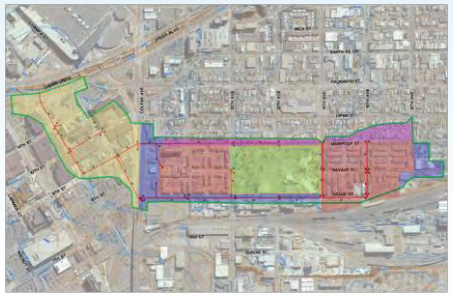
Partnership *for* Sustainable Communities

DENVER, COLORADO

South Lincoln Redevelopment Project Stormwater/Green Infrastructure Charrette

FINAL REPORT

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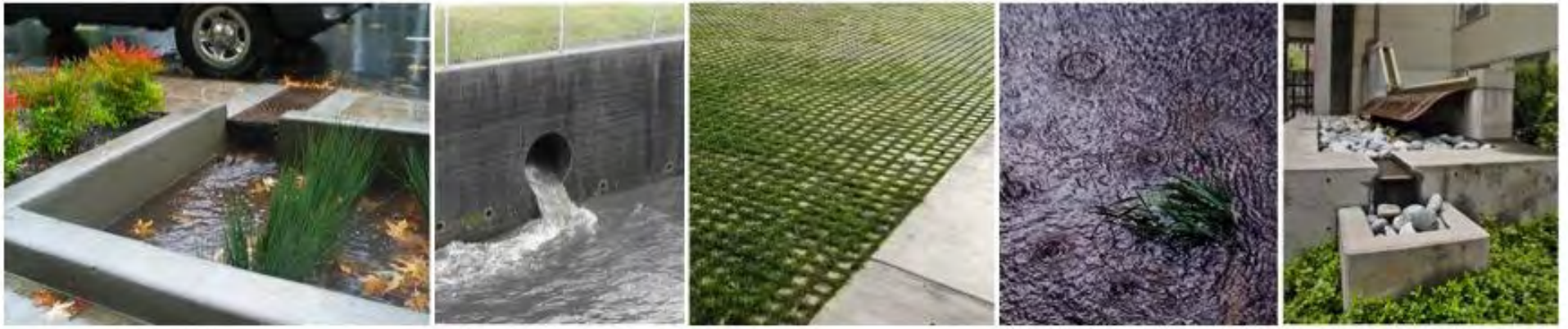
Prepared by:

www.sra.com/environment

www.yrgsustainability.com

www.visionlandconsultants.com



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1. Executive Summary

The Denver Partnership for Sustainable Communities Brownfield Pilot is led by the U.S. Environmental Protection Agency (EPA) Office of Brownfields and Land Revitalization (OBLR) and the Office of Sustainable Communities (OSC), and is comprised of the EPA, Department of Housing and Urban Development (HUD), and Department of Transportation (DOT). These agencies are working together to ensure federal resources and policies support the development of sustainable communities. The partnership is based on "livability principles" that guide inter-agency collaboration and support the integration of safe, reliable and economical transportation; affordable, energy-efficient housing; and sustainable reuse of unoccupied or underutilized land. Pilot communities were selected by EPA's Brownfields Program with input from HUD and DOT, and receive technical assistance and support from these agencies to build on past investments, identify opportunities to connect housing, transit and brownfields within the development, and to coordinate resources that can further the integration of sustainability.

The Denver Housing Authority (DHA) is an affordable housing provider whose South Lincoln Redevelopment Project (SoLi) was selected as a Partnership for Sustainable Communities Pilot in 2010. In recent years, the SoLi project has received much collaborative support from state, local and community stakeholders and leaders in defining and establishing its concept and goals. In 2008, prior to being selected as a Pilot project, a 3-acre portion of the SoLi site (at 10th & Osage, included as part of Phase 1 of the project) received funding from the EPA's Brownfield Cleanup grant program to cleanup the area to unrestricted residential use cleanup standards. In September 2009, the DHA and key project team members finalized a Master Plan for SoLi focusing on land use, energy, transportation and public health. In addition, this Master Plan identifies sustainability goals as integral to the project vision (to view the SoLi Master Plan, go to: http://www.denverhousing.org/development/SouthLincoln/MasterPlan/Pages/default.aspx).

DHA is committed to making SoLi a successful development that includes progressive stormwater management strategies addressing both water quality and quantity for storm and surface water. The analysis herein clearly shows that the La Alma / Lincoln Park stormwater system is not able to manage the 100-year storm, and in some areas the 5-year storm. When the watershed overflows during a storm event, pollutants drain into Cherry Creek and eventually the South Platte River impacting water quality. Additionally, the South Platte and Cherry Creek confluence have poor water quality, and stormwater runoff from the City of Denver only makes this problem worse. Currently, flooding occurs during large storm events at the 10th and Osage light rail station, the intersections of 13th and Osage and Colfax and Osage, and on the Auraria Campus at 9th and 10th Streets. It will be important for the City and neighborhood stakeholders to address these issues by improving stormwater quantity and quality, increasing infrastructure, or a combination of both. It is the goal of DHA to incorporate low-impact design (LID) strategies to greatly improve these issues, and support best management practices for SoLi and the regional watershed.

