo of Charrette Board:



Participant Feedback:

Aesthetic/Function

- Create hydraulic connection between the two corner bulbouts
- Expand and integrate bioretention area into adjacent planting area
- Add concrete/rip-rap pretreatment forebay
- Connect the two facilities. Keep trees on upland, remove existing curb
- Organic mulch feeds soil
- Forebay at entrance – low growing grasses
- Potential meander into upland area
- Low flow path meander, get water all the way into facility
- Subdrain or trench drain to connect the facilities
- Consider offline condition
- Don't need both overflow and outflows
- Remove inside curb wall due to existing trees

Cost

- Keep one ADA ramp at corners if existing traffic lights impede using two ramps. (Conflicts with path of travel). Moving traffic light cost prohibitive. S.M. prefers 2 ramps at corners
- Complicated concrete forms are more money
- Sidewalk drains to upper planted strip
- More SD structures = more money
- Study if raised portion of planter wall on sidewalk side could be flush since it's not immediately adjacent to sidewalk
- Consider extra costs of reducing crowns C street
- Safe route to school/crosswalk design issue

Construction/Maintenance

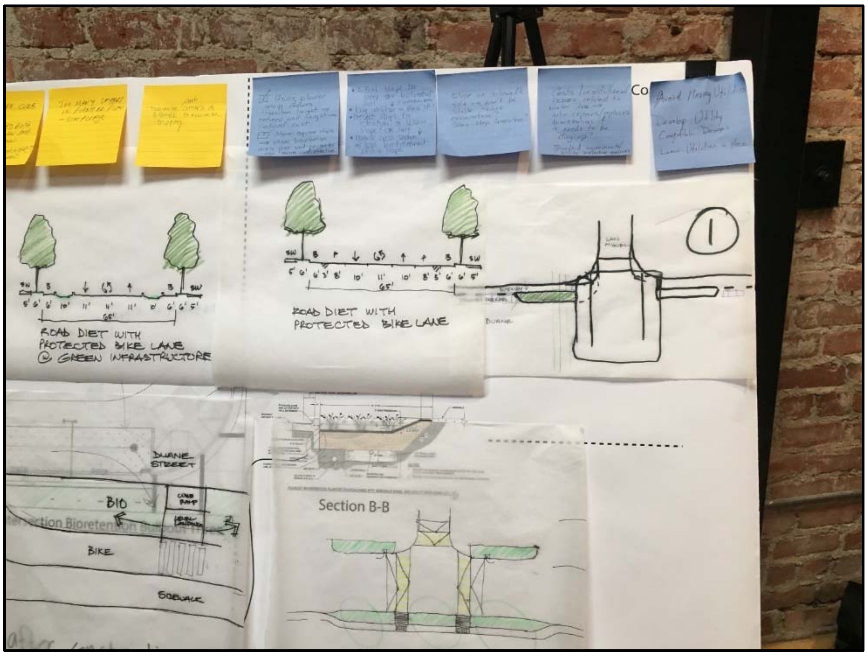
- Split with curb ramp
- Increase width of splash pad and mortar cobbles for energy dissipaters (maintenance)
- Or provide an enhance forebay design to capture sediments and trash

Repeatability/Synergy

- Bi-directional ADA ramps everywhere
- Use LIDAR/reroute data sets to screen sites (technical support needed)
- Create decision support system (parameters) "kit of parts"
- Seek opportunities – safe routes to schools (example)
- One page report with constraints to do field reviews
- Integrate planting strip if no existing trees (or need replacement)
- Curb extension nose can be landscaped (no treatment too small)

Bulbout Variation Three

Photo of Charrette Board:



Participant Feedback:

Aesthetic/Function

- Need to make sure water spreads throughout facility
- Variability of planting for intersection
- Two terraces for interest
- Taper bioretention soil to lose deep curb, but lose bioretention soil
- Use ground cover in bioretention area – but not a lot of good experience with it.
- Add more curb cuts
- Don't need both overflow and outflow
- Why 90-degree corner? Tripping hazard
- Too many layers in planting plan – simplify
- Minimize curb corners in sidewalk to minimize tripping

Cost

- Using planter strip reduces transition height – reduced wall height – reduced cost
- More square shape → more bioretention area per unit perimeter → more cost effective
- 2.5:1 slope too steep for biotreatment soil. ID protection BMPs
- Is keeping utilities in place feasible?

- Precast strips for retention to lessen slope? Or just reduce cross-section w/ less biotreatment soil @ slope
- Slope on sidewalk side won't be stable. Reduce excavation? Stair-step transition?
- Cost/institutional issues related to water line → who repairs/replaces bioretention if it needs to be dug up?
- Standard agreements/utility protection measures
- Avoid moving utility
- Develop utility compatible designs
- Leave utilities in place

Construction/Maintenance

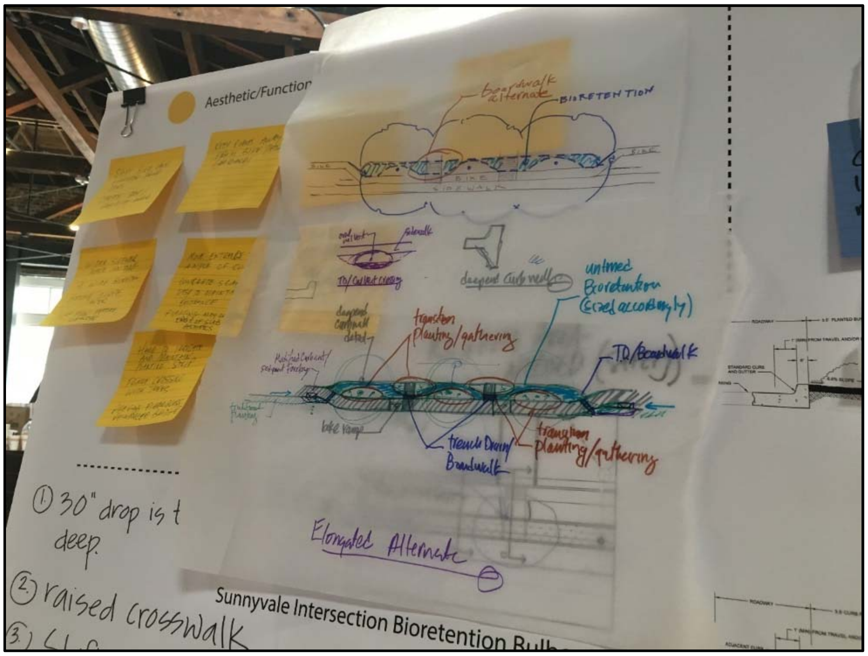
- Additional curb cuts
- False curb
- Round corner with curb
- Soil settlement during and after construction
- Possibly not enough support (dowel, foundation)

