United States Environmental Protection Agency

2014 GREEN INFRASTRUCTURE TECHNICAL ASSISTANCE PROGRAM
Albuquerque Metropolitan Arroyo Flood Control Authority
Albuquerque, NM

Imperial Building Site Design

On-site Treatment of Stormwater Runoff and Fugitive Flows

SEPTEMBER 2016
EPA 832-R-16-007

About the Green Infrastructure Technical Assistance Program

Stormwater runoff is a major cause of water pollution in urban areas. When rain falls in undeveloped areas, soil and plants absorb and filter the water. When rain falls on our roofs, streets, and parking lots, however, the water cannot soak into the ground. In most urban areas, stormwater is drained through engineered collection systems and discharged into nearby water bodies. The stormwater carries trash, bacteria, heavy metals, and other pollutants from the urban landscape, polluting the receiving waters. Higher flows also can cause erosion and flooding in urban streams, damaging habitat, property, and infrastructure.

Green infrastructure uses vegetation, soils, and natural processes to manage water and create healthier urban environments. At the scale of a city or county, *green infrastructure* refers to the patchwork of natural areas that provides habitat, flood protection, cleaner air, and cleaner water. At the scale of a neighborhood or site, *green infrastructure* refers to stormwater management systems that mimic nature by soaking up and storing water. Green infrastructure can be a cost-effective approach for improving water quality and helping communities stretch their infrastructure investments further by providing multiple environmental, economic, and community benefits. This multibenefit approach creates sustainable and resilient water infrastructure that supports and revitalizes urban communities.

The U.S. Environmental Protection Agency (EPA) encourages communities to use green infrastructure to help manage stormwater runoff, reduce sewer overflows, and improve water quality. EPA recognizes the value of working collaboratively with communities to support broader adoption of green infrastructure approaches. Technical assistance is a key component to accelerating the implementation of green infrastructure across the nation and aligns with EPA's commitment to provide community focused outreach and support the President's *Priority Agenda Enhancing the Climate Resilience of America's Natural Resources*. Creating more resilient systems will become increasingly important in the face of climate change. As more intense weather events and dwindling water supplies stress the performance of the nation's water infrastructure, green infrastructure offers an approach to increase resiliency and adaptability.

For more information, visit *http://www.epa.gov/greeninfrastructure.*

Acknowledgements

Principal EPA Staff

Christopher Kloss, EPA
Jamie Piziali, EPA
Tamara Mittman, EPA
Eva Birk, EPA ORISE Participant
Suzanna Perea, EPA Region 6

Community Team

Jerry Lavato, Albuquerque Metropolitan Arroyo Flood Control Authority
David Silverman, Geltmore, LLC
Paul Silverman, Geltmore, LLC
Ron Witherspoon, Dekker Perich Sabatini
Ronald Bohannan, Tierra West, LLC
Dory Wegrzyn, YES Housing
Michelle Den Bleyker, YES Housing
David Kim, Anderson Kim Architecture + Urban Design
Robin Seydel, La Montanita Co-Op
Andrew Werth, ACE Leadership High School
Sandra Mack, Amy Biehl High School

Consultant Team

Jason Wright, Tetra Tech
Bobby Tucker, Tetra Tech
Vic D’Amato, Tetra Tech
Martina Frey, Tetra Tech
John Kosco, Tetra Tech
Robin Cunningham, Tetra Tech

This report was developed under EPA Contract No. EP-C-11-009 as part of the 2014 EPA Green Infrastructure Technical Assistance Program.

Cover Photo: Urban Farm, Albuquerque, New Mexico

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Acronyms

AMAFCA	Albuquerque Metropolitan Arroyo Flood Control Association
ASTM	American Society for Testing and Materials
cfs	cubic feet per second
EPA	U.S. Environmental Protection Agency
ET	evapotranspiration
ft	feet/foot
gpd	gallons per day
gpm	gallons per minute
HVAC	heating, ventilation, and air conditioning
in	inch/inches
MS4	municipal separate storm sewer
sq ft	square feet/foot
TMECC	Testing Methods for the Examination of Compost and Composting
USDA	U.S. Department of Agriculture
VFP	Veteran Farmer Project

Executive Summary

The City of Albuquerque (City), working with private developer Geltmore, LLC and nonprofit housing developer YES Housing, Inc., is engaged in a large multiuse redevelopment project on a 1-acre lot in its downtown area. The Imperial Building will reclaim a former brownfield site and provide a wide range of benefits to the community, including downtown Albuquerque's first grocery store, retail space, 74 residential units (which will provide both affordable and market rate housing), and operating space for a local veterans group. As part of the project, the City wants to integrate green infrastructure into the site design as an initial step towards incorporating those principles on a larger scale into the City's planning and development process.

The primary goal of the project's green infrastructure elements is to capture stormwater and reuse it on-site. Following a charrette held in June 2014, stakeholders decided to focus the design on the use of a cistern. Specifically, rooftop runoff will be collected by the cistern and used to irrigate a rooftop garden. Detailed designs were developed using climate data, an evaluation of irrigation demand, and typical cistern operating conditions to calculate the appropriate cistern size.

Designs for ground-level bioretention planter boxes also were developed. Although initial plans for the site included treatment of *fugitive* stormwater flows in the City's storm sewers and surface runoff to irrigate landscaping around the base of the building, the final design did not include the fugitive flows treatment because of cost concerns.

Groundbreaking for the project was held in January 2015, with an expected completion date of spring 2016.

1. Introduction

The City of Albuquerque, New Mexico (City), lies within the northern edge of the Chihuahua Desert ecoregion and is the most populous city in the state, with a population of 545,852 (AED 2016).

Several neighborhoods in downtown Albuquerque date back to the 1880s, when the transcontinental railroad was established. Today, most of the neighborhoods are located in a flat river bottom and are protected by levees, which create problems for storm drainage by blocking natural flow patterns. Downtown Albuquerque has a significant homeless population, many of whom are veterans, as well as a lack of fresh produce and grocery stores. This project (to redevelop a former brownfield site) aims to mitigate the storm drainage problems by capturing stormwater and recycling it through an urban garden, and providing locally produced food as well as therapeutic work for veterans. Through this project, the City also hopes to integrate the concept of green infrastructure for future buildings and to educate developers, engineers, and architects on the design principles. In addition, local students will be able to learn through observation and documentation.

1.1. Water Quality Issues/Goals

Albuquerque is located within the Middle Rio Grande watershed, which is listed as impaired for *Escherichia coli* (*E. coli*). A total maximum daily load has been established to address that issue by reducing *E. coli* loading by 66 percent. The climate of the watershed is arid with rainfall events that are few and far between; the average annual rainfall for the area is approximately 9.5 inches (in) per year (NOAA 2013).

The U.S. Environmental Protection Agency (EPA) has assessed representative predevelopment hydrology conditions for the Middle Rio Grande watershed (Tetra Tech 2014). On December 11, 2014, EPA issued a general permit for municipal separate storm sewer system (MS4) dischargers in the Middle Rio Grande watershed. The permit requires new development sites to manage on-site the 90th percentile storm event, which approximates predevelopment hydrological conditions. Redevelopment sites must manage on-site the 80th percentile storm event.

1.2. Project Overview and Goals

The Imperial Building project features a proposed 120,000-square-foot (-sq-ft) mixed-use (residential and retail) building in downtown Albuquerque on Silver Avenue SW between 2nd Street SW and 3rd Street SW (Figure 1-1). It is being undertaken by a public-private partnership between the City and UR 205 Silver, LLC, which is affiliated with Geltmore, LLC (the Developer). The Developer has designed a 5-story building that includes a 100-car below-ground parking garage, 23,000 sq ft of ground floor retail space (including a grocery store), 74 apartments, and space for an urban vegetable garden on the roof of the building (Figure 1-2).

Source: Tetra Tech

Figure 1-1. Location and existing condition of the Imperial Building site.

Source: Rendering by Dekker/Perich/Sabatini

Figure 1-2. Imperial Building: Perspective from 3rd Street.

The development site is a 0.97-acre tract of vacant land located on one-half of a city block that has been designated by the federal government as a *food desert*—an area where affordable and nutritious food is difficult to obtain, particularly for those without access to a car. One goal of this project is to change the food desert into a sustainable development for the benefit of the entire community. By relocating an existing urban farm and installing a stormwater capture system in the new development, the project will support that goal.

The Veteran Farmer Project (VFP) is an existing urban agriculture program located across the street from the project site. VFP is in need of a new location, as its lease on the current space expires soon. The proposed development will include a new home for the VFP as a rooftop garden, creating another connection to the healthy food movement. The Developer intends to use the stormwater runoff on-site before releasing the flow into the storm drainage network, which can be a demonstration of green infrastructure development in the Southwest.

The project includes an innovative water collection system that will recycle a portion of the annual rainfall to water the garden on the roof of the structure. Originally, the project also included a design element to capture some of the dry weather, or *fugitive*, flows in the storm drain system adjacent to the property; however, Albuquerque Metropolitan Arroyo Flood Control Association (AMAFCA) ultimately decided not to include that element in the project.[1] To potentially serve other communities that might

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[1] AMAFCA is one of several entities involved in the design of the development and obtained green infrastructure technical assistance for the project from the U.S. Environmental Protection Agency.

be interested in including the fugitive flow capture element in their projects, this report contains the conceptual designs for that element and presents them in section 3. The flows would have been treated in a series of bioretention treatment planter boxes and then used to irrigate the street trees surrounding the property and other ground-level site landscaping. The system also would have included a storage tank with associated pumps, piping, drains, and controls.

1.3. Project Benefits

The proposed development will benefit a number of segments of the City's population and provide benefits in many ways. Combining this development with best practices in stormwater management furthers the interests of four public agencies tasked with working in public-private partnerships, supports a project that will provide healthy foods to a low-income area, and stimulates economic development. Some of the valuable outcomes the City hopes to foster include providing a positive impact for veterans outside of the economic mainstream and teaching lower income children about careers in green infrastructure and urban farming.[2] Further, the City envisions this development as an opportunity to make the area a community asset by using the roof of the building to improve the walkability of the area (i.e., space currently dedicated to the VFP can be used for other purposes) and using green building principles such as installing photovoltaic panels to power site lighting.

There is a tremendous amount of public support for this project in the community. The opening of a grocery store in downtown Albuquerque was identified as a catalytic project in the *Downtown 2010 Sector Development Plan*, the planning document for the downtown area. The Mayor has made it a priority of his administration, and the City has passed a resolution to authorize workforce housing funds for the affordable housing component of the project. The County has passed an inducement resolution to provide industrial revenue bonds to help finance the project, and the New Mexico Environment Department is providing financing to help offset the cost of mitigating the loose soil and gas vapors on the site that have made this property a brownfield. Making this development a demonstration project for stormwater capture only furthers the efforts of all of these agencies who are working to make this development a reality.

Students from ACE Leadership High School, a charter school that specializes in the fields of architecture, construction, and engineering, will be included in the process, providing them with an opportunity to learn about green infrastructure techniques and helping train the future work force to pursue careers in this field. The City also will prepare a video handbook that captures the green infrastructure design process at the early planning stage (and perhaps during the installation / implementation phase).

1.4. Local Challenges

A lack of knowledge about green infrastructure practices has been a concern of the development community as the City implements the new MS4 permit. Through the very popular Imperial Building project, AMAFCA hopes to provide leadership in implementing green infrastructure solutions and to use the development as a demonstration project on incorporating the modern practices into new development in the Southwest going forward.

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[2] The VFP has obtained a grant from the Veterans Administration.

The City believes that techniques learned from this project will be copied by others in the community. It is in discussions with the Developer about using the proposed growing bed technology developed for this project on land owned by AMAFCA in other parts of the City that currently is sitting idle. Along with additional fugitive water in the stormwater system, new parks and community gardens could be developed and operated by the VFP to increase the amount of produce grown locally.

2. Design Approach

On June 23–24, 2014, AMAFCA hosted a design charrette to bring together all of the professionals involved in developing the Imperial Building project.

The intent of the design charrette was to discuss incorporating four main concepts into the site plan and building design: rooftop urban agriculture, irrigation of the rooftop urban agriculture with rainwater harvested from the rooftop, treating additional stormwater runoff on-site using green infrastructure practices, and treating fugitive flows in an adjacent storm drain through a series of bioretention planter boxes with irrigation of associated street trees. The charrette provided an opportunity for people with a wide range of backgrounds (including architects, engineers, landscape architects, and flood control experts) to team up and cooperate on the site plan.

The first day of the charrette began with an overview of green infrastructure concepts, including a brief discussion of the impacts of development on the quantity and quality of stormwater runoff, site design principles, and green infrastructure practices. The presentation included a brief discussion of how green infrastructure concepts could be applied to the Imperial Building site, emphasizing the potential configuration for bioretention areas, green roofs, and water harvesting systems. Students from ACE Leadership High School also attended the presentation and participated in the discussion. The remainder of the day was spent discussing the site configuration and constraints as well as general concepts that could be applied at the site to meet treatment goals.

The second day focused on refining the site plan and developing as many details as possible for the green infrastructure concepts to be implemented at the Imperial Building. Potential sources of runoff were categorized as rooftop rainwater, fugitive or nuisance flows, ground-level runoff (e.g., from the parking deck ramp), fire-test flow water, and condensate from the condenser units. It was determined that the flows from testing the fire suppression system, condensate, and runoff from the rooftop would be the cleanest sources of water from the site and would be harvested in a cistern. Nuisance flows and runoff from the parking deck ramp could pick up pollutants and require substantial treatment before it could be used within the building. That treatment could be cost-prohibitive and, therefore, those flows will be treated and used to irrigate perennial landscape plantings (e.g., sidewalk trees), with the remainder routed to the City’s storm drainage network.

The information gathered at the charrette and the green infrastructure practice concepts were integrated into the conceptual design for the Imperial Building site. It was determined in the charrette that two design strategies would be incorporated into the site: water harvesting via cisterns and rain barrels and bioretention planter boxes (which later were not adopted). Those two strategies are described further below, with detailed design specifications provided in Appendices A and B.

2.1. Cisterns and Rain Barrels

Figure 2-1. Rain barrels at San Pasqual Academy, Escondido, California.