Representatives from local, state and federal government agencies, community and resident groups, non-profit and private sectors participated in an EPA sponsored Stormwater / Green Infrastructure Charrette to identify the current efforts, barriers, opportunities, and key partners for creating a comprehensive stormwater / green infrastructure solution on the DHA site and for the Curtis Street Outfall Watershed (the watershed within which SoLi exists). Charrette participants also focused on developing an implementation plan to increase interagency collaboration on these issues in the regional watershed. As part of the Pilot and charrette process, technical assistance was provided under contract by SRA International, Inc. and YRG sustainability, as well as Vision Land Consultants, Inc. and Wenk Associates, Inc. (Technical Assistance Team).

Confluence of the South Platte River and Cherry Creek

Cherry Creek bike path during flooding

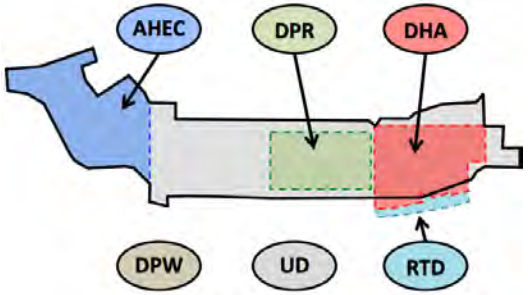
1.1 Stormwater and Green Infrastructure Priorities

The overarching goal of the South Lincoln Stormwater / Green Infrastructure Charrette was to outline a path for developing a comprehensive regional stormwater plan for the Curtis Street Outfall Watershed and La Alma / Lincoln Park (LA / LP) neighborhood that balances the needs and goals of all major developers within and adjacent to the watershed. DHA and Auraria Higher Education Campus (AHEC) are the two major developers in this watershed. Denver Parks and Recreation (DPR) own a significant amount of land in the watershed, as well as the Regional Transportation District (RTD) who have light rail stations and tracks that are impacted by stormwater overflows at the 10th & Osage light rail station and at Colfax Street and 13th Avenue. In addition, Denver Public Works (DPW) and Urban Drainage and Flood Control District (UD) are key players in the regional stormwater planning and infrastructure implementation.

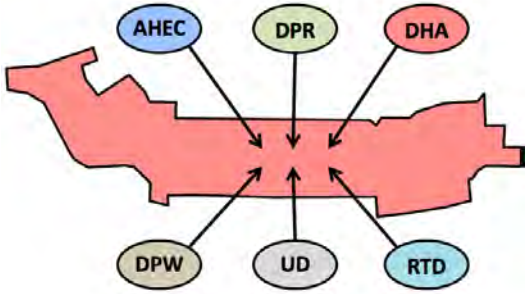
These major developers and landowners need to coordinate their stormwater management efforts and investments in order to achieve a comprehensive regional solution that will minimize development cost, increase functionality and create economies of scale. However, several major barriers are preventing this from happening. Current stormwater management efforts focus on individual site solutions that can be costly and limit site development. It is possible that a shared regional solution will increase the development potential within the neighborhood while being more cost effective and sustainable in the long term.

Curtis Street Outfall Watershed (DHA site highlighted in red)

CURRENT PRACTICE - INDIVIDUAL SITE SOLUTIONS WITH WATERSHED MAJOR LANDHOLDERS



GOAL - SHARED REGIONAL SOLUTION WITH WATERSHED MAJOR LANDHOLDERS



1.2 Summary of Key Findings

The following report is a detailed summary of the discussions, working group sessions, presentations and analysis that occurred before and during the Stormwater / Green Infrastructure Charrette. The key findings below are a summary and synthesis of the major issues that were identified during the charrette.

- **Fund and complete a regional stormwater engineering study:** Analysis completed for the charrette was primarily site-oriented but did included some evaluation of how LID would impact the stormwater issues on a regional level. Although there was a general consensus at the charrette that a shared regional stormwater solution is probably more efficient and cost effective, this is not yet proven. A stormwater engineering study would evaluate the regional stormwater impacts and opportunities and build upon the analysis that was completed for the charrette. Neighborhood stakeholders, who will likely see reduced capital costs with a regional solution, will need to fund or pursue joint grants for this study. Those same stakeholders will also need to determine the boundaries and scope of the study in order to address and capture possible opportunities that may be outside of the watershed.