Repeatability/Synergy

- Pay attention to bulb radii to support existing/desired uses (bike lane)
- Effective turning radius
- Bike parking?
- Small trees okay

Bulbout Variation Four

Photo of Charrette Board:



Participant Feedback:

Aesthetic/Function

- Shift bike lane farther from cars
- Create stop/respite area
- Wider sidewalk make inviting
- 9' wide bioretention
- Gentle slope, taper
- Low flow feature/meander
- Keep plants away from bike path (hazard)
- Move entrance to angle of curb
- Concrete slab easy to maintain at entrance
- Planting may overhang edge of slab for aesthetics
- Hard to irrigate and maintain planting strip
- Frame crosswalk with trees
- Prefab fiberglass reinforced bridge
- Combine planting areas
- Create congregation zone

- Create bioretention zones
- Flip-flop zones to create interest
- Check dam, terracing
- Put bioretention closer to street
- Don't separate – join the 2 planting strips

Cost

- Remove one crosswalk
- Consider long term maintenance cost
- Instead of bridging curb ramp, use sleeves through to connect bioretention areas
- Trash capture/curb cut pad
- Community buy in – adopt a biofilter
- Combine bioretention planter C street/ move bike lane south
- Cheaper to irrigate one larger strip vs. two long, skinny strips

Construction/Maintenance

- 30" drop is too deep
- Raised crosswalk
- Shift bike-lane
- No trench drain
- Check-dams

Repeatability/Synergy

- Bikeway X-slope
- T-intersection on Mid-Block Example
- Pre-cast bulbout
- Move curb cuts better
- Road diet conflict
- X-walk