A *cistern* is an above-ground storage vessel with either a manually operated valve or a permanently open outlet (Figure 2-1 shows a rain barrel, a small cistern). If the cistern has an operable valve, the valve can be closed to store stormwater for irrigation or infiltration between storms. This system requires continual monitoring by the resident or grounds crew, but provides flexibility in water storage and metering. If a cistern is provided with an operable valve and water is stored inside for long periods, the cistern must be covered to prevent mosquitoes from breeding. A cistern system with a permanently open outlet also can provide for metering stormwater runoff. If the cistern outlet is significantly smaller than the size of the downspout inlet (e.g., ¼- to ½-in diameter), runoff will build up inside the cistern during storms and will empty slowly after peak intensities subside. The cistern must be designed and maintained to minimize clogging by leaves and other debris.

2.1.1. Hydrology

Cisterns are typically placed near roof downspouts so that flows from the downspouts can be easily diverted into the cistern. Runoff enters the cistern near the top and is filtered to remove large sediment and debris. Collected water exits the cistern from the bottom or can be pumped to areas more conducive to infiltration. Cisterns can be used as a reservoir for temporary storage or as a flow-through system for peak flow control. Each cistern is fitted with a valve that can hold the stormwater for reuse or release the stormwater at a rate below the design storm rate. Regardless of the intent of the storage, an overflow must be provided for times when the capacity of the cistern is exceeded. The overflow system should convey the runoff away from structures, either routing the flow to a green infrastructure practice for treatment or safely passing it into the stormwater drainage system. The volume of the cistern should be allowed to slowly release, preferably into a green infrastructure practice for treatment or into a landscaped area where infiltration has been enhanced.

Cisterns have been used for millennia to capture and store water. Droughts in recent years have prompted a resurgence of rainwater harvesting technology as a means of offsetting potable water use. Studies have shown that adequately designed and used systems reduce the demand for potable water and can provide important hydrologic benefits (Vialle et al. 2012; DeBusk et al. 2012). Hydrologic performance of rainwater harvesting practices varies with design and use; systems must be drained between rain events to reduce the frequency of overflow (Jones and Hunt 2010). When a passive drawdown system is included (e.g., an orifice that slowly bleeds water from the tank into an adjacent vegetation bed or infiltrating practice), significant runoff reduction can be achieved (DeBusk et al. 2012).

2.1.2. Water Quality

Because most rainwater harvesting systems collect rooftop runoff, the water quality of runoff harvested in cisterns is largely determined by surrounding environmental conditions (e.g., overhanging vegetation, bird and wildlife activity, atmospheric deposition), roof material, and cistern material (Despins et al. 2009; Lee et al. 2012; Thomas and Greene 1993). Rooftop runoff tends to have relatively low levels of physical and chemical pollutants, but elevated microbial counts are typical (Gikas and Tsihrintzis 2012; Lee et al. 2012; Lye 2009; Thomas and Greene 1993). Physicochemical contaminants can be further reduced by implementing a first-flush diverter; however, such diverters generally have little impact on reducing microbial counts (Lee et al. 2012; Gikas and Tsihrintzis 2012).

The pollutant reduction mechanisms of cisterns and rain barrels are not yet well understood, but sedimentation and chemical transformations are thought to help improve water quality. Despite limited data describing reduction in stormwater contaminant concentrations in cisterns, rainwater harvesting can greatly reduce pollutant loads to waterways if stored rainwater is infiltrated into surrounding soils using a low-flow drawdown configuration or when it is used for alternative purposes such as toilet flushing or vehicle washing. Rainwater harvesting systems also can be equipped with filters to further improve water quality.

2.1.3. Applications

Cisterns come in a variety of sizes and configurations and can hold several hundred to several thousand gallons (gal) of rainwater. Figure 2-2 shows a typical aboveground plastic cistern, and Figure 2-3 shows the same cistern with a wooden wrap. Cisterns also can be decorative, such as the one shown in Figure 2-4 at the Children's Museum in Santa Fe, or can be placed below ground, as shown in Figure 2-5.

Smaller cisterns (fewer than 100 gal), or rain barrels, can be used on a residential scale (Figure 2-6). Collected water can be used to supplement municipal water for nonpotable uses, primarily irrigation. Although useful for meeting basic irrigation needs, rain barrels do not typically provide substantial hydrologic benefits because they tend to be undersized relative to the size of the contributing drainage area. Figure 2-7 shows rain barrels adequately sized for the contributing roof area.

Figure 2-2. Typical plastic cisterns.

Figure 2-3. Wood wrapped cisterns.

Source: Santa Fe, New Mexico, Children's Museum

Figure 2-4. Decorative cistern.

Figure 2-5. Below-ground cistern.

Figure 2-6. Residential rain barrel.

Figure 2-7. Rain barrels adequately sized for contributing roof area.

2.2. Bioretention Planter Boxes

Figure 2-8. Bioretention planter box.

A *bioretention planter box* is typically a concrete box containing soil media and vegetation that functions like a small bioretention area but is lined on the sides and might require an underdrain (Figure 2-8). Bioretention treatment planters are most often implemented along paved streets, or around parking lots and buildings to provide initial stormwater detention and treatment of runoff. Such applications offer an ideal opportunity to minimize directly connected impervious expanses in highly urbanized areas. In addition to stormwater management benefits, flow-through planters provide green space and improve natural aesthetics in tightly confined urban environments. Refer to section 3 for vegetation specifications and to Appendix B for soil media details.

2.2.1. Hydrology

A planter box is a vegetated, landscaped (i.e., mulched or grassed) shallow depression that captures, temporarily stores, and filters stormwater runoff before directing it toward a stormwater conveyance system or other green infrastructure practice via underdrain pipes. The captured runoff infiltrates through the bottom of the depression and an approximately 2–4-foot- (-ft-) deep soil media layer that has an infiltration rate capable of draining the planter box (to the bottom of the soil media) within a specified design drawdown time (usually 48 hours). The soil media provide treatment through filtration, adsorption, and biological uptake. Some volume reduction (15–20 percent) also is possible through evapotranspiration (ET) and storage in the soil media (Hunt et al. 2006). Flow-through planters are typically planted with grasses, shrubs, and trees that can withstand short periods of saturation (10–24 hours) followed by longer periods of drought. Flow-through planters are ideal for treating cistern discharge if infiltration is restricted.

2.2.2. Water Quality

Planter boxes are typically volume-based green infrastructure practices intended primarily for water quality treatment that also can provide some peak-flow and volume reduction. Planter boxes should be used only in place of bioretention areas where geotechnical conditions do not allow for infiltration into the subsoils. Although planter boxes do not allow for infiltration, they still provide functions considered fundamental for green infrastructure practices and water quality treatment. They remove pollutants through physical, chemical, and biological mechanisms. Similar to bioretention areas, they specifically use sorption, microbial activity, plant uptake, sedimentation, and filtration. Planter boxes are capable of consistent and high pollutant removal for sediment, metals, and organic pollutants (e.g., hydrocarbons). Current research shows that pollutant removal is possible with underdrains through the function provided at the surface and by the soil media. Table 2-1 reports the water quality performance of bioretention planter boxes.

Table 2-1. Pollutant removal characteristics of bioretention planter boxes

Pollutant	Typical Literature Removal Efficiency	Median Effluent Concentration (mg/L unless otherwise noted)	Removal Processes	Minimum Recommended Media Depth for Treatment (ft)	References
Sediment	High	8.3	Settling in pretreatment and mulch layer, filtration and sedimentation in top 2–8 inches of media.	1.5	Geosyntec and Wright Water Engineers 2012; Hatt et al. 2008; Hunt et al. 2012; Li and Davis 2008; Stander and Borst 2010
Metals	High	TCd: 0.94 µg/L TCu: 7.67 µg/L TPb: 2.53 µg/L TZn: 18.3 µg/L	Removal with sediment and sorption to organic matter and clay in media.	2	Geosyntec and Wright Water Engineers 2012; Hsieh and Davis 2005; Hunt et al. 2012
Hydro-carbons	High	N/A	Removal and degradation in mulch layer.	N/A	Hong et al. 2006; Hunt et al. 2012
Total Phosphorus	Medium (-240–99%)	0.09	Settling with sediment, sorption to organic matter and clay in media, and plant uptake. Poor removal efficiency can result from media containing high organic matter or with high background concentrations of phosphorus.	2	Clark and Pitt 2009; Davis 2007; Geosyntec and Wright Water Engineers 2012; Hsieh and Davis 2005; Hunt et al. 2006; Hunt and Lord 2006; Li et al. 2010

Pollutant	Typical Literature Removal Efficiency	Median Effluent Concentration (mg/L unless otherwise noted)	Removal Processes	Minimum Recommended Media Depth for Treatment (ft)	References
Total Nitrogen	Medium (TKN: -5–64%, Nitrate: 180%)	TN: 0.90, TKN: 0.60, $NO_{2,3}$-N: 0.22	Sorption and settling (TKN), denitrification in internal water storage (nitrate), and plant uptake. Poor removal efficiency can result from media containing high organic matter.	3	Barrett et al. 2013; Clark and Pitt 2009; Geosyntec and Wright Water Engineers 2012; Hunt et al. 2006; Hunt et al. 2012; Kim et al. 2003; Li et al. 2010; Passeport et al. 2009
Bacteria	High	*Enterococcus*: 234 MPN/100 mL, *E.coli*: 44 MPN/100 mL	Sedimentation, filtration, sorption, desiccation, predation, and photolysis in mulch layer and media.	2	Geosyntec and Wright Water Engineers 2012; Hathaway et al. 2009; Hathaway et al. 2011; Hunt and Lord 2006; Hunt et al. 2008; Hunt et al. 2012; Jones and Hunt 2010
Thermal Load	High	68–75 °F	Heat transfer at depth and thermal load reduction by volume reduction (ET and infiltration). Internal water storage enhances thermal load reduction.	4	Hunt et al. 2012; Jones and Hunt 2009; Jones et al. 2012; Wardynski et al. 2013; Winston et al. 2011

Notes: ft = feet; mg/L = milligram per liter; µg/L = microgram per liter; mL = milliliter; MPN = most probable number; $NO_{2,3}$-N = Nitrate and Nitrite Nitrogen; TCd = total cadmium; TCu = total copper; TKN = total Kjehldahl nitrogen; TN = total nitrogen; TPb = total lead; TZn = total zinc

2.2.3. Applications

Planter boxes can be implemented in situations in which infiltrating bioretention is not feasible, including areas near buildings or in rights-of-way when utility conflicts restrict infiltration (Figure 2-9).

Figure 2-9. Roadside flow-through planter.

3. Conceptual Design

The Developer has designed a 5-story building that includes a parking basement, retail space, residential units, and a rooftop urban garden. The site will be excavated approximately 12 feet below the existing surface to provide structural support and to ensure that the parking garage is appropriately sealed. The excavation will extend into the right-of-way to the back of the existing curb along 3rd Street SW, Silver Avenue SW, and 2nd Street SW.

Approximately 4,000 sq ft of the rooftop is intended as a patio for use by the residents and an urban farm that will be managed by the La Montanita Co-Op. An existing urban farm is currently located on a site immediately adjacent to the Imperial Building site, as shown in Figure 3-1. Much of the remaining rooftop space will be used for condenser units for climate control of the building. The grocery store roof cannot be used at this time but could potentially be incorporated for residential use or urban farming depending on the agreements made with the future tenant.

A 60-in diameter reinforced concrete pipe storm drain flows under 3rd Street SW on the west side of the Imperial Building site. According to AMAFCA, a consistent flow of approximately 0.02 cubic feet per second (cfs), or 8 gallons per minute (gpm), has recently been measured in through pipe. These flows are considered *fugitive*, or *nuisance*, flows thought to be generated by activities of the residents and City staff that include car washing, overirrigation, sidewalk scrubbing, street sweeping, and heating, ventilation, and air conditioning (HVAC) condensate discharge. Some of the fugitive flows also could consist of groundwater entering the storm drainage network through leaks in the pipes. The quality of the fugitive flows is thought be relatively good; however, concerns about potential contaminants currently precludes its use in the interior of the building or for spray irrigation.

Figure 3-1. Existing urban farm at 2nd Street and Gold Avenue SW.

This project aims to mitigate the impacts of on-site stormwater runoff by capturing the water from the rooftop areas and recycling it through an urban garden, to provide locally produced food and therapeutic work for veterans, and to set an example for developers of similar buildings to be built in the future. Stormwater runoff from the street level, including the parking ramp and the sidewalks along the building frontage, would have been treated in a series of planter boxes along 2nd Street SW, Silver Avenue SW, and 3rd Street SW. Through this project, the City hopes to educate (1) other developers on the use of green infrastructure, (2) engineers and architects on the design concepts, (3) students through observation and documentation, and (4) veterans through implementing the urban garden for therapy, sustenance, and survival.

Additionally, AMAFCA has an interest in using redevelopment sites located throughout the City as areas for treating nuisance water flows and providing incentives to developers (e.g., credits) who incorporate on-site treatment of nuisance flows into their projects.

3.1. Water Treatment Strategy

The schematic in Figure 3-2 summarizes the potential sources of water, potential reuse opportunities, and the proposed integrated water reuse and treatment concept for the Imperial Building. Several sources of water were targeted for treatment and reuse at the Imperial Building site. Since each source has different water quality characteristics, a fit-for-purpose strategy was used to match each source with an appropriate treatment method and end use.