- **Create a convening body that supports inter-agency communication and collaboration:** It was clear during the charrette discussions that there is a real need for a "convener" that can bring together the major developers and land owners in the watershed to communicate and coordinate efforts and investments. This "convener" will need to be a key stakeholder in the neighborhood and have decision-making authority over possible regional solutions. The City of Denver, RTD, and the EPA were three organizations identified as possible "conveners", and it was acknowledged that participation by Urban Drainage would be crucial. Major stakeholders will likely need an incentive to opt-in to the group since it will require additional time and effort beyond current practices.
- **Develop a funding mechanism for shared regional stormwater projects:** One of the major barriers charrette participants identified is that individual developers work with separate budgets and schedules. This makes it very difficult for developers to collaborate on joint stormwater management solutions. Another challenge is that the city and federal funding cycles are much shorter than the time required to develop a comprehensive stormwater solution for the watershed. A funding mechanism needs to be developed that will allow individual developers to both buy into a regional solution and acquire funding for stormwater solutions that go beyond the requirements of individual projects. This mechanism will likely need to pay for temporary short-term strategies as well as comprehensive long-term solutions. Several charrette participants recommended a 20 to 40 year bond to achieve this goal.
- **Use the South Lincoln Redevelopment Project to verify effectiveness and operational costs of innovative stormwater strategies:** Some of the more innovative stormwater strategies, such as porous retention basins in the right-of-way, are considered by some to be risky and unproven in Denver, yet the potential benefits of these strategies is significant. The SoLi project is ideal as a pilot project for various innovative stormwater strategies because DHA has a strong working relationship with the City of Denver and Phase 1 of the project (1099 Osage) has already incorporated some of these strategies. (Under the pilot program at 1099 Osage, DHA is responsible for monitoring and maintenance of these systems). In the long run, the City and its stakeholders will need to determine how to incorporate these designs into the City standards to ensure adoption by the development community. The City will need to work with the independent community to determine the best approach to monitoring, maintenance, and overseeing the long-term improvements to these stormwater strategies. This pilot project would also allow the city to verify the effectiveness of new stormwater strategies and implement those that are most successful in other watersheds throughout the city.
- **Implementation of Low-Impact Design (LID) strategies can provide significant benefits to Curtis Street Outfall Watershed:** Low-impact design utilizes decentralized small-scale strategies to manage stormwater. LID strategies are typically implemented on a site-by-site basis but can manage large stormwater volumes when integrated at a regional scale. With the right partnerships and approach, SoLi could be an ideal project for showcasing innovative LID strategies such as rain gardens, vegetated swales and permeable pavements.
- **Develop shared metrics for success:** Each neighborhood stakeholder will have their own goals and needs for a regional stormwater solution. It will be important for all of the key stakeholders to develop a shared definition of success that identifies specific goals and metrics. These metrics and goals will likely be influenced by the results of the potential regional engineering study and the potential strategies identified therein.

All of these recommendations are focused on determining whether a shared regional solution to stormwater management is more cost effective and efficient than maintaining the current practice of individual site-based solutions. Once this is determined, neighborhood developers and local regulators can coordinate any viable regional solutions.

Charrette working group sketch

Charrette working group report out

2. Introduction

The South Lincoln Redevelopment Project is a 17.5 acre development that seeks to revitalize the La Alma / Lincoln Park community by enabling residents the opportunity to enjoy the unique advantages of a holistic, transit-oriented development realized through the core attributes established during the design process: a highly green mixed-use community, focused on a healthy lifestyle, increased non-auto mobility, an integration of resource conservation and management systems, and a diverse mix of new and existing residents. The redevelopment will include new residential units and a mix of retail, commercial and community services at the ground floor to encourage and promote activity along the streets. The project also includes planned outdoor amenities, including a new plaza and promenade, and a variety of open spaces, to enrich the neighborhood.

SoLi is a large multi-phase development project that is currently constructing the Phase 1 building (1099 Osage) and site plan in the Northwest corner of the development. Active and continuous community involvement and support has contributed to the development of the Master Plan that was created in September 2009 and the Neighborhood Plan that was approved in September 2010. An ongoing group of committed stakeholders have focused on defining the project goals and vision, and have begun to identify the design elements of the project. As the SoLi project has been selected to receive support by the Partnership agencies (HUD, DOT, and EPA), DHA plans to utilize this interagency support to execute the vision and ideals for the project. Although future phases of the project included in the SoLi Master Plan are awaiting funding and have not yet been designed, the scope of the Stormwater/Green Infrastructure Charrette focused on the full development of all future phases of the SoLi development and surrounding neighborhood areas. The charrette utilized the efforts and progress to date, and allowed opportunity to further define the project's vision and next steps.