APPENDIX D

Design Exercise II Images from Charrette Board

Bulbout Variation One

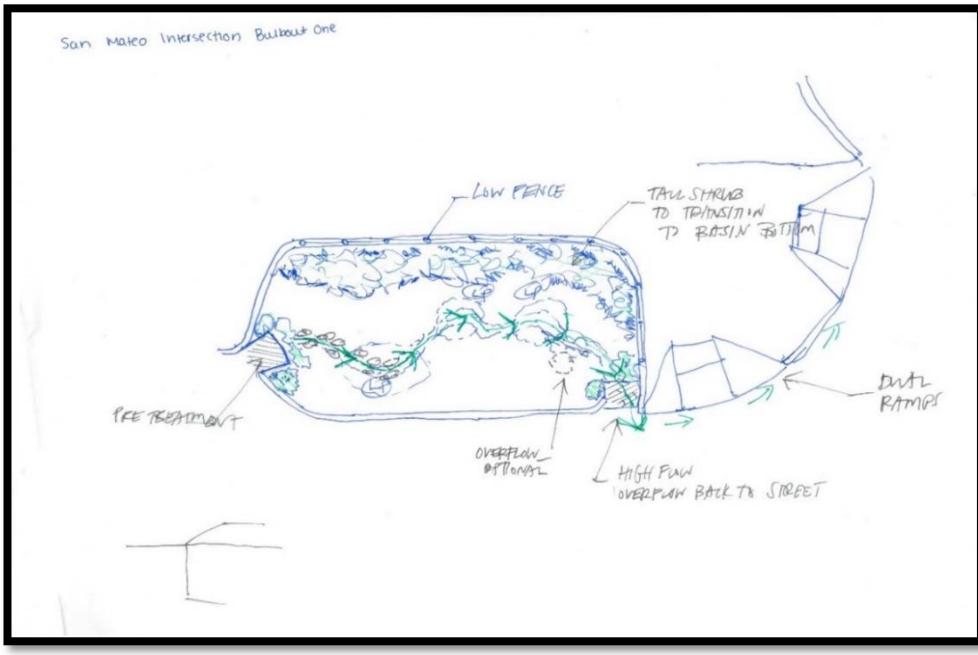


Figure D-112: Bulbout Design Variation 1, Option a: Deep, Flat Bioretention Area

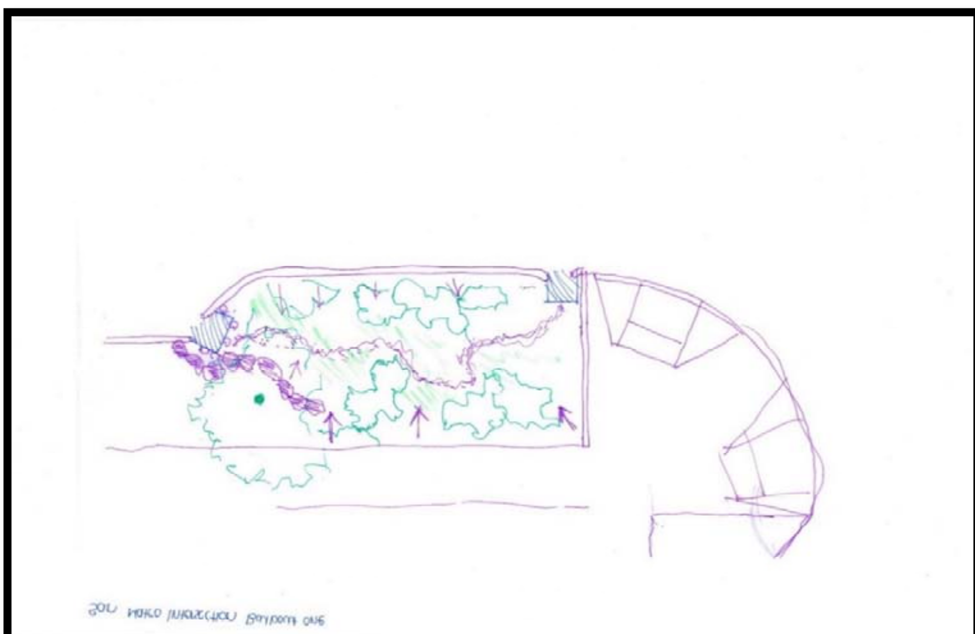


Figure D-2: Bulbout Design Variation 1, Option b: Bioretention Area with Gradual Slope from Sidewalk to Curb

Bulbout Variation Two

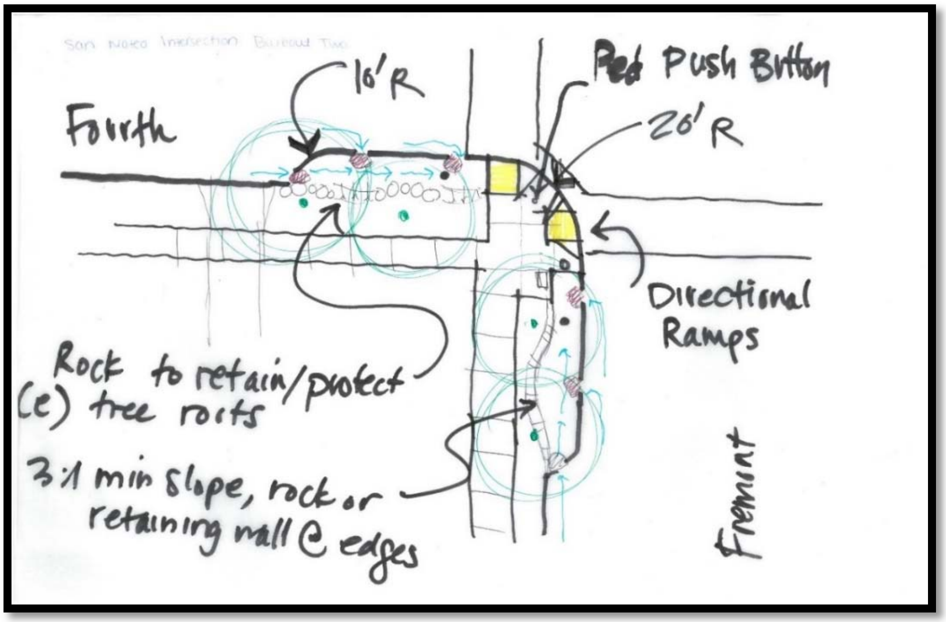


Figure D-3: Bulbout Design Variation 2, View a: Overview of Proposed Design Solutions