- Rainfall runoff from 30,000 sq ft of rooftop
- Dry-weather nuisance flows from adjacent storm sewer (approximately 0.02 cfs, or 8 gpm, continuous flow in pipe)
- Ground-level on-site runoff from the parking area, courtyard, pedestrian access paths, and building frontage
- Fire-test flows (approx. 1,000 gal per year)
- HVAC condensate

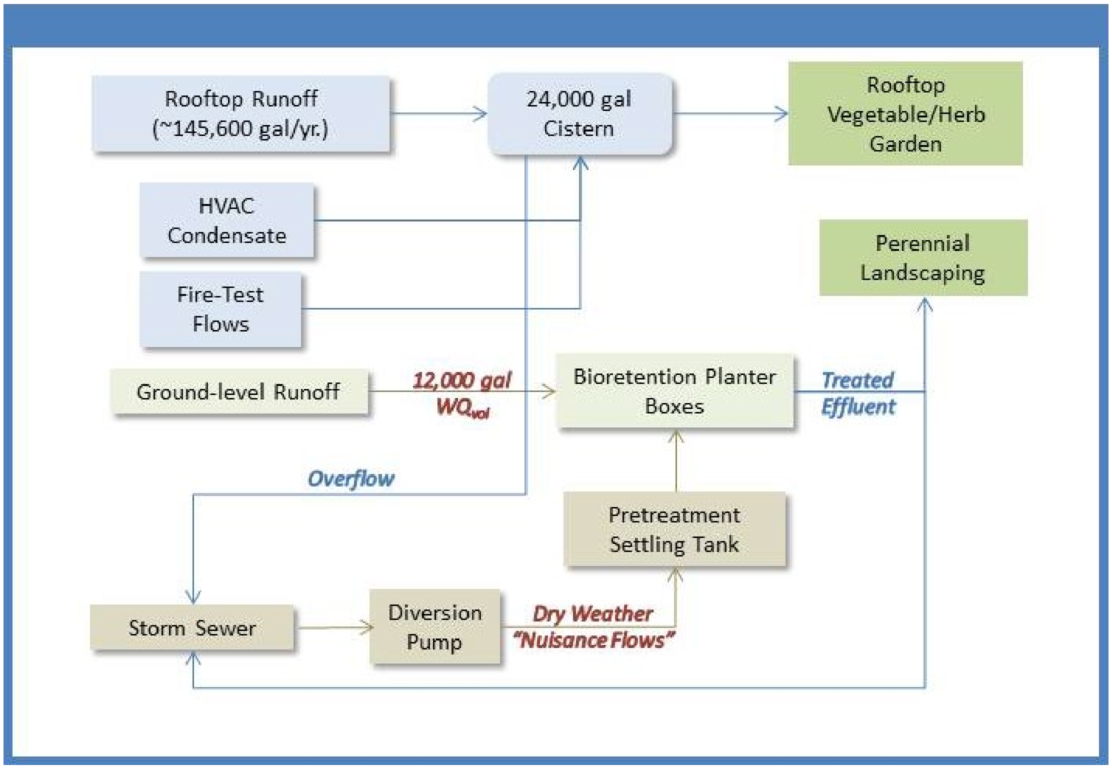

Figure 3-2. Flow diagram for water reuse strategy at Imperial Building.

Runoff from the building's roof and the fugitive flows in the storm sewer are the focus of the green infrastructure design. The design for the runoff also will account for HVAC and fire-test flows, while the design for the fugitive flows also would have incorporated flow volumes from ground-level runoff.

3.2. Treatment of Rooftop Runoff

The source of the cleanest urban stormwater runoff is typically rooftops. Access to open space for storing stormwater runoff in the soil or a reservoir, however, can be limited in higher density landscapes like downtown Albuquerque. As a result, aboveground or belowground cisterns become viable options for preserving the quality of rooftop runoff and storing it for subsequent irrigation of higher value food crops. Annual vegetables, commercial mushroom operations, and aquaponic or hydroponic systems—all of which require a relatively clean and constant water supply—are ideal uses for cistern water. From a stormwater management perspective, these proposed revenue-generating, beneficial end uses establish a reliable incentive for implementing stormwater volume and pollutant load reductions.

The runoff from the rooftop, as well as intermittent discharges from HVAC condensate and fire-testing, will be harvested by being conveyed directly to a 24,000-gal cistern after coarse filtration and first-flush diversion treatment of the rooftop runoff. A back-up municipal water supply should be connected to the cistern to ensure irrigation water during extreme dry periods. The cistern also will include an overflow pipe that discharges into the adjacent storm sewer. Cisterns are most effective for stormwater treatment when adequate storage volume is available. A full water balance was performed to determine the irrigation demand and to ensure that the cistern will be empty at the start of a rain event.

3.2.1. Irrigation Demand

Initially, potential irrigation demands for the rooftop garden were calculated using local ET rates, typical crop demands, irrigation system efficiencies, soil texture, plant available water, and other factors associated with the proposed planter box system for the rooftop. These irrigation rates, however, appeared much lower than those reported by existing urban farm sites and other local produce growers, all of whom use similar drip irrigation products and timing schedules for their production. As a result, a conservative approach was ultimately used that assumes set monthly irrigation durations (based on the schedules currently used by local growers) and a 12-month production season. The calculated monthly irrigation demands in Table 3-1 are based on a drip system with 8-in emitter spacing, 0.5-gal per hour emitter rates, and three drip lines per 3–4-ft bed.

Table 3-1. Typical irrigation demands for vegetable production in Albuquerque

Month	Irrigated Minutes/Day	Gal/Day-100 sq ft
January	20	40
February	20	40
March	20	40
April	20	40
May	30	60
June	40	80
July	40	80
August	40	80
September	30	60
October	20	40
November	20	40
December	20	40

As currently proposed, the rooftop garden will include a minimum 810 sq ft of planter boxes. Based on the assumed irrigation schedule described in Table 3-1, the annual irrigation demand for the garden is approximately 72,500 gal.

3.2.2. Water Balance Modeling

The Rainwater Harvester (RH) model (Jones and Hunt 2010) simulates the performance of rainwater harvesting systems using historical precipitation data to evaluate a daily or hourly water balance. The model includes options for daily and hourly rainfall input files, customized water demand inputs, automatic irrigation demand calculations, payback period costs, annual nitrogen reductions, and various hydrologic performance output metrics.

Several input scenarios were modeled for this project to evaluate the performance of the Imperial Building rainwater harvesting system in offsetting the rooftop garden irrigation demand; the results are shown in Table 3-2. Two cistern sizes—24,000 gal and 36,000 gal—were selected based on the 100-year, 6-hour peak flood detention requirement. The 24,000-gal cistern assumes that the 12,000-gal water quality volume for the site will be mitigated through capture and treatment of the ground-level runoff using the roadside planter boxes. The 36,000-gal cistern scenario was modeled to evaluate the hydrologic benefits of maximizing the cistern capacity on the site.

Table 3-2. Cistern performance results

Cistern Size (gal)	Rainfall Record	Annual Usage (gal)	Irrigation Offset (%)	Overflow Frequency (%)	Dry Frequency (%)
24,000	5/2003–4/2013	59,247	95	38	4
24,000	6/2009–4/2013	59,001	94	24	4
36,000	5/2003–4/2013	60,185	98	37	2
36,000	6/2009–4/2013	60,614	98	21	1

The cistern will be located in the lower-level parking garage as shown in the site plan in Appendix A. Planning level costs for treating the rooftop runoff are shown in Table 3-3.

Table 3-3. Cistern costs

Item No.	Description	Quantity	Unit	Unit Cost	Total
1	Excavation	133.3	CY	$8.50	$1,133
2	6-in gravel bedding layer	8.2	CY	$30.34	$248
3	24,000-gal storage tank	1.0	EA	$37,906.25	$37,906
4	Pump system	1.0	EA	$8,971.43	$8,971
5	Filter package	1.0	EA	$1,847.29	$1,847
6	Filter assembly	1.0	LS	$2,744.43	$2,744
	Total Cistern Cost				$52,851

Notes: CY = cubic yards; EA = each; LS = Lump sum.

3.3. Fugitive Flow Treatment

If AMAFCA had decided to include the fugitive flow treatment system in the Imperial Building project, runoff from the parking deck ramp and the fugitive flows from AMAFCA's adjacent storm sewer would have been routed through a pretreatment system installed at 3rd Street SW and the alley between Silver Avenue SW and Gold Avenue SW. The flows would have passed through a primary treatment and effluent distribution system installed under the sidewalks along 2nd Street SW, Silver Avenue SW, and 3rd Street SW, providing treatment as well as a consistent irrigation source for the required street trees. Figure 3-3 shows the potential routing and treatment of the flows.

Figure 3-3. Potential routing and treatment of fugitive flows.

Nuisance flows in the storm drain along 3rd Street SW would have been pumped directly into the pretreatment system. Runoff from the parking deck would have been treated and stored in an oil/grit separator and then transferred into the effluent dispersal/irrigation system. Primary treatment would have been in a baffled tank, similar to a septic tank, with an effluent screen. There are a variety of commercially available systems that could be used under the sidewalk to provide additional storage, including a tree filter system with suspended pavement. The typical planter box configuration recommended for implementation along 3rd Street SW, Silver Avenue SW, and 2nd Street SW is shown in Figure 3-4.

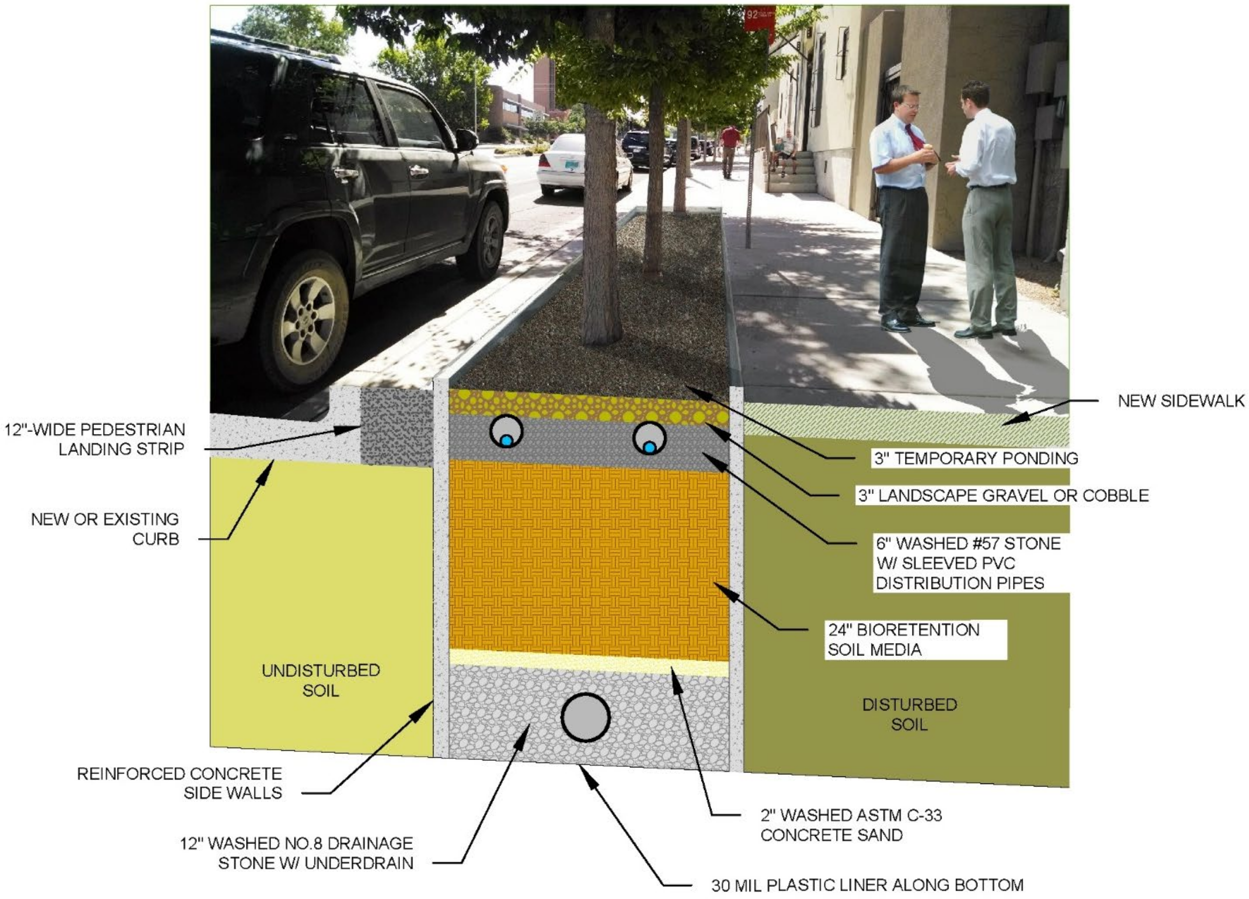

Figure 3-4. Typical bioretention planter box configuration.

Three treatment scenarios were developed to demonstrate increasing levels of treatment in the bioretention areas along 2nd Street SW, Silver Avenue SW, and 3rd Street SW. The first treatment scenario is the minimum bioretention area required to treat the runoff produced by the 0.44-in event at the site, along with a corresponding amount of fugitive flow treatment during dry weather. The second and third treatment scenarios each covers an increasingly larger treatment area intended to provide additional treatment capacity for fugitive flows. Each treatment scenario includes capturing the runoff from the parking ramp in a tank at the base of the ramp (shown in Figure 3-5) and then pumping the flows to an irrigation dosing tank below the sidewalk on 3rd Street SW, as shown in Figure 3-6. The full site plan is provided in Appendix A.

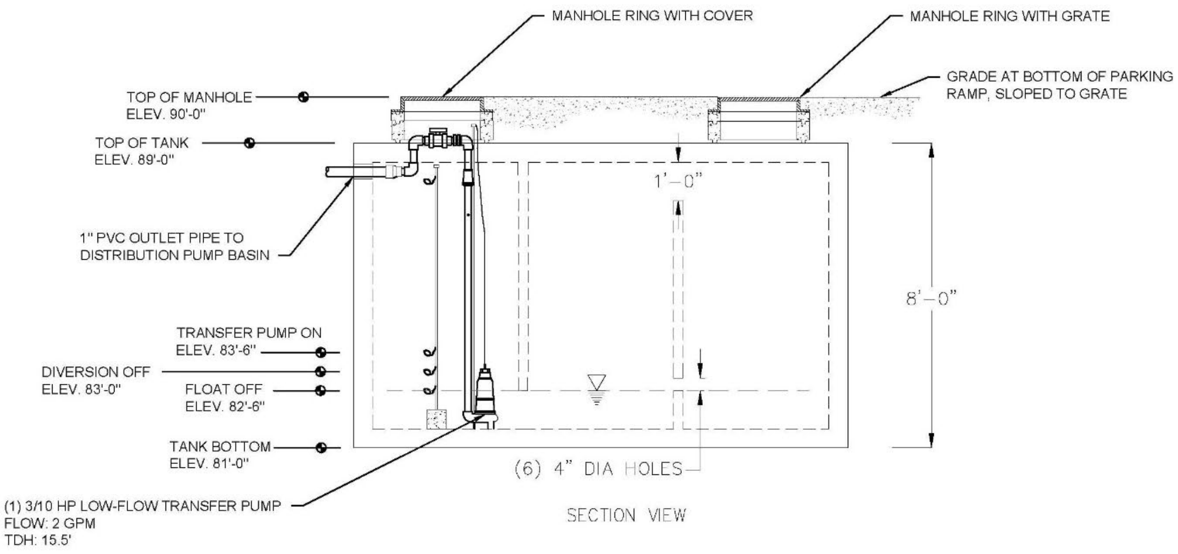

Figure 3-5. Tank to collect ramp runoff.