2.1 Framing the Problem

The SoLi project sits at the top of the Curtis Street Outfall Watershed that drains North and East into Cherry Creek and eventually the South Platte River. This project has the potential to significantly improve the quality and quantity of the stormwater flowing out of the watershed but it is unclear which strategies will be most effective at SoLi and how these strategies will compliment other efforts in the watershed. Although there are questions about the technical and financial feasibility of some innovative stormwater strategies, the real challenge at SoLi and in the neighborhood is a lack of adequate coordination between the major developers and landowners as well as coordination between those developers, the City, and other regulatory agencies. As one working group put it:

> **"*There seems to be efforts underway within silos - but not between…*"** – a comment from the charrette

The SoLi project team and other developers in the Curtis Street Outfall Watershed need to find a way to break down the barriers between the key players in the neighborhood and develop a comprehensive stormwater plan that is feasible, and benefits the neighborhood and all of the parties involved.

2.2 Charrette Process

DHA is committed to making the South Lincoln Redevelopment Project a successful development that includes progressive stormwater management strategies addressing both water quality and quantity for storm and surface water. The purpose of the charrette was to identify the current efforts, barriers, opportunities, and key partners for creating a comprehensive stormwater / green infrastructure solution for the DHA project and the Curtis Street Outfall Watershed.

The "Leadership Team" below was responsible for planning the charrette. This effort included defining the overall charrette goals, identifying the scope of any analysis needed, and ensuring that charrette outcomes and lessons learned are distributed throughout the Partnership agencies to support implementation on the SoLi project. This team included representatives from each of the Partnership agencies as well as the design and technical assistance team. The members of this team included the following:

Devon Bertram, YRG sustainability
Cindy Cody, EPA Region 8
Kimball Crangle, DHA
Greg Dorolek, Wenk Associates
Stacey Eriksen, EPA Region 8
Rebecca Fox, SRA International
Jim Godwin, Vision Land
Narada Golden, YRG sustainability
Jay Peters, Vision Land
Josh Radoff, YRG sustainability
Bill Wenk, Wenk Associates

The Stormwater / Green Infrastructure Charrette was an 8-hour session that occurred on December 6th and 7th of 2010. A charrette is an interactive meeting with a large group of stakeholders that is intended to generate innovative design ideas, identify strategies and barriers to implementation, and build key partnerships. The Stormwater / Green Infrastructure Charrette participants were introduced to the analysis completed by Vision Land Consultants, Inc., and were then asked to focus on PARTNERSHIPS and TECHNICAL solutions in the working groups and discussions by first identifying current stormwater efforts, barriers, and key stakeholders in the neighborhood (Day 1), and then exploring solutions to some of the major challenges (Day 2). The following report is a summary of these discussions and working groups' outcomes.

2.3 Stormwater / Green Infrastructure Charrette Goal

The Stormwater / Green Infrastructure Charrette goal was developed to guide the charrette agenda, discussions, and working groups. Charrette participants discussed and agreed to this goal at the beginning of the charrette.

> *Identify the current efforts, barriers, and opportunities to creating a comprehensive stormwater / green infrastructure solution within the DHA site and develop an implementation plan to increase interagency collaboration on these issues in the regional watershed.*

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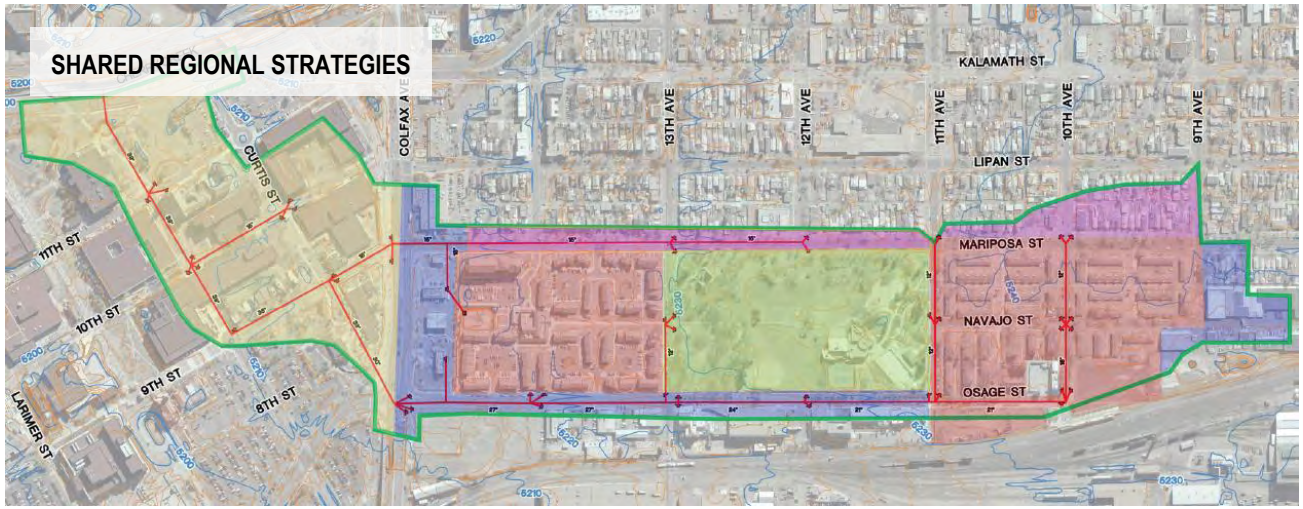
3. Stormwater Management Strategy Overview