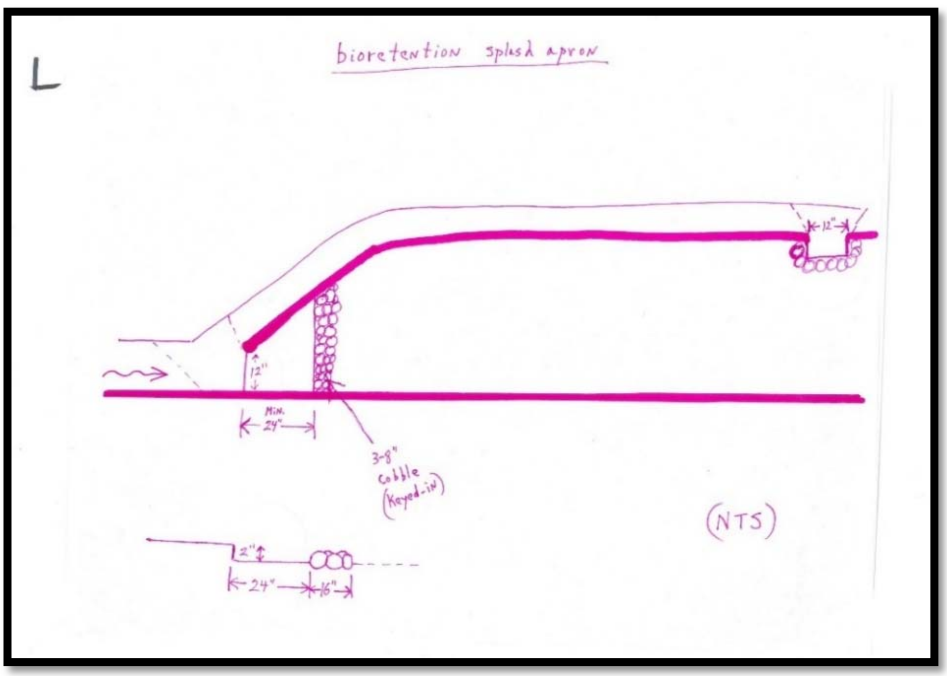


Figure D-4: Bulbout Design Variation 2, View b: Splash Apron Details

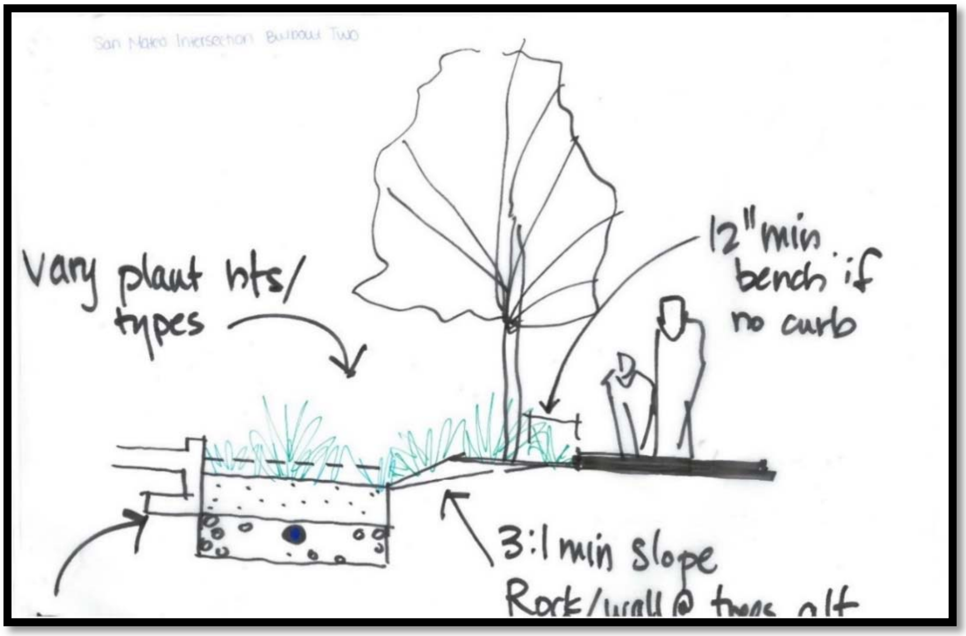


Figure D-5: Bulbout Design Variation 2, View c: Profile Annotated to Allow Design Variants

Bulbout Variation Three

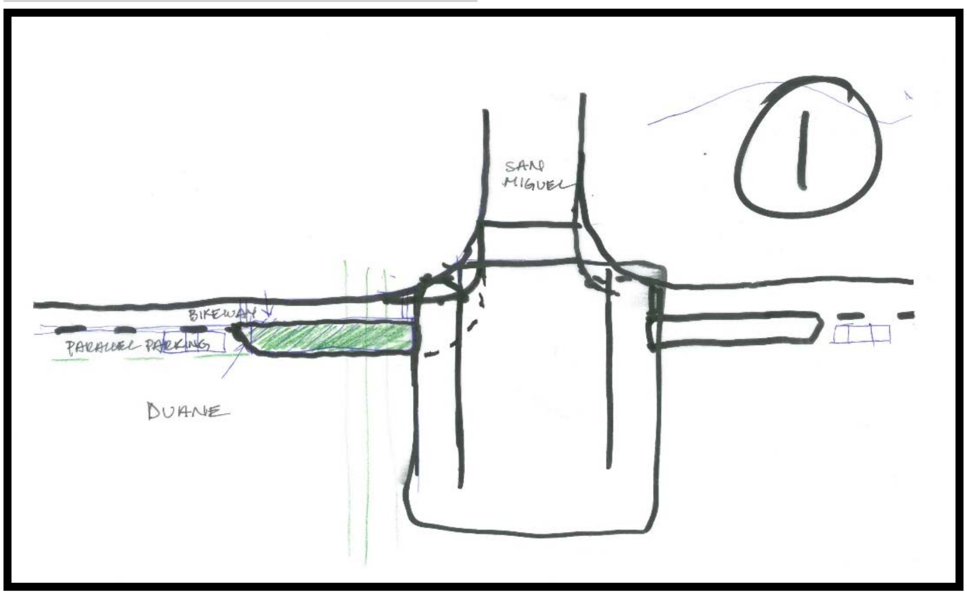


Figure D-6: Bulbout Design Variation 3, View a: Plan View of Proposed Protected Bike Lane

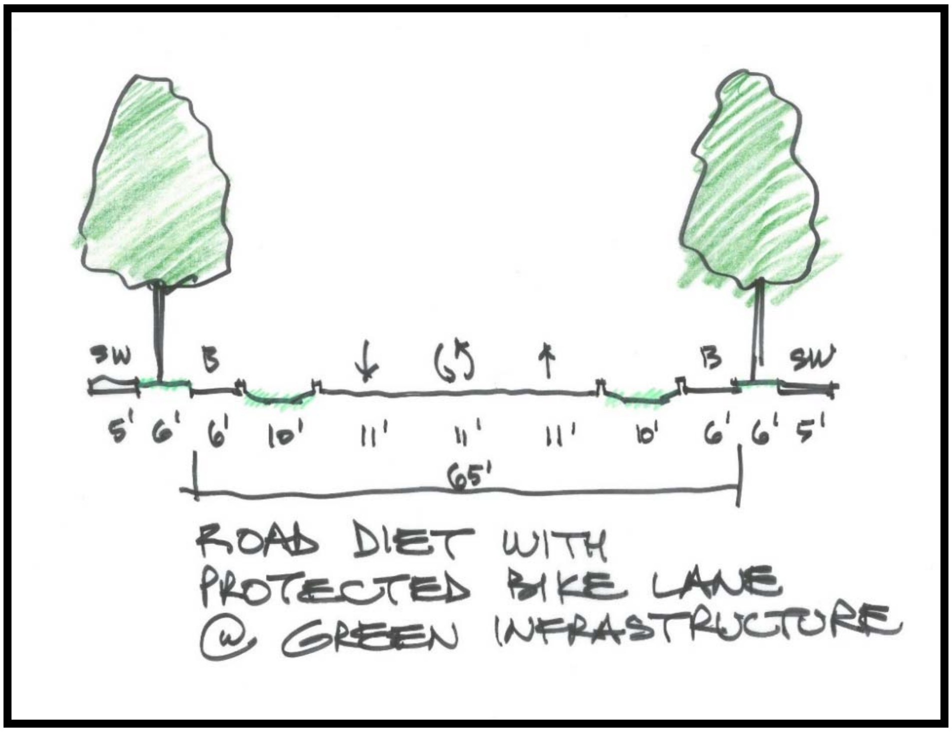


Figure D-7: Bulbout Design Variation 3, View b: Proposed Lane Widths at Bioretention Location