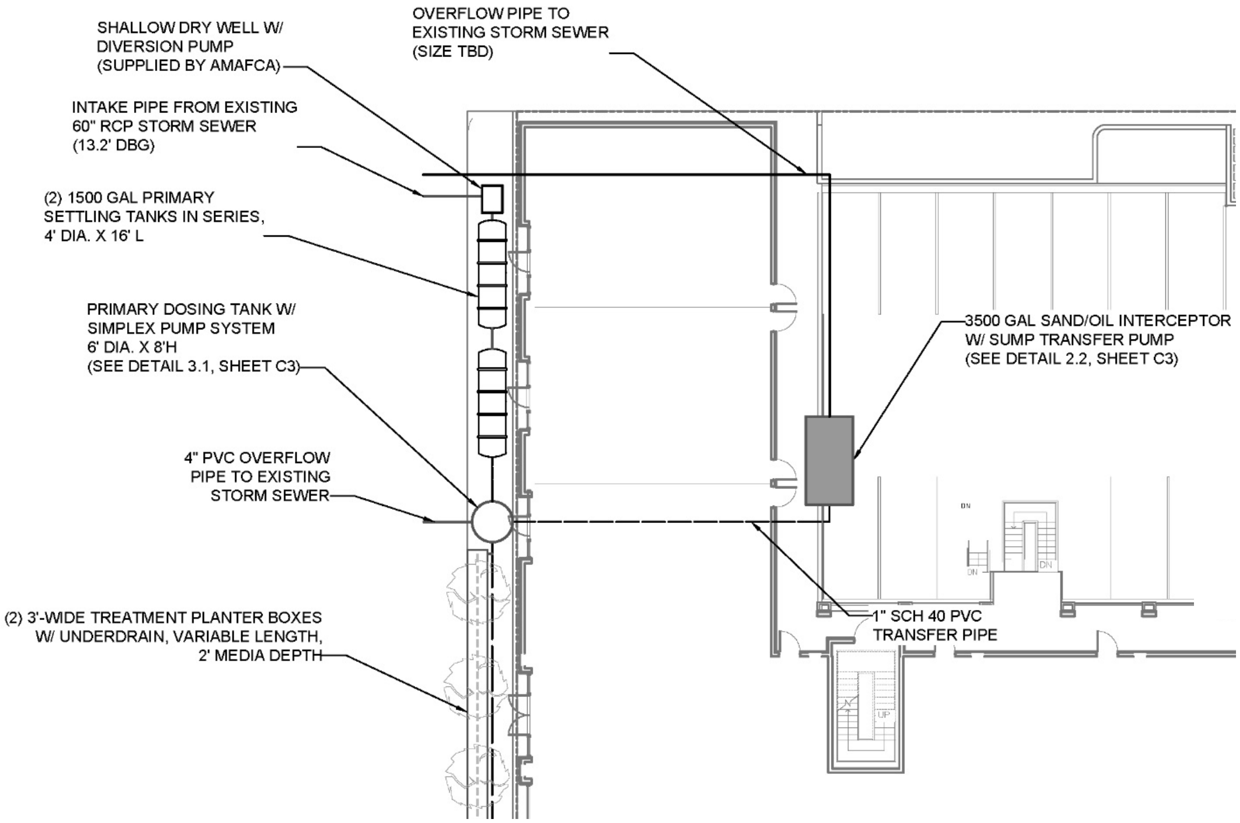

Figure 3-6. Routing of ramp stormwater runoff.

As noted above, AMAFCA ultimately decided not to include the fugitive flow treatment as part of the final design plan for the Imperial Building site. The conceptual design is a viable design option, however, and might be relevant to efforts in other communities and was, therefore, included in the proposed conceptual design.

3.3.1. Treatment Scenario 1

A treatment planter box system with a minimum surface area of 775 sq ft is required to treat the 0.44-in water quality event from the parking deck ramp and the sidewalk in front of the Imperial Building. The planter box system will be dosed with runoff from the parking ramp at a rate of 1,550 gallons per day (gpd). Fugitive flows can be applied to the system at the same rate when it is not raining. A cross section of the planter box system is shown in Figure 3-7. Full plan details are included in Appendix A. Specifications for the bioretention soil media are included in Appendix B.

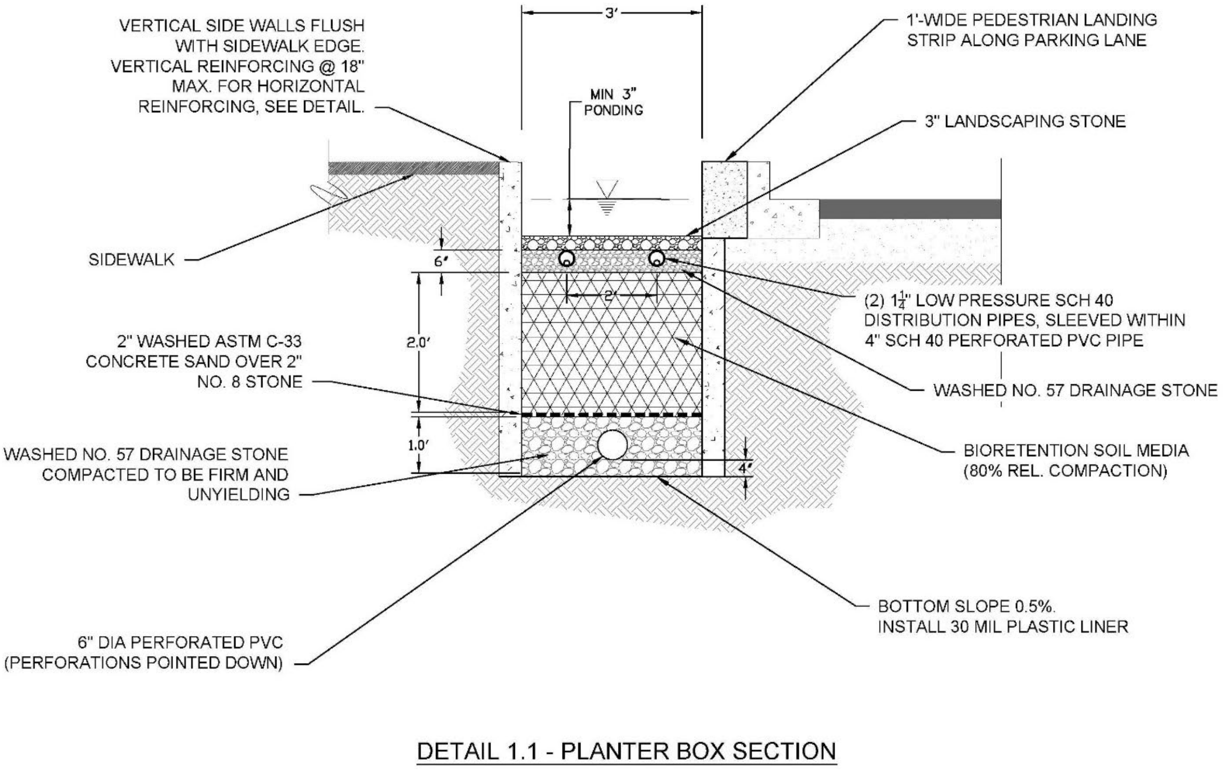

Figure 3-7. Treatment planter box.

Planning level cost estimates for Treatment Scenario 1 are provided in Table 3-4.

Table 3-4. Ground-level runoff and nuisance flow treatment construction cost (Treatment Scenario 1)

Item No.	Description	Quantity	Unit	Unit Cost	Total
	Nuisance Flow Treatment				
1	8,000-gal fiberglass settling tank (6-ft dia, 40-ft length)	1.0	EA	$22,000.00	$22,000
2	Bedding and backfill	1.0	LS		$0
3	Distribution pump system (pump, control, floats)	1.0	LS	$1,000.00	$1,000
4	Pump basin	1.0	LS	$1,200.00	$1,200
5	4-in Schedule 40 PVC pipe	258.5	LF	$9.15	$2,365
6	3-in Schedule 40 PVC pipe	90.0	LF	$6.60	$594
7	2-in Schedule 40 PVC pipe	106.5	LF	$3.33	$355

Item No.	Description	Quantity	Unit	Unit Cost	Total
8	1.5-in Schedule 40 PVC pipe	45.0	LF	$2.73	$123
9	1.25-in distribution line	513.3	LF	$3.30	$1,694
	Total Nuisance Flow Treatment				$29,331
	Parking Ramp Treatment				
10	3,500-gal sand/oil interceptor	1.0	LS	$7,000.00	$7,000
11	Ring and cover	1.0	EA	$330.00	$330
12	Ring and grate	1.0	EA	$350.00	$350
13	Excavation	30.3	CY	$7.00	$212
14	Transfer pump system (pump, screens, controls)	1.0	LS	$600.00	$600
	Total Parking Ramp Treatment				$8,492
	Planter Boxes				
15	Hydraulic restriction layer (6-in concrete)	2,650.0	sq ft	$16.00	$42,400
16	Bioretention media	72.6	CY	$40.00	$2,904
17	No. 8 stone	4.8	CY	$26.00	$124
18	Washed ASTM C-33 concrete sand	9.5	CY	$30.00	$285
19	Drainage stone (washed no. 57 stone)	40.9	CY	$45.00	$1,841
20	6-in Schedule 40 perforated PVC pipe	256.7	LF	$30.00	$7,700
21	6-in Schedule 40 PVC pipe	294.3	LF	$35.00	$10,302
22	6-in Schedule 40 perforated PVC pipe cleanout	11.0	EA	$100.00	$1,100
23	Hydraulic restriction layer (30-mil liner)	3,420.0	sq ft	$0.50	$1,710
	Total Planter Boxes				$68,365
	Earthwork				
24	Fill	38.0	CY	$8.50	$323
25	Pipe backfill and bedding	20.8	CY	$46.95	$976
26	Finish grading	7.8	SY	$0.17	$1
	Total Earthwork				$1,300
	Landscaping				
27	Bioretention planting	770.0	sq ft	$1.00	$770
28	Landscaping rock	7.1	CY	$60.00	$428
	Total Landscaping				$1,198
	Electrical Control Integration				
29	Electrical control integration	1	EA	$3,000	$3,000
	Total Electrical Control Integration				$3,000
	Construction Subtotal				$112,030
	Mobilization and Stakeout 5%				$5,601
	Bonds and Insurance 5%				$5,601
	Construction Contingency 20%				$22,406
Total Construction Cost					$145,638

Notes: CY = cubic yards; EA = each; LF = linear feet; LS = lump sum; PVC = polyvinyl chloride; SY = square yards.

3.3.2. Treatment Scenario 2

The maximum area available for planter boxes is 1,320 sq ft along 2nd Street SW, Silver Avenue SW, and 3rd Street SW using the cross section shown in Figure 3-7 and increasing the length. Increasing the area by 545 sq ft above the Treatment Scenario 1 treatment area allows for 2,640 gpd to be applied to the planter boxes, an increase of 1,090 gpd. Adding the additional treatment capacity increases the projected costs by approximately $46,000 compared to Treatment Scenario 1, as shown in Table 3-5.

Table 3-5. Ground-level runoff and nuisance flow treatment construction cost (Treatment Scenario 2)

Item No.	Description	Quantity	Unit	Unit Cost	Total
	Nuisance Flow Treatment				
1	8,000-gal fiberglass settling tank (6-ft dia, 40-ft length)	1.0	EA	$22,000.00	$22,000
2	Bedding and backfill	1.0	LS		$0
3	Distribution pump system (pump, control, floats)	1.0	LS	$1,000.00	$1,000
4	Pump basin	1.0	LS	$1,200.00	$1,200
5	4-in Schedule 40 PVC pipe	258.5	LF	$9.15	$2,365
6	3-in Schedule 40 PVC pipe	90.0	LF	$6.60	$594
7	2-in Schedule 40 PVC pipe	106.5	LF	$3.33	$355
8	1.5-in Schedule 40 PVC pipe	45.0	LF	$2.73	$123
9	1.25-in distribution line	880.0	LF	$3.30	$2,904
	Total Nuisance Flow Treatment				$30,541
	Parking Ramp Treatment				
10	3,500-gal sand/oil interceptor	1.0	LS	$7,000.00	$7,000
11	Ring and cover	1.0	EA	$330.00	$330
12	Ring and grate	1.0	EA	$350.00	$350
13	Excavation	30.3	CY	$7.00	$212
14	Transfer pump system (pump, screens, controls)	1.0	LS	$600.00	$600
	Total Parking Ramp Treatment				$8,492
	Planter Boxes				
15	Hydraulic restriction layer (6-in concrete)	4,500.0	sq ft	$16.00	$72,000
16	Bioretention media	124.4	CY	$40.00	$4,978
17	No. 8 stone	8.1	CY	$26.00	$212
18	Washed ASTM C-33 concrete sand	16.3	CY	$30.00	$489
19	Drainage stone (washed no. 57 stone)	70.1	CY	$45.00	$3,156
20	6-in Schedule 40 perforated PVC pipe	440.0	LF	$30.00	$13,200
21	6-in Schedule 40 PVC pipe	111.0	LF	$35.00	$3,885
22	6-in Schedule 40 perforated PVC pipe cleanout	11.0	EA	$100.00	$1,100
23	Hydraulic restriction layer (30-mil liner)	5,820.0	sq ft	$0.50	$2,910
	Total Planter Boxes				$101,930

Item No.	Description	Quantity	Unit	Unit Cost	Total
	Earthwork				
24	Fill	38.0	CY	$8.50	$323
25	Pipe backfill and bedding	20.8	CY	$46.95	$976
	Finish grading	13.3	SY	$0.17	$2
	Total Earthwork				$1,301
	Landscaping				
26	Bioretention planting	1,320.0	sq ft	$1.00	$1,320
27	Landscaping rock	12.2	CY	$60.00	$733
	Total Landscaping				$2,053
	Electrical Control Integration				
28	Electrical control integration	1	EA	$3,000	$3,000
	Total Electrical/Controls				$3,000
	Construction Subtotal				$147,906
	Mobilization and Stakeout 5%				$7,395
	Bonds and Insurance 5%				$7,395
	Construction Contingency 20%				$29,581
Total Construction Cost					$192,278

Notes: CY = cubic yards; EA = each; LF = linear feet; LS = lump sum; PVC = polyvinyl chloride; SY = square yards.