Charrette participants divided into working groups to discuss stormwater management strategies, current efforts, major barriers, and key partnerships for a regional approach. They were also asked to develop separate implementation plans focused on funding opportunities, policy and coordination, technical solutions, and operations and maintenance. Below is a summary of the outcomes from these working groups divided into three broad categories.

Site-based strategies include all stormwater iniatives included in the building designs and on the SoLi Development property

Right-of-way strategies include all stormwater efforts in the public right-of-way



Shared regional strategies include comprehensive stormwater initiatives within the Curtis Street Outfall Watershed and require collaboration and coordination between key stakeholders.

3.1 Site Strategies

Although stormwater management extends beyond the SoLi property and needs to be addressed at a regional level, DHA has the ability to significantly improve the current stormwater issues by implementing LID strategies within the SoLi Redevelopment Project. This impact will extend beyond the property boundaries by reducing the frequency of surface discharges into the RTD light rail station, the frequency of split flows to the west at 13th Ave. and reduce the Total Suspended Solids (TSS) leaving the site.

SoLi will have approximately 82% imperviousness made up of 23 new buildings (including townhomes and mid-rise buildings 3-8 stories in height), parking lots, alleys, improved roadways, plaza areas and green space and park areas. The *Summary of Land Uses* Table and the corresponding map are based on the current Master Plan and depict the land use breakdown at the site. As the planned redevelopment will increase the density of the site as well as improve roadways, water, sewer and stormwater management facilities and infrastructure, various stormwater and green infrastructure management strategies have been evaluated to determine their beneficial impact to the site.

Impact on water quantity and rate, water quality improvements, maintenance demands, and water collection and reuse capabilities were considered for all strategies outlined below. The cost of each strategy relative to traditional stormwater management practices has also been considered.

In addition to the site strategy analysis provided, the 1099 Osage project is a valuable Pilot project to SoLi as it has implemented many of the stormwater management and LID strategies explored for the larger development, and can provide first hand feedback on the strategies' implementation and success.

Summary of Land Uses

Type	Area (acres)	Percent of Total
Pervious	3.98	18
Streets	4.43	20
Sidewalks, Plaza Areas	3.90	18
Alleys and Parking Lots	2.63	12
Townhomes	1.94	9
Large Buildings	3.55	16
Areas not Improved	1.45	7
Total	21.88	100

LID Functions

LID Type	Function		Cost Comparison*
	Water Quality	100-Year Detention	
Porous Landscape Detention	✓	✓	Moderate
Grass Buffers and Swales	✓		Low
Porous Pavement	✓	✓	Moderate
Rooftop Detention		✓	Very Low
Green Roofs	✓		High

*For capital costs only, and does not include land values

Porous Landscape Detention (PLD)

Implementing deeper (6 - 12") detention areas on the project site and adjacent to buildings can improve water quality and provide modest improvements to water quantity. This strategy has a moderate cost impact in comparison to the other site strategies explored. Maintenance demands including trash removal and safety / trip hazards would need to be considered.

Grass Buffers and Swales

Providing additional vegetated areas such as grass buffers and swales within the development can also help manage and improve water quality on-site, and is considered a low cost strategy (capital cost only) relative to traditional management practices. These strategies can be implemented along parking lots and within streetscapes.

Porous Pavement

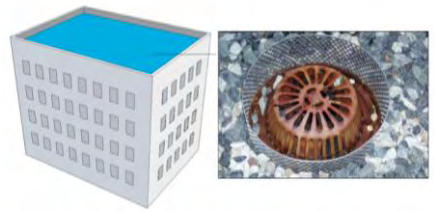
Porous pavement can be implemented in the alleys and parking lots within SoLi, as well as the plaza areas to improve water quality and support detention of the 100-year flood. These areas make up 30% of the SoLi development. The 1099 Osage pilot project is implementing porous paving on-site, so can provide valuable information in regards to installation, maintenance, and costs of the strategy (estimated as moderate in comparison to traditional approaches).