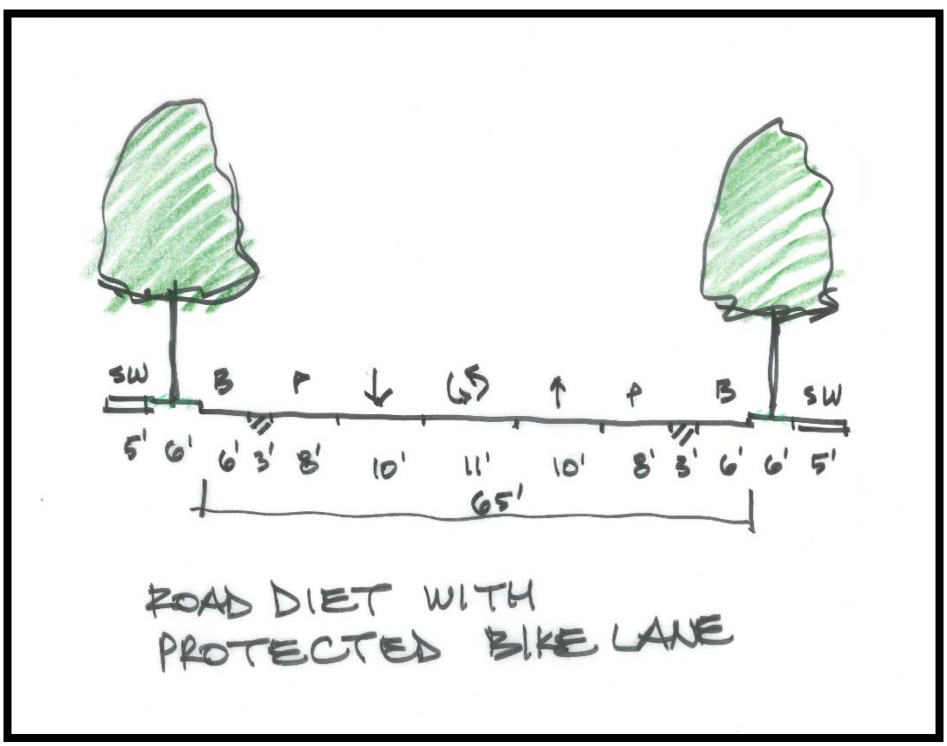


Figure D-8: Bulbout Design Variation 3, View c: Proposed Lane Widths (No Bioretention)

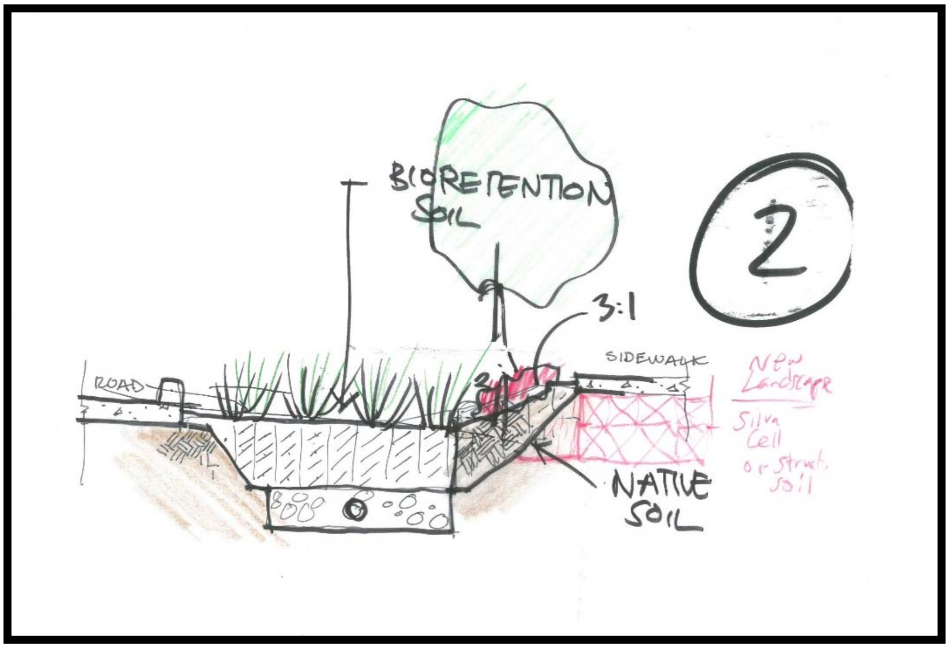


Figure D-9: Bulbout Design Variation 3, View d: Cutaway View – Bioretention Adjacent to Sidewalk