3.3.3. Treatment Scenario 3

To maximize the treatment potential at the site, a suspended pavement system could be implemented under the sidewalk adjacent to the planter boxes, as shown in Figure 3-8.

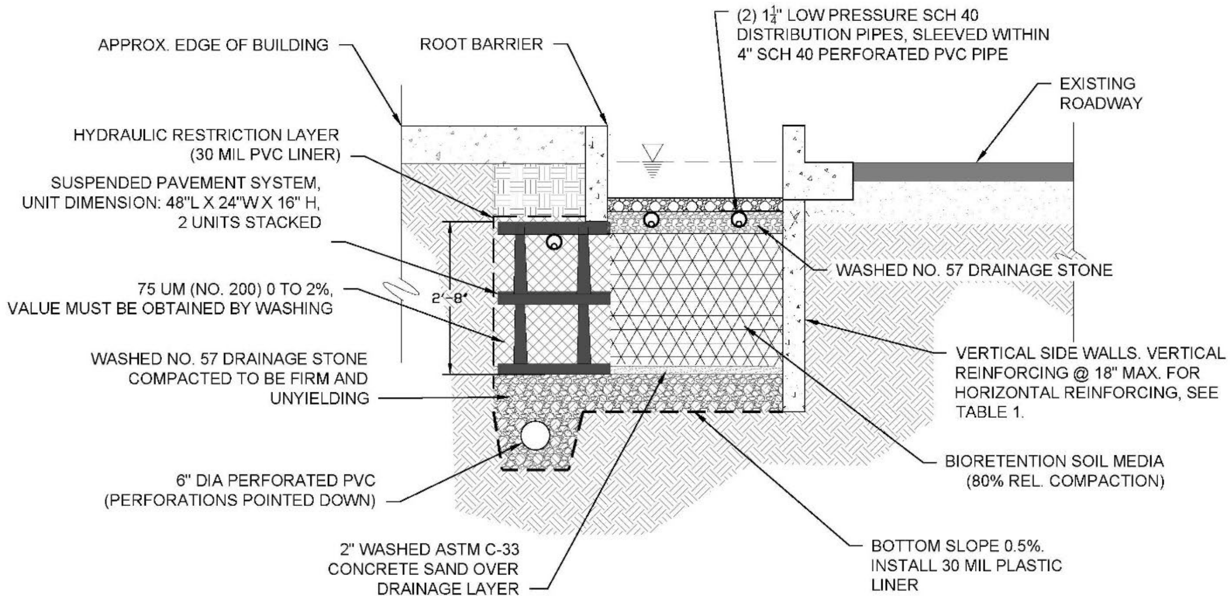

Figure 3-8. Planter boxes with a suspended pavement system.

Adding the suspended pavement system increases the surface area of the treatment system, allowing treatment of 4,400 gpd, an increase of 1,760 gpd above Treatment Scenario 2 and 2,850 gpd above Treatment Scenario 1. Adding the additional treatment capacity increases the projected costs by approximately $30,000 compared to Treatment Scenario 2 and approximately $77,000 compared to Treatment Scenario 3, as shown in Table 3-6.

Table 3-6. Ground-level runoff and nuisance flow treatment construction cost (Treatment Scenario 3)

Item No.	Description	Quantity	Unit	Unit Cost	Total
	Nuisance Flow Treatment				
1	8,000-gal fiberglass settling tank (6-ft dia, 40-ft length)	1.0	EA	$22,000.00	$22,000
2	Bedding and backfill	1.0	LS		$0
3	Distribution pump system (pump, control, floats)	1.0	LS	$1,000.00	$1,000
4	Pump basin	1.0	LS	$1,200.00	$1,200
5	4-in Schedule 40 PVC pipe	258.5	LF	$9.15	$2,365
6	3-in Schedule 40 PVC pipe	90.0	LF	$6.60	$594
7	2-in Schedule 40 PVC pipe	106.5	LF	$3.33	$355
8	1.5-in Schedule 40 PVC pipe	45.0	LF	$2.73	$123
9	1.25-in distribution line	1,320.0	LF	$3.30	$4,356
	Total Nuisance Flow Treatment				$31,993
	Parking Ramp Treatment				
10	3,200-gal sand/oil interceptor	1.0	LS	$6,038.00	$6,038
11	Ring and cover	1.0	EA	$330.00	$330
12	Ring and grate	1.0	EA	$350.00	$350
13	Excavation	30.3	CY	$7.00	$212
14	Transfer pump system (pump, screens, controls)	1.0	LS	$600.00	$600
	Total Parking Ramp Treatment				$7,530
	Planter Boxes				
15	Hydraulic restriction layer (6-in concrete)	2,940.0	sq ft	$16.00	$47,040
16	Bioretention media	124.4	CY	$40.00	$4,978
17	No. 8 stone	8.1	CY	$26.00	$212
18	Washed ASTM C-33 concrete sand	16.3	CY	$30.00	$489
19	Drainage stone (washed no. 57 stone)	70.1	CY	$45.00	$3,156
20	6-in Schedule 40 perforated PVC pipe	440.0	LF	$30.00	$13,200
21	6-in Schedule 40 PVC pipe	111.0	LF	$35.00	$3,885
22	6-in Schedule 40 perforated PVC pipe cleanout	11.0	EA	$100.00	$1,100
23	Hydraulic restriction layer (30-mil liner)	5,820.0	sq ft	$0.50	$2,910
24	Suspended pavement system	880.0	sq ft	$53.00	$46,640
	Total Planter Boxes				$123,610
	Earthwork				
25	Fill	38.0	CY	$8.50	$323
26	Off-site hauling	173.0	CY	$12.00	$2,076

Item No.	Description	Quantity	Unit	Unit Cost	Total
27	Pipe backfill and bedding	20.8	CY	$46.95	$976
28	Finish grading	13.3	SY	$0.17	$2
	Total Earthwork				$3,377
	Landscaping				
29	Bioretention planting	1,320.0	sq ft	$1.00	$1,320
30	Landscaping rock	12.2	CY	$60.00	$733
	Total Landscaping				$2,053
	Electrical Control Integration				
31	Electrical control integration	1	EA	$3,000	$3,000
	Total Electrical/Controls				$3,000
	Construction Subtotal				$171,105
	Mobilization and Stakeout 5%				$8,555
	Bonds and Insurance 5%				$8,555
	Construction Contingency 20%				$34,221
Total Construction Cost					$222,437

Notes: CY = cubic yards; EA = each; LF = linear feet; LS = lump sum; PVC = polyvinyl chloride; SY = square yards.

3.3.4. Summary

A comparison of the costs and treatment capacities for the three treatment scenarios is shown in Table 3-7.

Table 3-7. Treatment Scenario comparison.

Element	Scenario 1	Scenario 2	Scenario 3
Treatment Area (sq ft)	775	1,320	2,200
Treatment Capacity (gpd)	1,550	2,640	4,400
Cost	$145,638	$192,278	$222,437

Site plans and details for each treatment scenario are included in Appendix A.

3.4. Planting Plan

For a green infrastructure practice to function properly as stormwater treatment and blend into the landscape, vegetation selection is crucial. Appropriate vegetation will have the following characteristics:

- Tolerant of drought, ponding fluctuations, and saturated soil conditions for 10–48 hours.
- A combination of a minimum of three tree, three shrubs, and/or three herbaceous groundcover species incorporated, where possible, to protect against facility failure from disease and insect infestations of a single species.
- Native plant species or hardy cultivars that are not invasive and do not require chemical inputs used to the maximum extent practicable.

The vegetation shown in Table 3-8 was recommended by the design team to fit the specific site constraints.

Table 3-8. Recommended vegetation

Plant Species	**Common Name**	**Mature Size** (height x width)	**Irrigation Demands** High - H ▪ Moderate - M Low - L ▪ Rainfall Only - N	**Light Requirements** Sun - SU ▪ Shade - SH Part Shade – PS Sun or Shade - SS	**Season** Evergreen - E, Deciduous - D Semi-Evergreen – SE
Acer negundo	Box Elder	30 ft x 20 ft	L	SU	D
Celtis occidentalis	Common Hackberry	60 ft x 60 ft	M	PS	D
Amelanchier arborea	Downy Serviceberry	20 ft x 20 ft	M	SU	D
Amelanchier canadensis	Shadblow Serviceberry	25 ft x 20 ft	M	SU	D
Sambucus	Elderberry	10 ft x 10 ft	M	SU	D
Aronia	Chokeberry	6 ft x 6 ft	M	SU	D

3.5. Operation and Maintenance

General maintenance activities for cisterns and rain barrels are similar to the routine periodic maintenance for on-site drinking water wells. The primary maintenance requirement is to inspect the tank and distribution system and test any backflow-prevention devices. Rain barrels require minimal maintenance several times a year and after major storms to prevent any clogging. Cisterns require inspection for clogging and structural soundness twice a year, including inspection of all debris and vector control screens. If a first-flush diverter is used, it should be dewatered and cleaned after each significant storm event. Self-cleaning filters and screens, such as the ones shown in Figure 3-9, can help prevent debris from entering the cistern and reduce maintenance. Accumulated sediment in the tank must be removed at least once a year.

Figure 3-9. Self-cleaning inlet filters.

Table 3-9 provides a detailed list of maintenance activities.

Table 3-9. Inspection and maintenance tasks for cisterns

Task	Frequency	Indicator That Maintenance Is Needed	Maintenance Notes
Inspect the gutter and rooftop.	Biannually and before heavy rains	Inlet is clogged with debris	Clean gutters and roof of debris that has accumulated; check for leaks.
Remove accumulated debris.	Monthly	Inlet is clogged with debris	Clean debris screen to allow unobstructed stormwater flow into the cistern.
Inspect the foundation.	Biannually	Cistern is leaning or soils are slumping / eroding	Check cistern for stability; anchor system if necessary.
Inspect the structure.	Annually	Cistern leaks and is slow draining	Check pipe, valve connections, and backflow preventers for leaks; verify that flows empty the structure within 24–48 hours.
Add ballast.	Before any major wind-related storms	Tank is less than half full	Add water to half full.
Perform miscellaneous upkeep.	Annually		Make sure cistern manhole is accessible, operational, and secure.

Maintenance activities for vegetated green infrastructure practices should be focused on the major system components, especially landscaped areas. Landscaped components should blend over time through plant and root growth and organic decomposition, and they should develop a natural soil horizon. These biological and physical processes will lengthen the facility's life span and reduce the need for extensive maintenance.

Irrigation might be needed, especially during plant establishment or periods of extended drought. Irrigation frequency will depend on the season and type of vegetation. Native plants require less irrigation than nonnative plants.

Table 3-10 outlines the required maintenance tasks, their associated frequency, and notes to expand on the requirements of each task based on recommendations from researchers in the green infrastructure field.

Table 3-10. Inspection and maintenance tasks for bioretention planter box

Task	Frequency	Maintenance Notes
Monitor infiltration and drainage.	Annually	Inspect drainage time (12–24 hours); might have to determine the infiltration rate (every 2–3 years); turning over or replacing media (top 2–3 in) might be necessary to improve infiltration (at least 0.5 in per hour).
Prune the vegetation.	Annually	Nutrients in runoff often cause bioretention vegetation to flourish.
Mulch the vegetation.	Annually	Recommend maintaining 1–3-in uniform mulch layer.
Remove mulch.	Every 3–4 years	Biodegraded mulch accumulation reduces available water storage volume; removal of mulch also increases surface infiltration rate of fill soil.
Water the vegetation.	1 time/2–3 days for first 1–2 months; sporadically after establishment	If drought conditions exist, watering after the initial year might be required.
Fertilize the vegetation.	1 time initially	One-time spot fertilization for first-year vegetation.
Remove and replace dead plants.	Annually	It is common for 10% of plants to die during first year; survival rates tend to increase with time.
Inspect the inlet.	Once after first rain of the season, then monthly during the rainy season	Check for sediment accumulation to ensure that flow into the retention area is as designed; remove any accumulated sediment.
Inspect the outlet.	Once after first rain of the season, then monthly during the rainy season	Check for erosion at the outlet and remove any accumulated mulch or sediment.
Perform miscellaneous upkeep.	Biannually	Includes trash collection, plant health, spot weeding, and removing mulch from the overflow device.

4. Conclusion

With the arid Southwest facing water supply challenges, innovative solutions are necessary to reduce potable water demand. Methods to maximize the use of the limited rainfall that occurs in the region are needed.

This project designed a water harvesting system to capture rooftop runoff and reuse it for irrigation on the rooftop garden. The garden serves multiple purposes, including reducing rooftop temperatures and stormwater runoff, and as an urban food source. The system can serve as a model for developments in other Southwest communities.

A second component of the project, not included in the final design, was development of a system to capture and treat fugitive flows from an adjacent storm sewer. Even during dry weather, storm sewers can produce significant volumes of stormwater from excess irrigation runoff and other sources. A system to capture and reuse these fugitive flows for irrigation would reduce potable water use. Although challenging, systems to capture and use fugitive flows should be considered in future developments where practical.