Rooftop Detention

Providing rooftop detention on buildings with flat roofs at SoLi can greatly support the management of the 100-year flood, and is considered a very low cost strategy requiring little maintenance. By incorporating weirs at the roof drain inlets, the roof is able to create temporary ponding and slow the release of stormwater. Additional research is needed to determine if and how rooftop detention can help to improve water quality. This strategy could also support water reuse for on-site demands if it can be approved as a pilot project through the City.

Green Roofs

Green roofs, although a higher cost strategy, can provide numerous benefits to the SoLi development. While improving water quality and supporting some stormwater detention, green roofs can also improve building energy use, provide green amenity space, provide habitat for increased biodiversity, and support reducing the urban heat island effect.



BMP Performance Analysis

Urban Storm Drainage: Stormwater Manual – Volume 3

	Hydrologic Processes		
	Peak	Volume	
UDFCD BMP	Flow Attenuation	Infiltration	Evapo-transpiration
Grass Swale	I	S	I
Grass Buffer	I	S	I
Constructed Wetland Channel	I	N/A	P
Green Roof	P	S	P
Permeable Pavement Systems	P	P	N/A
Bioretention	P	P	S
Extended Detention Basin	P	I	I
Sand Filter	P	P	I
Constructed Wetland Pond	P	I	P
Retention Pond	P	I	P
Underground BMPs	Variable	N/A	N/A

	Treatment Processes				
	Physical			Chemical	Biological
UDFCD BMP	Sedimentation	Filtration	Straining	Adsorption/ Absorption	Biological Uptake
Grass Swale	S	S	P	S	S
Grass Buffer	S	S	P	S	S
Constructed Wetland Channel	P	S	P	S	P
Green Roof	N/A	P	N/A	I	P
Permeable Pavement Systems	S	P	N/A	N/A	N/A
Bioretention	P	P	S	S[1]	P
Extended Detention Basin	P	N/A	S	S	I
Sand Filter	P	P	N/A	S[1]	N/A
Constructed Wetland Pond	P	S	S	P	P
Retention Pond	P	N/A	N/A	P	S
Underground BMPs	Variable	Variable	Variable	Variable	N/A

Notes:

P = Primary; S = Secondary, I = Incidental; N/A = Not Applicable

[1] Depending on media

3.2 Right-of-Way Strategies

One of the ideas that was discussed extensively at the Stormwater / Green Infrastructure Charrette was constructing stormwater BMPs into the public right-of-way. This idea would allow more land area within a given acre to manage stormwater because the streets, sidewalks, and planting strips next to the sidewalks are not typically used to manage stormwater. It could also allow some developers to build out more of their property because they would need less land dedicated to stormwater management. Finally, stormwater management strategies in the public right-of-way would create a unique identity in the neighborhood by acting as a visible commitment to regional stormwater management and sustainability.

Representatives from the City of Denver Public Works department who attended the charrette were open to this idea as they are willing to investigate green infrastructure solutions, yet wanted to ensure that any development within the right-of-way did not significantly increase the City's liability or operations and maintenance costs. Several questions and concerns about right-of-way developments included:

- **Safety:** There is concern that open stormwater detention basins directly adjacent to sidewalks and the street (similar to the one shown on the left) could become a safety hazard. Since these basins are typically 12-18 inches deep and are surrounded by a continuous 4-6 inch curb, it is possible that they could become a tripping hazard. The city has approved a basin with no curb at DHA's 1099 Osage project but this design requires a full grate to cover the depressed area. Furthermore, the fire department has required that this grate be engineered to support a fire truck. The approved design has addressed these safety concerns but comes at a significantly increased cost.

- **Operations and Maintenance:** The long term operations and maintenance costs for BMP strategies such as porous landscape detention areas and permeable paving is not yet established in Denver. There is some concern that a large number of small BMPs, all possibly different sizes and designs, could significantly increase the time and effort it would take to maintain and repair them. It will be important for several designs to be tested and evaluated, and for operations and maintenance efforts to be streamlined. If the city were to approve a large-scale implementation of stormwater management strategies in the right-of-way, it may make sense to develop a training program for the contractors who would operate and maintain these BMPs. Other cities such as Portland, OR have developed similar programs that could act as a model for the City of Denver.

- **Long Term Performance**: The City needs to ensure that permitted stormwater management strategies can provide adequate long term water quality and quantity performance. If BMPs do not provide consistent performance, the City will need to implement additional strategies to improve overall stormwater management because they are responsible for maintaining regional stormwater quality and quantity. Because of this, it is risky for the City to test and approve new unproven strategies. Research from local pilot projects that have installed and maintained new and innovative BMPs will be critical for the approval of a large-scale rollout of such strategies.