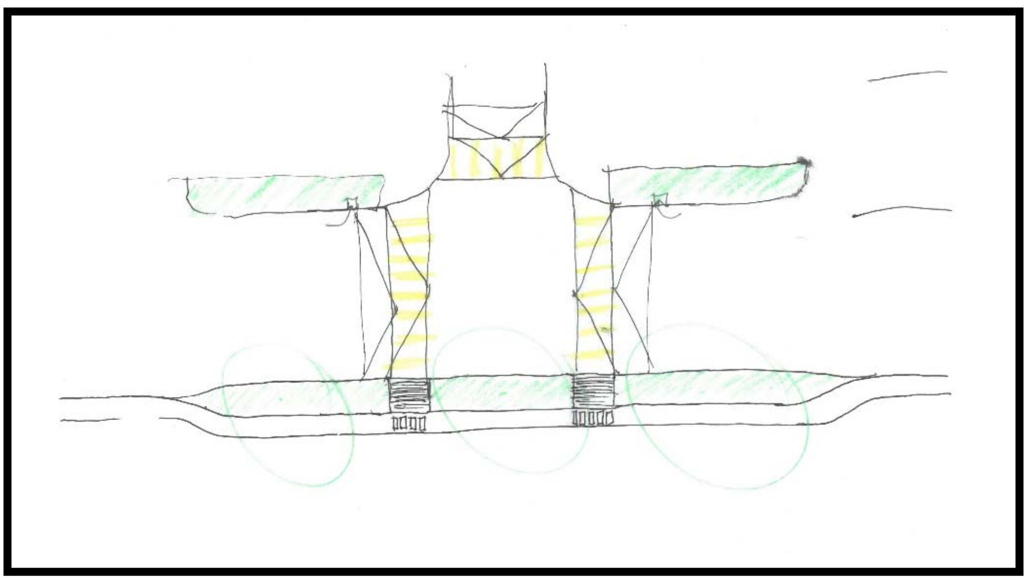


Figure D-10: Bulbout Design Variation 3, View e: Plan View Showing Full Intersection

Bulbout Variation Four

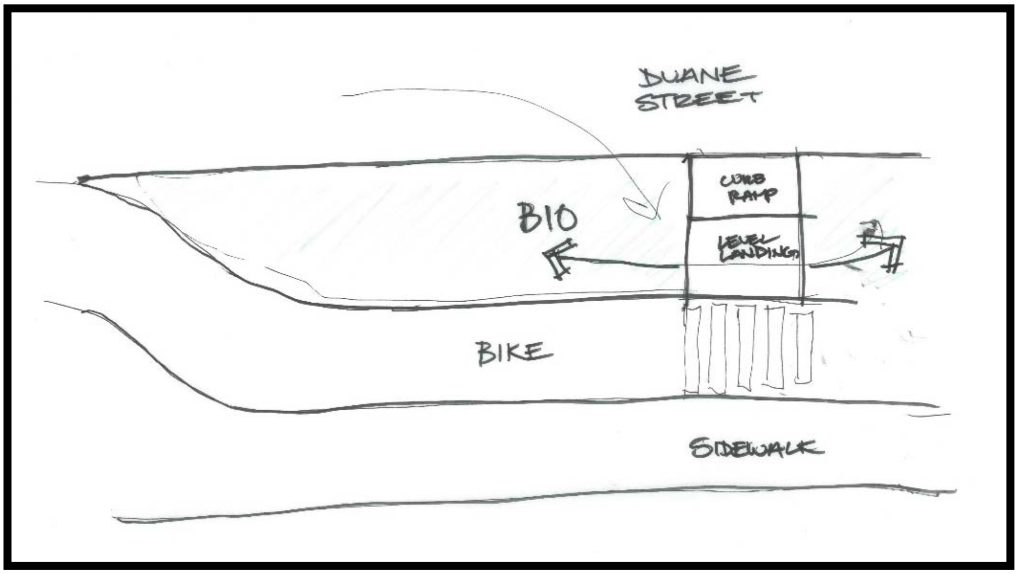


Figure D-11: Bulbout Design Variation 4, View a: Partial Plan View of Pedestrian Crossing Bike Lane and Bioretention Within Bulbout

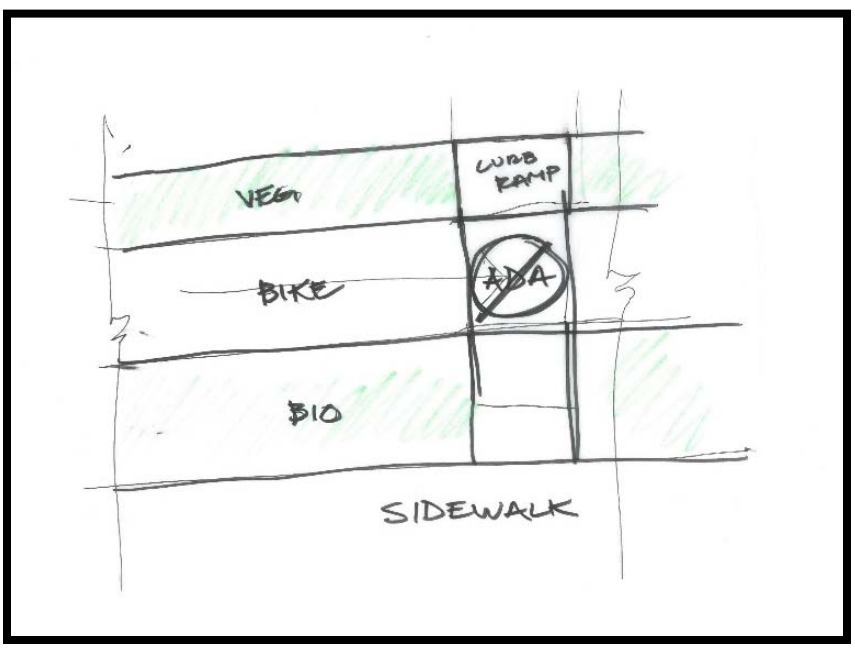


Figure D-12: Bulbout Design Variation 4, View b: Plan View Showing ADA Conflicts with Current Bulbout Design