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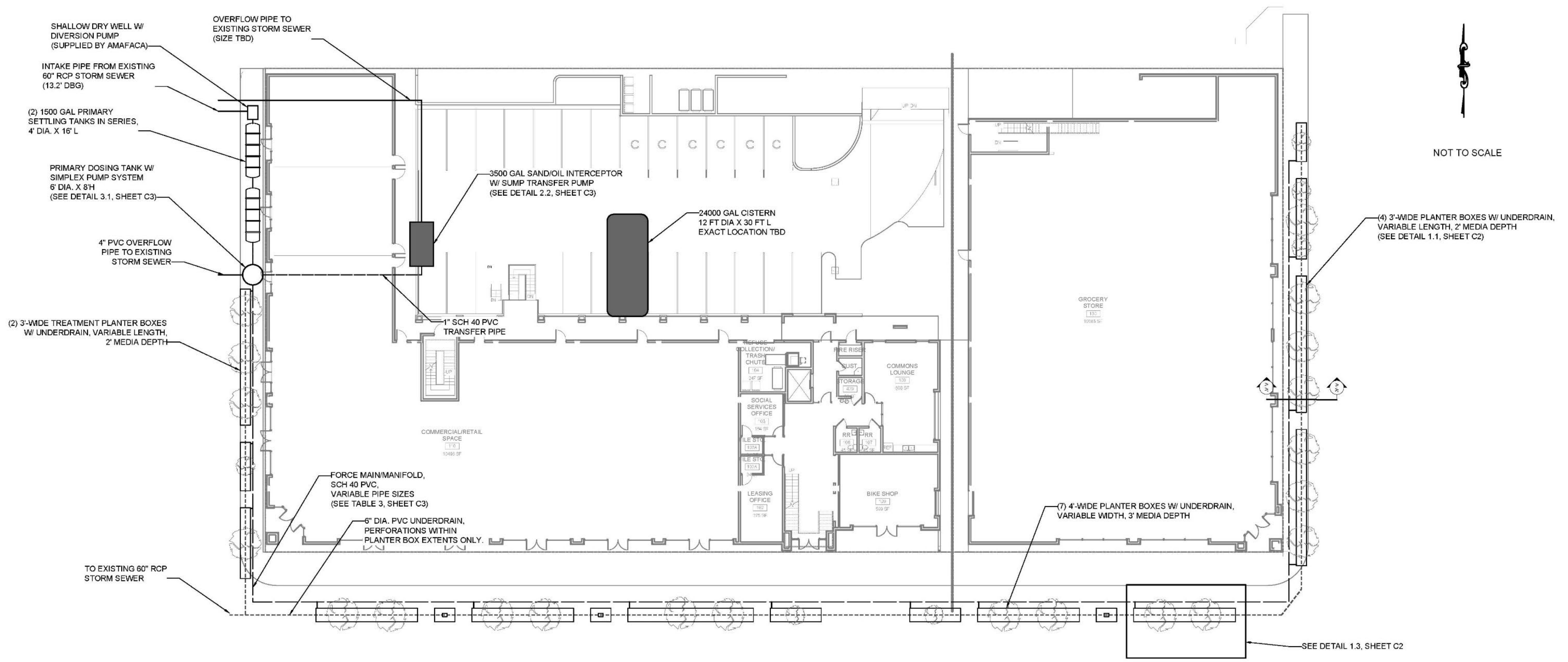
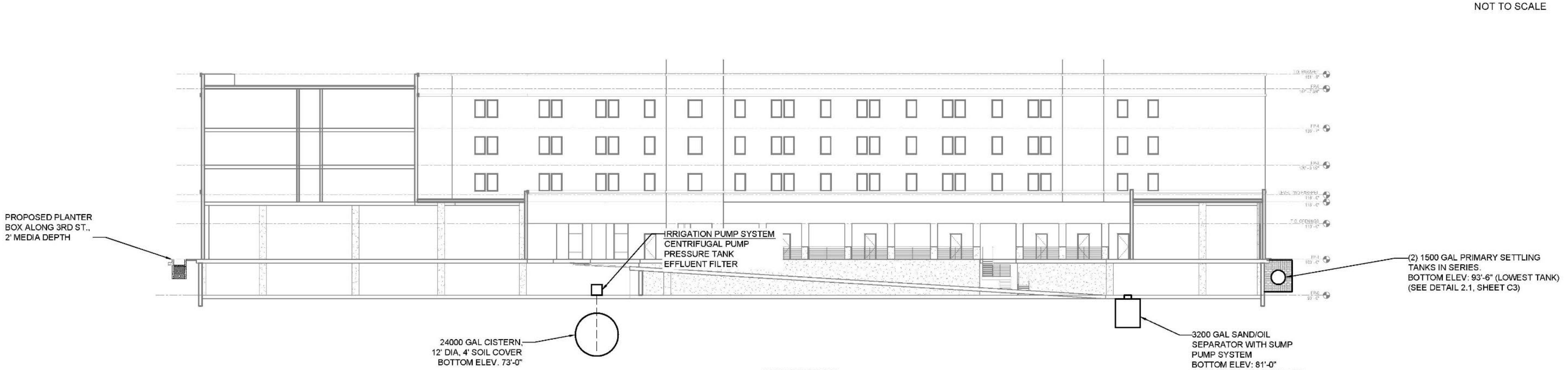
Appendix A: Site Plan and Details



SITE PLAN



SECTION VIEW

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MARK	DATE	DESCRIPTION	BY
	7-25-14	DRAFT_SUBMITTAL	RST

Client: CLIENT_NAME
Proj. Loc.: PROJECT_LOCATION

IMPERIAL BUILDING
205 Silver Avenue SW
Albuquerque, NM 87102

SITE PLAN AND ELEVATIONS

Project No.: PROJECT-NO
Designed By:
Drawn By:
Checked By:

C1

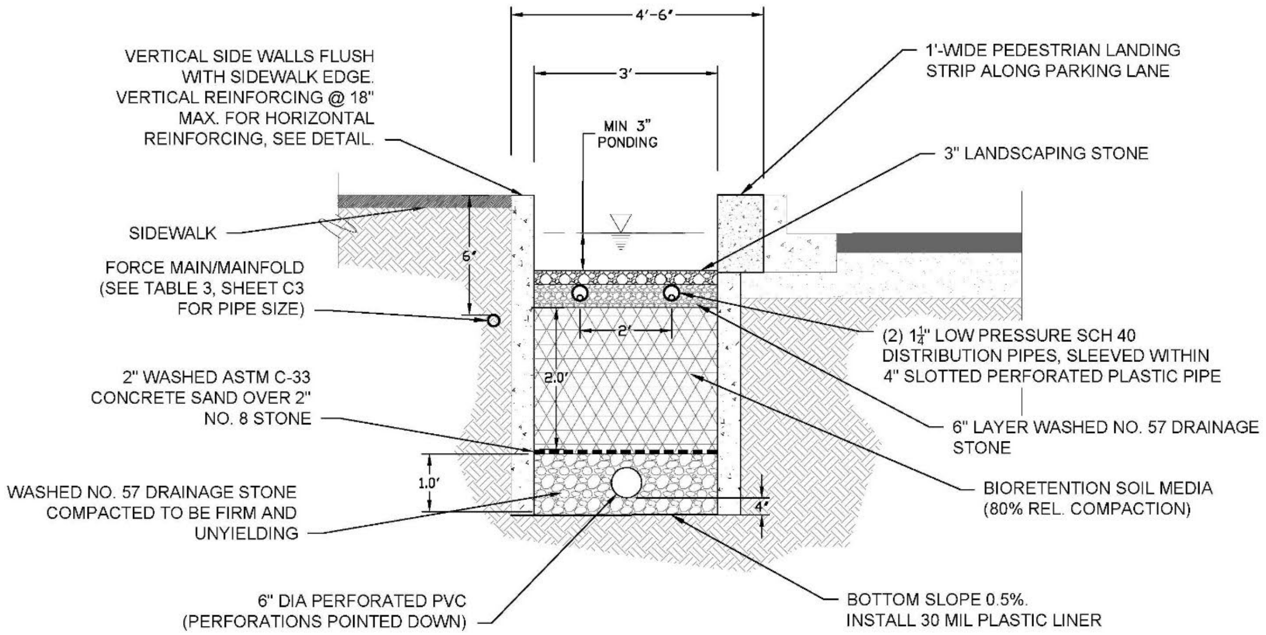
Tuesday, September 02, 2014 11:14:36 AM DRAWING: C:\PROJECTS\EPA_GI\Albuquerque\CAD\C1_v2.DWG LAYOUT: PLAN USER NAME: TUCKER, BOBBY

BIORETENTION MEDIA SPECIFICATION

BSM Composition	Sand	Sandy Loam			Compost
		Sand	Silt	Clay	
Volume	65%	20%			15%
Weight	75–80%		10% max.	3% max.	9% max.[1]

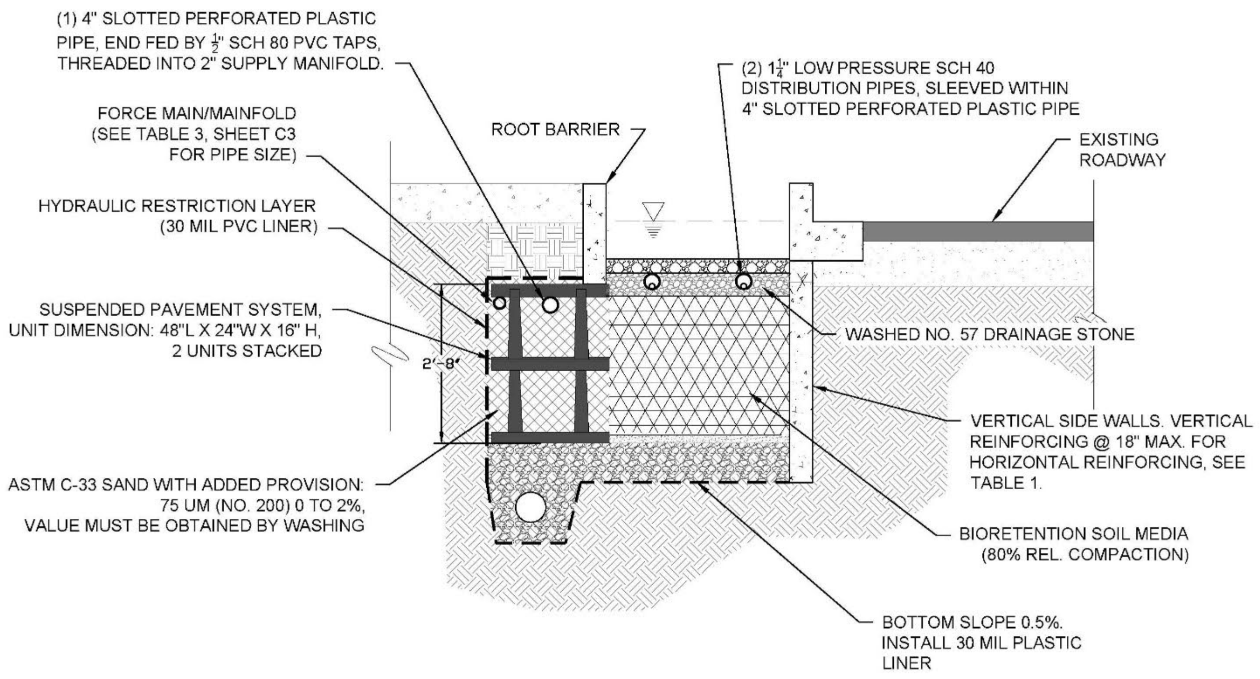
[1] compost by weight results in approximately 5% organic matter by weight.

NOT TO SCALE

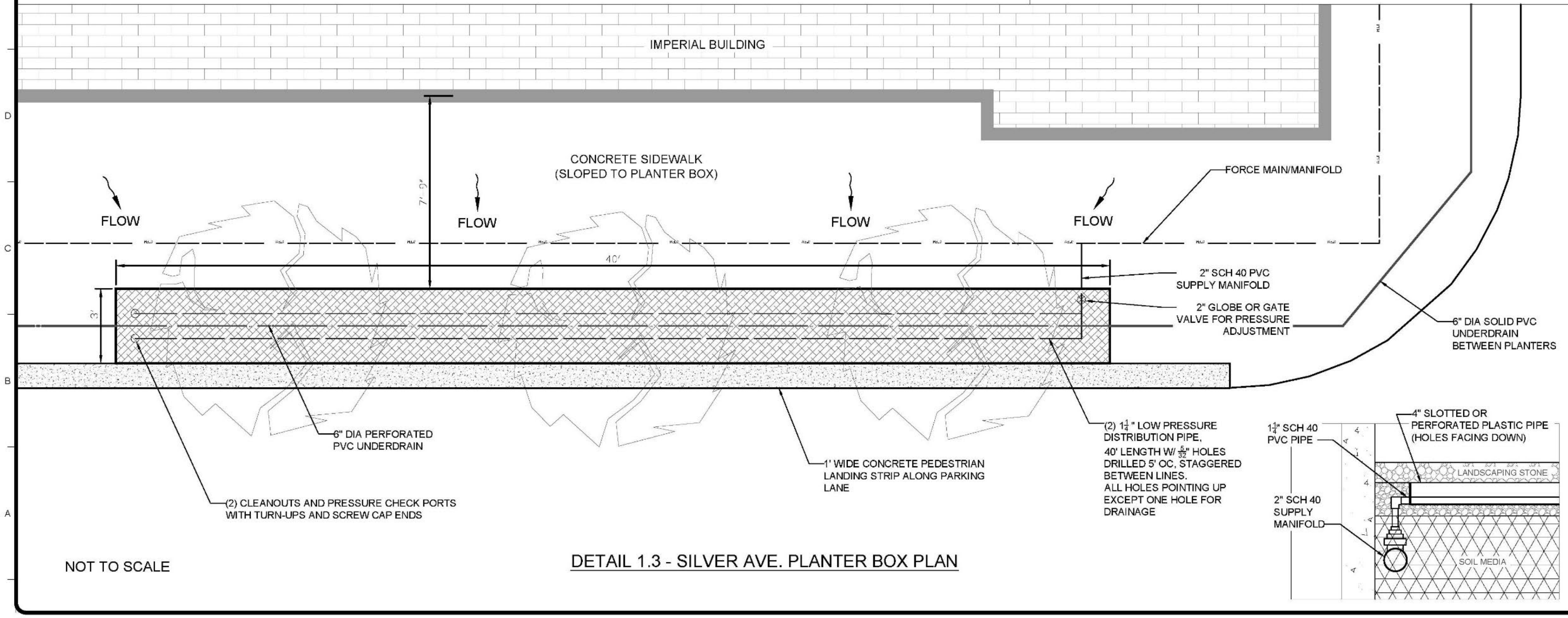


DETAIL 1.1 - (SECTION A-A) PLANTER BOX SECTION

NOT TO SCALE



DETAIL 1.2 - SCENARIO 3 PLANTER BOX SECTION W/ SUSPENDED PAVING TREATMENT



NOT TO SCALE

DETAIL 1.3 - SILVER AVE. PLANTER BOX PLAN

HORIZONTAL REINFORCING NOTES:

1. CONCRETE SHALL BE 560-C-3250 UNLESS OTHERWISE NOTED.
2. REINFORCING STEEL SHALL COMPLY WITH THIS DRAWING UNLESS OTHERWISE SPECIFIED.
3. REINFORCING STEEL SHALL BE INTERMEDIATE GRADE DEFORMED BARS CONFORMING TO LATEST ASTM SPECIFICATIONS.
4. BENDS SHALL BE IN ACCORDANCE WITH LATEST ACI CODE.
5. MINIMUM SPLICE LENGTH FOR REINFORCING SHALL BE 30 DIAMETERS.
6. FLOOR SHALL HAVE A WOOD TROWEL FINISH AND, EXCEPT WHERE USED AS JUNCTION BOXES, SHALL HAVE A MINIMUM SLOPE OF 1:12 TOWARD THE OUTLET.
7. DEPTH V IS MEASURED FROM THE TOP OF THE STRUCTURE TO THE FLOWLINE OF THE BOX.
8. WALL THICKNESS AND REINFORCING STEEL REQUIRED MAY BE DECREASED IN ACCORDANCE WITH TABLE 1.
9. WALL THICKNESS SHALL BE STEPPED ON THE OUTSIDE OF THE BOX.
10. WHEN THE STRUCTURE DEPTH V EXCEEDS 4', STEPS SHALL BE CAST INTO THE WALL AT 15" INTERVALS FROM 15" ABOVE FLOOR TO WITHIN12" OF TOP OF STRUCTURE. PLACE STEPS IN WALL WITHOUT PIPE OPENING, OTHERWISE OVER OPENING OF SMALLEST DIAMETER.
11. ALTERNATE STEP MAY BE AN APPROVED STEEL REINFORCED POLYPROPYLENE STEP.
12. UPON APPROVAL OF THE ENGINEER, AS DEFINED BY SECTION 6703 OF THE BUSINESS AND PROFESSIONS CODE, THE USE OF PRECAST STORM STRUCTURES IS ACCEPTABLE AS AN ALTERNATE TO CAST-IN-PLACE. PRECAST UNITS SHALL CONFORM TO ASTM STANDARDS AND BE MANUFACTURED IN A PERMANENT FACILITY DESIGNED FOR THAT PURPOSED.

TABLE 1. BOX SECTION REINFORCEMENT

MAXIMUM SPAN X OR Y	DEPTH V	THICKNESS T	HOR. & FLR. REINF.	
3'-0" TO 4'-0"	4'-0"	6"	#4	18"
4'-1" TO 7'-0"		6"	#4	12"
7'-1" TO 8'-0"		6"	#4	8"
3'-0" TO 4'-0"	4'-1" TO 8'-0"	6"	#4	18"
4'-1" TO 5'-0"		6"	#4	12"
5'-1" TO 6'-0"		6"	#4	8"
6'-1" TO 8'-0"		6"	#4	6"

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MARK	DATE	DESCRIPTION	BY
	7-25-14	DRAFT_SUBMITTAL	RST

Client:
Proj. Loc.:
IMPERIAL BUILDING
205 Silver Avenue SW
Albuquerque, NM 87102

PLANTER BOX DETAILS

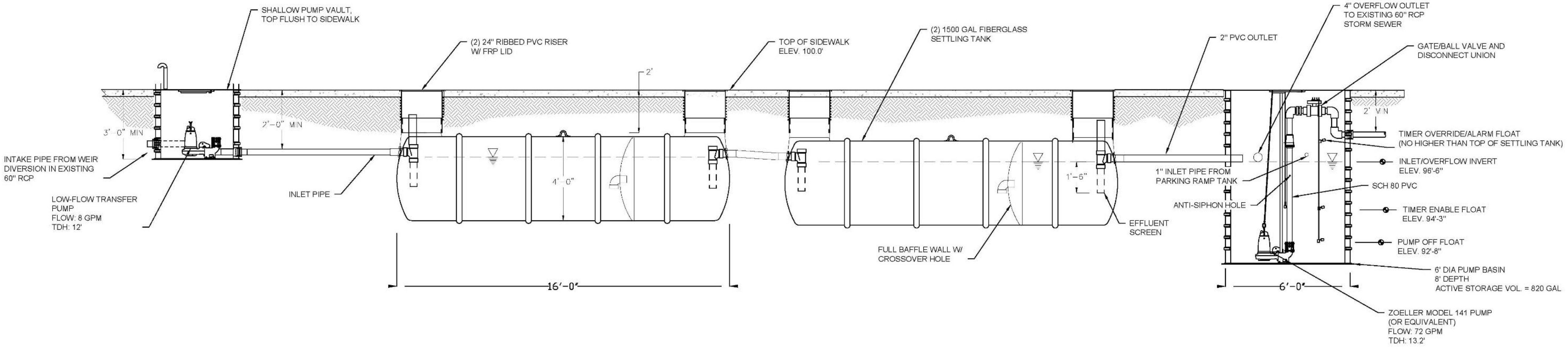
Project No.: PROJECT-NO
Designed By:
Drawn By:
Checked By:

C2

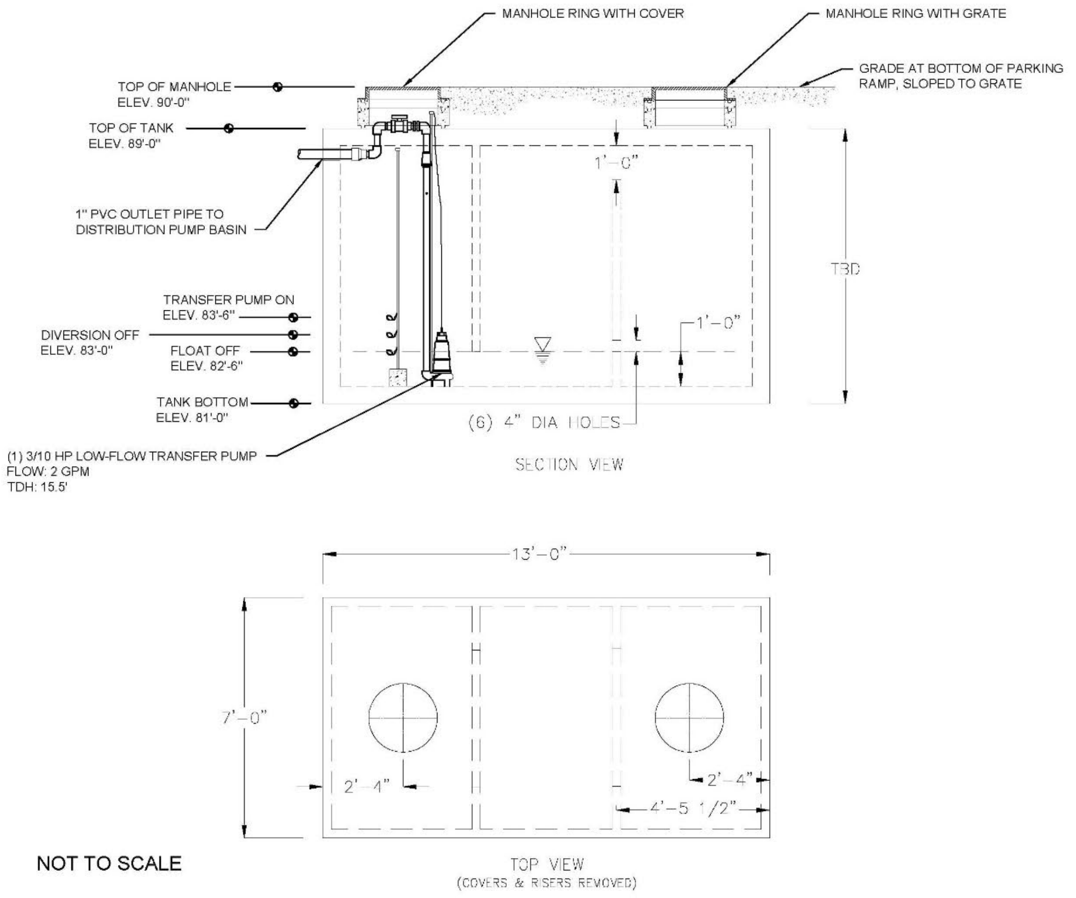
Friday, July 25, 2014 6:16:03 PM DRAWING: C:\PROJECTS\EPA G1\Albuquerque\CAD\C2.DWG LAYOUT: SECTION USER NAME: TUCKER, BOBBY

NOT TO SCALE

NOTES:
1. ELEVATIONS ARE RELATIVE, BASED ON BUILDING ELEVATIONS PROVIDED BY DEKKER/PERICH/SABATINI.
2. DESIGN DOES NOT INCLUDE STORM SEWER INFRASTRUCTURE REQUIRED TO CONNECT TO EXISTING 60" RCP.



DETAIL 2.1 - NUISANCE FLOW PRE-TREATMENT AND PUMP TANKS



NOT TO SCALE

DETAIL 2.2 - 3500 GAL PARKING RAMP COLLECTION TANK

NOTES:
1. REQUIRED STORAGE VOLUME BETWEEN FLOAT OFF ELEVATION AND OVERFLOW OUTLET IS 3,500 GALLONS. ACTUAL TANK SIZE WILL BE LARGER TO PROVIDE FOR OVERFLOW OUTLET, FREEBOARD, AND NECESSARY PUMP SUBMERGENCE.
2. TANK DESIGN DOES NOT INCLUDE OVERFLOW OUTLET AND CULVERT TO EXISTING 60" RCP.
3. TANK DIMENSIONS MAY VARY DEPENDING MANUFACTURER.

TABLE 2. DESIGN PARAMETERS BY SCENARIO

Parameter	**SCN 1**	**SCN 2**	**SCN 3**
Filter Area (sf)	775	1320	2200
Design Load (gpd)	1550	2640	4400
Distribution Pump			
# Doses/day	4	8	12
Vol/Dose (gal)	388	330	367
Dose Time (min)	3.6	5.3	3.9
Parking Ramp Pump			
Pump Rate (gpm)	1.1	1.8	3.1

TABLE 3. FORCE MAIN PIPE SIZES (SCENARIO 2)

Planter #	**Section L**	**Total L**	**Nominal D**	**Inside D**
from Pump Basin	ft	ft	in	in
1	2	2	2.5	2.47
2	45	47	2.5	2.47
3	20	67	2.5	2.47
4	39	106	2.5	2.47
5	46	152	2.5	2.47
6	46	198	2.0	2.07
7	42	240	2.0	2.07
8	41	281	2.0	2.07
9	20	301	2.0	2.07
10	46	347	1.5	1.61
11	70	417	1.5	1.61
12	45	462	1.5	1.61
13	45	507	1.0	1.05
14	29	536	0.5	0.60

SYSTEM OPERATION:

DRY-WEATHER PERIODS:
1. STORMWATER IS CONTINUOUSLY PUMPED FROM EXISTING 60" RCP INTO THE SETTLING TANK AT 8 GPM. PUMP RATE CAN BE INCREASED DEPENDING ON ACTUAL DRY WEATHER FLOWS.
2. EFFLUENT FROM THE SETTLING TANK FLOWS TO THE PUMP BASIN, WHERE IT IS DISTRIBUTED TO THE PLANTER BOXES ON A TIMER-BASED PUMPING SCHEDULE (SEE TABLE 2).
3. MAXIMUM AVAILABLE DOSING VOLUME IN THE PUMP TANK IS 820 GAL, WHICH PROVIDES FLEXIBILITY FOR DIFFERENT PUMPING SCHEDULES.

WET-WEATHER PERIODS:
4. RUNOFF FROM THE SIDEWALKS IS DIRECTLY TREATED BY THE PLANTER BOXES.
5. RUNOFF FROM THE PARKING RAMP AND ADJACENT SIDEWALK AREAS DRAINS TO THE 3500 GAL COLLECTION TANK LOCATED UNDER THE PARKING GARAGE.
6. FIRST FLOAT IN COLLECTION TANK TURNS OFF DIVERSION PUMP FROM EXISTING 60" RCP (AND STOPPING FLOW TO PUMP BASIN) AND OVERRIDES THE TIMER TO DELIVER A FULL DOSE TO THE PLANTER BOXES.
7. SECOND FLOAT ACTIVATES THE TRANSFER PUMP THAT PUMPS WATER TO THE PUMP BASIN AT A RATE THAT DOESN'T EXCEED THE DOSING SCHEDULE (SEE TRANSFER RATE, TABLE 2).
8. FLOW VOLUMES IN EXCESS OF THE 3500 GAL CAPTURE VOLUME OVERFLOW TO THE EXISTING 60" RCP.

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MARK	DATE	DESCRIPTION	BY
	7-25-14	DRAFT_SUBMITTAL	RST

Client:
Proj. Loc.:
IMPERIAL BUILDING
205 Silver Avenue SW
Albuquerque, NM 87102

DISTRIBUTION SYSTEM DETAILS

Project No.: PROJECT-NO
Designed By:
Drawn By:
Checked By:

C3

Tuesday, September 02, 2014 11:13:38 AM DRAWING: C:\PROJECTS\EPA_GI\Albuquerque\CAD\C3.DWG LAYOUT: SECTION USER NAME: TUCKER, BOBBY

Appendix B: Bioretention Soil Media Specifications

B.1 General Requirements

Bioretention soil media (BSM) should achieve a long-term, in-place infiltration rate of a minimum of 5 in per hour.

BSM also should support plant growth while providing pollutant treatment. To achieve those two goals, the BSM should be a mixture of sand, fines, and compost. The composition shown in Table B-1 includes the measurements for determining the BSM by volume and weight.