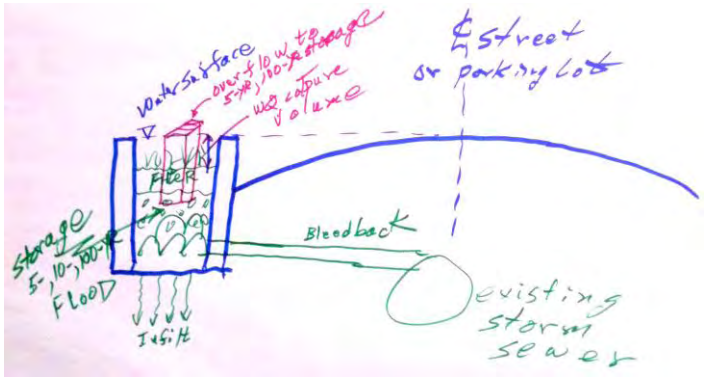
In addition to the concerns outlined above, any stormwater BMP that is developed in the right-of-way will need to comply with the right-of-way requirements of the City. This includes a possibility that the BMP could be partially or entirely dug up if the City or another agency needs to access utilities next to or under the BMP. This ongoing cost will be seen as a major barrier for developers, including DHA.

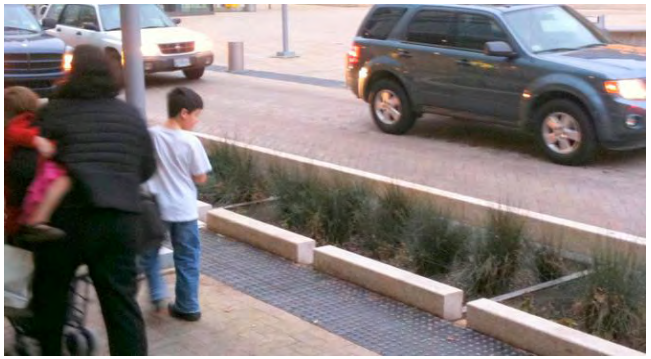
The following BMP strategies were identified by charrette participants and likely candidates for use in the public right-of-way. There are a number of possible designs to each of these strategies that could make them viable and effective for the project.

Porous Landscape Detention (PLD)

Implementing deeper (12" – 18") detention areas in the right-of-way can improve both water quality and water quantity downstream from the development. This strategy has a moderate cost impact in comparison to the other site strategies explored and is effective for managing sedimentation and peak water flows. As described above, this strategy would need additional support and approval from the City in order to manage maintenance and safety demands, as well as further evaluation regarding suitable vegetation to grow in this area.

Other cities around the country are using this strategy to manage stormwater in the public right-of-way. The City of Portland Green Street program (http://www.portlandonline.com/bes/index.cfm?c=44407) is one example of a program that has been developed over the last 10 years to support similar stormwater strategies.





Working group sketch of right-of-way detention basin for Denver

Porous Pavement

Porous pavement can be implemented in the roadways at SoLi to manage stormwater runoff and improve water quality. Roads make up 20% of the land area in the SoLi development so this strategy could have a significant impact on the overall management plan in addition to the strategies outlined in the Vision Land analysis included below.

The 1099 Osage project is piloting porous paving on-site and can provide valuable information in regards to installation, maintenance, and costs (estimated as moderate in comparison to traditional approaches) of the strategy. The project could help The City of Denver develop a long-term maintenance policy that could be used for porous paving applications throughout the city.

Aerial view of Lincoln Park

3.3 Shared Regional Strategies

Most of the discussion about shared regional stormwater solutions focused more on collaboration and coordination with key stakeholders than it did on actual stormwater strategies. The key recommendations for those discussions included the following:

- Acquire funds to complete a regional stormwater engineering study and start inter-agency convening body
- Complete a regional stormwater engineering study
- Create a convening body that supports inter-agency communication and collaboration
- Develop a funding mechanism for shared regional stormwater projects

There were also several discussions about specific regional strategies that may be important to explore further. A few of these strategies include:

- **Using a portion of Lincoln Park to detain and infiltrate most or all of the stormwater volume from the upper third of the Curtis Street Outfall Watershed**: Lincoln Park sits in almost the exact center of the Curtis Street Outfall Watershed. This park is a major amenity for the neighborhood and is heavily used on nice days. The central location of the park, along with its large land area, makes it an ideal place to capture and detain stormwater from large storm events (5-year storm or larger). This solution, in conjunction with a storm sewer improvement along a portion of Osage, would be able to eliminate all of the stormwater overflows into the RTD 10th & Osage station and slow a large percentage of the stormwater flowing from the upper third of the watershed. A representative from Denver Parks and Recreation attended the charrette and stated that the park may not be a viable location for managing stormwater due to its historic nature. However, understanding that this solution could be designed so the park would flood once every 5 years or less may make this a good option to explore further.
- **Auraria Campus's new recreational ball fields:** The Auraria Campus may be developing a new athletic complex South of Colfax and West of Osage. Since this project has not yet been confirmed, it could be designed to manage significant stormwater volumes from the upper half of the Curtis Street Outflow Watershed. In order for this project to move forward as a shared stormwater strategy, the planning and coordination goals above would need to be implemented so that other developers like DHA could provide both political and financial support for the project.
- **Neighborhood-wide approval of LID strategies:** The LID strategies that are addressed in this report and that are being implemented at the 1099 Osage project have the potential to manage much of the stormwater quality needs in the Curtis Street Outflow Watershed if they are approved and installed throughout the neighborhood. This type of regional approach will allow LID to be a major component in the regional stormwater plan.