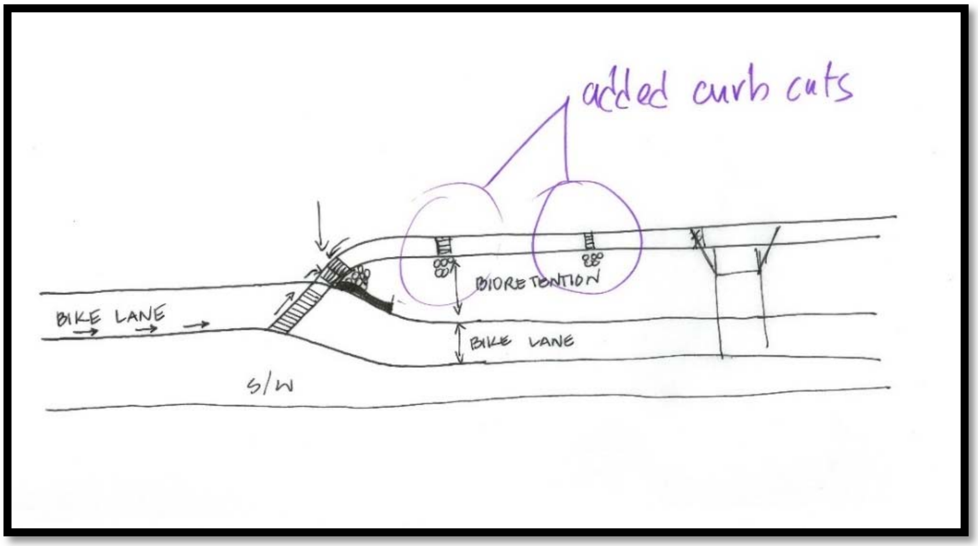


Figure D-13: Bulbout Design Variation 4, View c: Plan View Showing Bike Lane Shift and Inlets

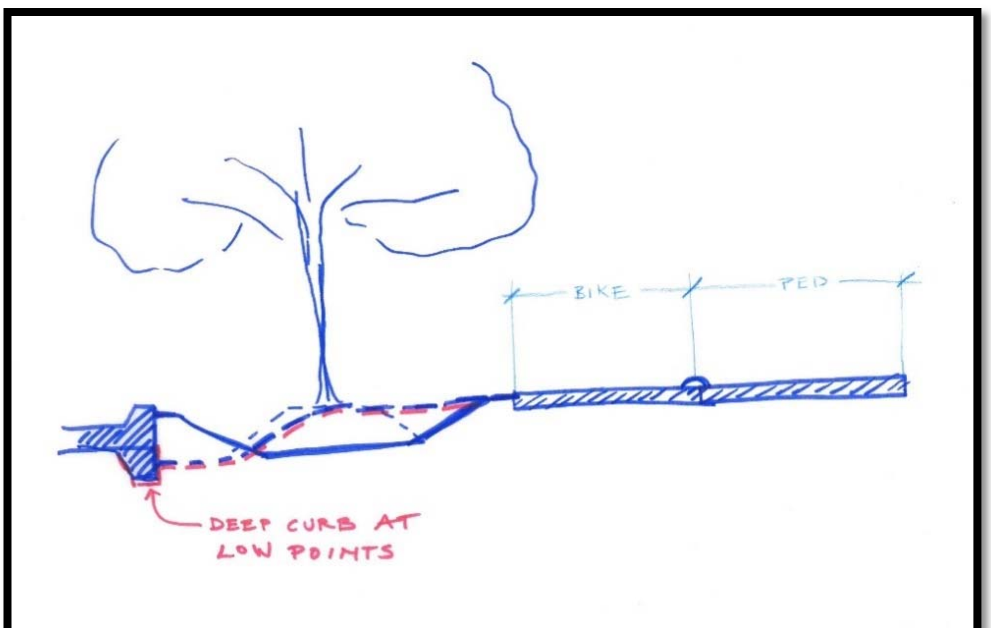


Figure D-14: Bulbout Design Variation 4, View d: Section View of Bulbout with Deepened Roadside Curb at Low Points Only

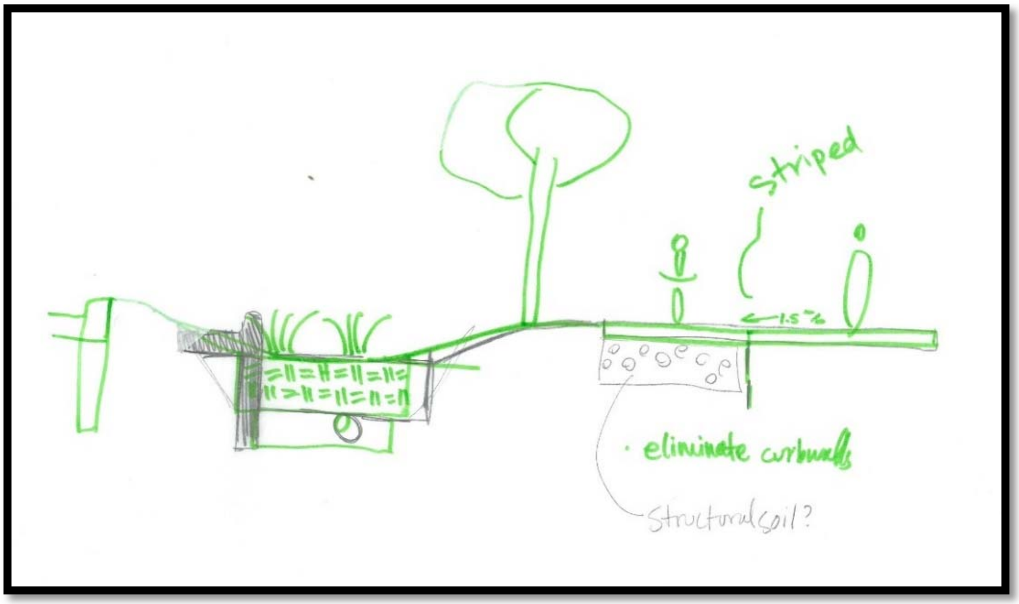


Figure D-15: Bulbout Design Variation 4, View e: Section View of Bulbout with Slope Down to Bioretention and Structural Soil under Bike Lane