Table B-1. Composition of bioretention soil media

BSM Composition	Sand[a]	Sandy Loam			Compost
		Sand	Silt	Clay	
Volume	65%	20%			15%
Weight	75–80%		10% max.	3% max.	9% max.[b]

Notes: max. = maximum.

[a] Sand shall be washed with a 75-μm (No. 200) fraction of no more than 2% (this requirement is stricter than ASTM C-33, but is extremely important).

[b] 9% compost by weight results in approximately 5% organic matter by weight.

B.2 Submittals

Product Data: Submit manufacturer's product data and installation instructions. Include required substrate preparation, list of materials, application rate/testing, and permeability rates.

Verifications: Manufacturer shall submit a letter of verification that the products meet or exceed all physical property, endurance, performance, and packaging requirements.

Tests should be conducted no more than 120 days prior to the delivery date of the BSM to the project site. Batch-specific test results and certification will be required for projects installing more than 100 cubic yards of BSM.

The applicant should submit the following materials and information to the municipality for approval if requested:

- A sample of mixed BSM.
- Results of the grain size analysis of the sand component performed in accordance with American Society for Testing and Materials (ASTM) D422, *Standard Test Method for Particle Size Analysis of Soils*.
- Results of the grain size analysis of the sandy loam soil component performed in accordance with ASTM D422.
- Results of the grain size analysis of the compost component performed in accordance with ASTM D422.
- Results of the organic matter content test of the compost performed in accordance with ASTM F 1647, *Standard Test Methods for Organic Matter Content of Athletic Field Rootzone Mixes* or Testing Methods for the Examination of Compost and Composting (TMECC) 05.07A, *Loss-On-Ignition Organic Matter Method*.

- A description of the equipment and methods used to mix the sand, sandy loam, and compost to produce the BSM.
- Results of constant head permeability testing of the mixed BSM. In accordance with ASTM D2434, *Standard Test Method for Permeability of Granular Soils (Constant Head)*, constant head permeability testing should be conducted on a minimum of two samples with a 6-in mold and vacuum saturation.
- The following information about the testing laboratory or laboratories, including:
  - Name(s) of laboratory or laboratories
  - Contact person(s)
  - Address(es)
  - Phone contact(s)
  - Email address(es)
  - Qualifications of laboratory or laboratories, including use of ASTM and U.S. Department of Agriculture (USDA) method of standards

B.3 Sand Specifications for BSM

B.3.1 Sand Quality

Sand should be thoroughly washed prior to delivery and free of wood, waste, and coatings such as clay, stone dust, carbonate, or any other deleterious material. All aggregate passing the No. 200 sieve size should be nonplastic.

B.3.2 Sand Texture

Sand for BSM should be analyzed by a qualified lab using nos. 200, 100, 40, 30, 16, 8, and 4, and 3/8-in sieves (ASTM D422 or as approved by municipality) and meet the gradation detailed in Table B-2.

Table B-2. Texture of sand

Sieve Size	**Percent Passing (by weight)**	
	Min.	**Max.**
3/8 in	100	100
No. 4	90	100
No. 8	70	100
No. 16	40	95
No. 30	15	70
No. 40	5	55
No. 100	0	15
No. 200	0	2

Notes: max. = maximum; min. = minimum.
All sands complying with ASTM C33, *Standard Specification for Concrete Aggregates*, for fine aggregate comply with these gradation requirements.

Sand shall be washed with a 75-µm (No. 200) fraction of no more than 2 percent (this requirement is stricter than ASTM C-33, but is extremely important).

B.4 Sandy Loam Soil Specifications for BSM

B.4.1 Sandy Loam Soil Quality

Sandy loam soil for the BSM shall be free of wood, waste, coating (e.g., stone dust, carbonate, and so forth), and any other deleterious material. All aggregate passing the No. 200 sieve size shall be nonplastic.

B.4.2 Sandy Loam Soil Texture

Sandy loam soil should comply with the following specifications by weight based on ASTM D422 (or as approved by municipality):

- 50–74 percent sand
- 0–48 percent silt
- 2–15 percent clay

Note: These ranges were selected from the USDA soil textural classification for a sandy loam, such that clay content does not exceed 15 percent of sandy loam.

B.5 Compost Soil Specifications for BSM

B.5.1 Compost Texture

A qualified laboratory should analyze compost using No. 200 and 1/2-in sieves (ASTM D422 or as approved by municipality), and meet the gradation detailed in Table B-3.

Table B-3. Texture of compost

Sieve Size	Percent Passing (by weight)	
	Min.	Max.
1/2 in	97	100
No. 200	0	5

Notes: max. = maximum; min. = minimum.

B.5.2 Compost Quality Testing

Compost should be a well-decomposed, stable, weed-free organic matter source derived from waste materials, including yard debris, wood wastes, or other organic materials, and not including manure or biosolids. Compost shall have a dark brown color and a soil-like odor. Compost that is exhibiting a sour or putrid smell, contains recognizable grass or leaves, or is hot (120 degrees Fahrenheit) upon delivery or rewetting is not acceptable.

Compost should be produced at a facility that is regulated by the New Mexico Environment Department’s Solid Waste Bureau. Recent tests of compost quality should be reviewed to verify that the compost is of acceptable quality.

Compost should comply with the requirements detailed in Table B-4.

Table B-4. Composition of compost

Parameter	Method	Requirement	Units
Bulk Density	N/A	400–600	dry lbs/CY
Moisture Content	Gravimetric	30%–60%	dry solids
Organic Matter	ASTM F 1647 or TMECC 05.07A	35%–75%	dry weight
pH	Saturation Paste	6.0–8.0	
Carbon:Nitrogen Ratio	N/A	15:1–25:1	
Maturity/Stability	Solvita®	> 5	index value
Metals			
Arsenic	N/A	< 20	mg/kg dry weight
Cadmium		< 10	
Chromium		< 600	
Copper		< 750	
Lead		< 150	
Mercury		< 8	
Nickel		< 210	
Selenium		< 18	
Zinc		< 1400	
Pathogens			
Salmonella	N/A	< 3	MPN per 4 g
Fecal Coliform		< 1000	MPN per 1 g
Inert Material/Physical Contaminants			
Plastic, Metal, and Glass	N/A	< 1%	by weight
Sharps (% > 4mm)		0%	by weight

Notes: CY = cubic yards; lbs = pounds; mg/kg = milligram per kilogram; mm = millimeter; MPN = most probably number

B.5.3 Alternative Organic Amendments

Alternative organic amendments (in lieu of previously defined compost) will be reviewed on a case-by-case basis. Organic amendments should make up no more than 5 percent of the BSM bulk volume, unless organic alternatives comply with the specifications of section B.5.2.

B.6 BSM Specifications

BSM shall be free of roots, clods, stones larger than 1 in in the greatest dimension, pockets of coarse sand, noxious weeds, sticks, lumber, brush, and other litter. It shall not be infested with nematodes or undesirable disease-causing organisms such as insects and plant pathogens. BSM shall be friable and have sufficient structure to give good aeration to the soil. The following specifications should govern the bulk BSM.

B.6.1 BSM Texture

Gradation Limit: The definition of the soil should be the following USDA classification scheme by weight:

- Sand: 85–90 percent
- Silt: 10 percent maximum
- Clay: 5 percent maximum

Compost should compose no more than 9 percent of the bulk BSM weight and should primarily fall into the sand component above (per section B.5.1 compost gradation limits).

B.6.2 BSM Quality Testing

In addition to the compost quality testing requirements outlined in section B.5.2, the final BSM should meet the following standards. Testing results from the specifications detailed in Table B-5 shall be submitted for approval prior to BSM acceptance.

Table B-5. Composition of media

Parameter	**Method**	**Requirement**	**Units**
Organic Matter	Loss on Ignition	2–5%	dry weight
pH	Saturation Paste	6.0–8.0	-
Carbon:Nitrogen Ratio	-	10:1–20:1	-
Cation Exchange Capacity (CEC)	-	≥ 5	meq/100 g of dry soil
Salinity (Electrical Conductivity)	Saturation Extract	0.5–3	dS/m
Boron	Saturation Extract	< 2.5	ppm
Chloride	Saturation Extract	< 150	ppm
Sodium Adsorption Rate (SAR)	-	< 3	-
Extractable Nutrients			
Phosphorus	Ammonium Bicarbonate/DPTA extraction method	< 15	mg/kg dry weight
Potassium		100–200	
Iron		24–35	
Manganese		0.6–6.0	
Zinc		1.0–8.0	
Copper		0.3–5.0	
Magnesium		50–150	
Sodium		0–100	
Sulfur		25–500	
Molybdenum		0.1–2.0	
Aluminum		< 3.0	

Notes: DPTA = diethylenetriaminepentaacetic acid; dS/m = deci Siemens per meter; meq/100 g = milliequivalents per 100 grams; ppm = parts per million;

B.7 Alternative BSM Specifications

BSM not meeting the above criteria can be evaluated on a case-by-case basis.

B.7.1 General Requirements

Alternative BSM should meet the following specifications:

- Should be sufficiently permeable to infiltrate runoff at a minimum rate of 5 in per hour during the life of the facility
- Should provide sufficient retention of moisture and nutrients to support adequate vegetation while providing pollutant removal
- Should meet the requirements of the compost chemical analysis outlined in section B.5.2 and the BSM quality testing in section B.6.2

The following guidance is offered to assist municipalities with verifying that alternative soil mixes meet the specifications.

B.7.2 Submittals

The applicant should submit the following material and information to the municipality for approval:

- A sample of the alternative BSM.
- Certification from the soil supplier that the BSM meets the requirements of these guidelines.
- Results of constant head permeability testing of the alternative BSM. In accordance with ASTM D2434, constant head permeability testing should be conducted on a minimum of two samples with a 6-in mold and vacuum saturation.
- Results of organic matter content testing of the BSM in accordance with ASTM F1647 or TMECC 05.07A.
- Results of the grain size analysis of alternative BSM performed in accordance with ASTM D422.
- A description of the equipment and methods used to mix the sand and compost to produce the alternative bioretention soil.
- The following information about the testing laboratory or laboratories:
  - Name(s) of laboratory or laboratories
  - Contact person(s)
  - Address(es)
  - Phone contact(s)
  - Email address(es)
  - Qualifications of laboratory or laboratories, including use of ASTM and USDA method of standards
- Alternative BSM texture

Alternative BSM should be analyzed by an accredited laboratory using No. 200 and 1/2-inch sieves (ASTM D422 or as approved by municipality) and should meet the gradation detailed in Table B-6.

Table B-6. Texture of media

Sieve Size	Percent Passing (by weight)	
	Min.	Max.
1/2 in	97	100
No. 200	2	5

Notes: max. = maximum; min. = minimum.

B.8 Installation of BSM

This section provides considerations for proper BSM installation.

B.8.1 Considerations Prior to BSM Installation

The following questions and guidelines should be discussed with the contractor prior to installing the BSM at the project site to prevent any confusion and errors.

- Ensure that the contractor is familiar with constructing bioretention systems.
- Plan how inspections will be handled as part of the construction process.
- Verify that the BSM meets specification prior to delivery and placement in the facility.
- Prevent overcompaction of native soils in areas of the basin where infiltration will occur. Delineate the facility area, and keep construction traffic off. Protect soils with fencing, plywood, and so forth.
- Provide erosion control in the contributing drainage areas of the facility. Stabilize upslope areas.
- Ensure that drainage is directed away from bioretention facilities until upslope areas are stabilized. The concentration of fines could prevent postconstruction infiltration and cause design failure.
- If drainage is to be allowed through the facility during construction, leave or backfill at least 6 in above the final grade. Temporarily cover the underdrain with plastic or fabric. Line or mulch the facility.
- Bioretention facilities should remain outside the limit of disturbance to prevent soil compaction by heavy equipment. Protect bioretention areas with silt fence or construction fencing.
- Verify that installation of the underdrain is correct prior to placing soil.

B.8.2 BSM Mixing and Placement

Follow these guidelines to ensure proper BSM mixing and placement:

- Implement these erosion and sediment control practices during construction to protect the long-term functionality of the bioretention:
  - Provide erosion control in the contributing drainage areas to the facility and stabilize upslope areas.
  - Do not use facilities as sediment control facilities, unless installation of all bioretention-related materials are withheld towards the end of construction, allowing the temporary use of the location as a sediment control facility, and appropriate excavation of sediment is provided prior to installation of bioretention materials.
- Do not excavate, place soils, or amend soils during wet or saturated conditions.

- Operate equipment adjacent to the facility. Equipment operation within the facility should be avoided to prevent soil compaction. If machinery must operate in the facility, use lightweight, low ground-contact pressure equipment.
- If constructing an infiltrating facility, rip or scarify the subgrade to a minimum depth of 9 in on 3-ft centers to promote greater infiltration.
- Consider the time of year and site working area when determining whether to mix BSM on-site or to import premixed soil. It is recommended that the BSM be mixed prior to being delivered to the site; also, mixing is not allowed on-site during rainy season. If BSM mixing occurs on-site during the dry season, use an adjacent impervious area or mix BSM on plastic sheeting. (Mixing should not occur within the bioretention basin.)
- Place soil in 6–12-in lifts with machinery adjacent to the facility (to ensure that equipment is not driven across soil). If working within the facility, place first lifts at far end from entrance and place backwards towards entrance to avoid overcompacting.
- Allow BSM lifts to settle naturally, and lightly water to provide settlement and natural compaction between lifts. After lightly watering, allow soil to dry between lifts. Soil cannot be worked when saturated, so this method should be used with caution to ensure dry conditions. After all lifts are placed, wait a few days to check for settlement and add additional media as needed. No mechanical compaction is allowed.
- The long-term hydraulic conductivity rate should not be less than 5 in per hour when tested with a double ring infiltrometer (in accordance with ASTM D3385, *Standard Test Method for Infiltration Rate of Soils in Field Using Double Ring Infiltrometer*), a single ring infiltrometer, a Modified Philip-Dunne Infiltrometer, or other approved method.
- Vehicular traffic and construction equipment shall not drive on, move onto, or disturb the BSM once placed and water-compacted.
- Rake bioretention soil as needed to level out. Verify BSM elevations before applying mulch or installing plants.

Other Considerations:

- Protect adjacent infiltration systems including swales, soils, and porous pavement from sediment.
- Protect adjacent trees.