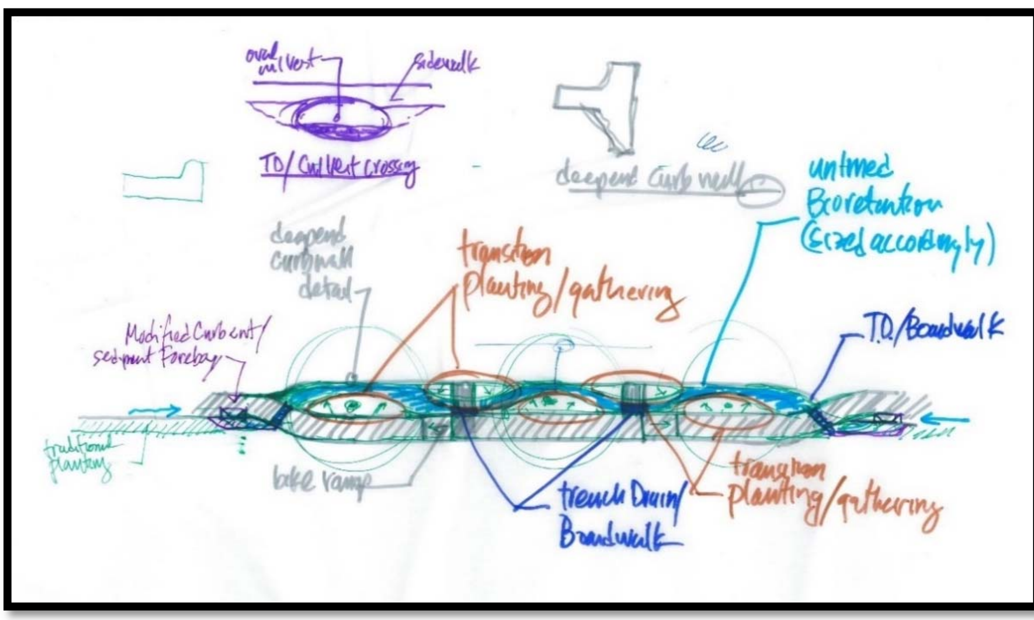


Figure D-16: Bulbout Design Variation 4, View f: Plan View of Entire Bulbout Summarizing the Suggested Changes

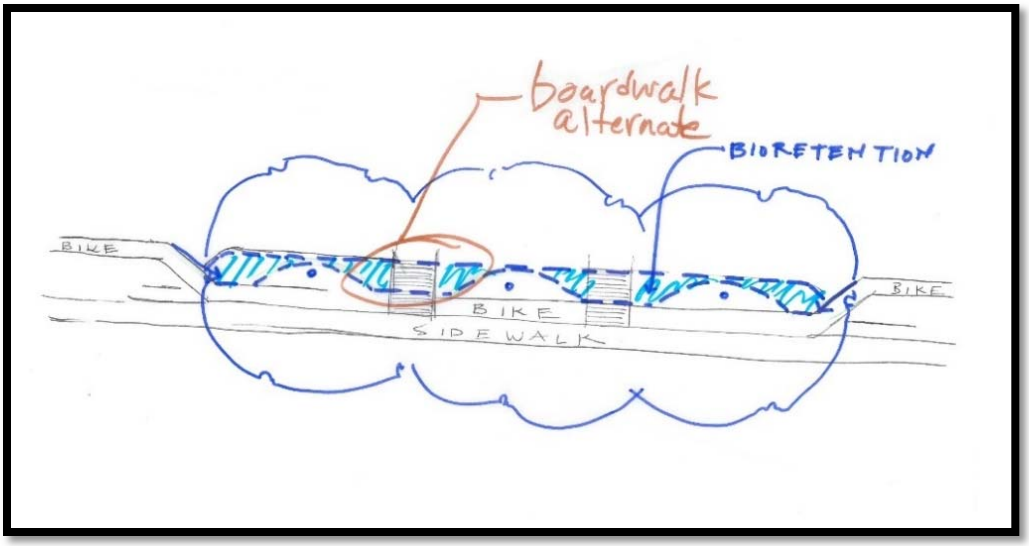


Figure D-17: Bulbout Design Variation 4, View g: Plan View Showing Boardwalk Crossing Alternate and Trees within Bulbout

APPENDIX E

Closing Comments from Public Sector Participants

Elaine Marshall (City of Sunnyvale):

- Intersection in a package of other improvements as part of One Bay Area Round 2 (OBAG2) Funding Application
- Try to not have stormwater be last component of design but think holistically
- Reaffirmed belief in collaboration
- Want to bring these ideas/concepts back to Sunnyvale, but need to determine how to do this when most of the design is not conducted in house
- Cost is an ongoing challenge not addressed significantly
- How to isolate stormwater cost in transportation or bigger projects

David Swartz (City of Fremont):

- Fremont has money for Safe Routes to School and bike/pedestrian safety
- Haven't started bulb-outs
- Have design standards for stormwater tree planters, but have found issues with "plug and play" approach
- Interested in seeing how this will work coming out of charrette

Leo Chow (City of San Mateo):

- Learned most about cost and maintenance
- Cost reduction discussions were valuable
- Standard design – interested in how it will work with every intersection

Shari Carlet (City of Palo Alto):

- Pilot projects were used as standards for city
- Trying to incorporate Green Infrastructure into transportation projects
- Have issues with existing trees
    - Worried about incorporation and maintenance of new mature trees
- Understanding utility conflicts was helpful
    - Moving towards private
- Helpful for guidelines/standards
- Understanding constraints and how they impact standard design is very important (i.e. tree well lesson learned)
- Options for different conditions may be useful (David)

Otis Chan (City of San Mateo):

- Lesson 1 – involve the fire department early in the design process
- Lesson 2 –bus drivers don't like raised crosswalks/intersections
- Have 6 intersections with bulbouts
- Still have flooding because water did not flow around corner
- Did not have time for additional detailed survey when design changed
- Changed decision to just one side of the corner instead of both

Matt Fabry (BASMAA):

Guidance/checklists for constraints/opportunities needs would be helpful