Additional regional stormwater goals include:

- Detain about 2 acre-feet immediately upstream of Colfax Avenue at Osage Street to achieve a 100-year level of service to Colfax Avenue and eliminate the split flow to the west.
- Detain about 1-acre-foot on the Auraria Campus to alleviate the split flows to the west and provide a 100-year level of service to the storm sewer system.
- Detain 3.3 acre-feet on the South Lincoln site in a regional approach rather than on an individual site-specific approach to eliminate the overflows into the RTD light rail station and the split flow west down 13th Street for events up to and including the 100-year event.
- Mariposa and Osage Streets from 9th Avenue to Colfax Avenue have wider tree lawns that could more easily allow for the implementation of PLDs within the right-of-way to further address water quality and flooding issues within the watershed.

4. Vision Land Analysis and Results

This section presents the stormwater analysis for the South Lincoln Redevelopment Site and the Curtis Street Outfall Watershed. Discussed are the South Lincoln and Curtis Street watersheds, the hydrology and hydraulics, results of the analysis, potential LID strategies at South Lincoln, the benefits of stormwater improvements at South Lincoln, and regional improvements that address the identified problem areas.

Vision Land Consultants, Inc. (VLC) conducted a hydrologic and hydraulic analysis as well as a pollutant loading analysis for both the South Lincoln Redevelopment site and the Curtis Street Outfall Watershed. The background and results of the analysis are discussed below.

LID Functions

LID Type	Function		Cost Comparison*
	Water Quality	100-Year Detention	
Porous Landscape Detention	✓	✓	Moderate
Grass Buffers and Swales	✓		Low
Porous Pavement	✓	✓	Moderate
Rooftop Detention		✓	Very Low
Green Roofs	✓		High

*For capital costs only, and does not include land values

4.1 Summary of Analysis

South Lincoln lies within a local sub-watershed that is 28 acres in size at the project outfall at 11th and Osage. There are off-site flows from the east that enter the site from a 5 acre area, as well as a 2 acre area from the south. The watershed is 100% developed, consisting of single-family houses to the east, some commercial development to the south, and the DHA multi-family units.

The stormwater infrastructure serving the South Lincoln Site is limited to 12- to 21-inch diameter vitrified clay pipe storm sewers. There are currently no water quality treatment or detention basins that serve the site. The site has mild slopes to the west at an average of 1.5%. There is a low point at the intersection of 10th Ave. and Osage Street, preventing overland flow to the north when the storm sewer capacities are exceeded. Runoff in excess of the storm sewer capacities flows to the west into the RTD light Rail Station. In March of 2006, 8 soil borings were taken at South Lincoln to for structural engineering purposes, and it was found that the soils were predominately clayey sands falling within hydrologic soil groups B and C. The clay content of the soil varies from 5 to 45%, with an average of 35%.

The site is located within the upper reach of the Curtis Street Watershed which outfalls to Cherry Creek. The watershed is served by a storm sewer system ranging in size of 12-inches to 39-inches at the outfall to Cherry Creek.

As part of this project, VLC evaluated the implementation of low-impact development stormwater management strategies on the South Lincoln Site. LID that could be implemented on the site are:

- Porous Landscape Detention or grass buffers and swales within the green space areas and tree lawns in the roadway right-of-way;
- Rooftop detention on the multi-story buildings;
- Green Roofs on the multi-story buildings;
- Porous pavement in alleys and parking lots; and

Volume and Depths for LID Scenarios

Description	Volume in Pervious Areas (AF)	Depth in Pervious Areas (ft)
Detention in Pervious Areas Only	3.3	0.8
Rooftop Detention	2.7	0.7
Rooftop Detention, Pervious Pavement in Parking Lots and Alleys	2	0.5
Rooftop Detention, Pervious Pavement, 50% Plaza areas with PICP	1.7	0.4
Rooftop Detention, Pervious Pavement, 50% PICP, Green Roofs	1.5	0.4

PICP = Permeable Interlocking Concrete Pavers

4.2 Analysis Conclusions and Recommendations

The results of the analysis indicate the following:

- The 21-inch storm sewer in Osage Street from 10th to 11th Avenue, and the storm sewer in 10th Avenue between Mariposa and Osage have less than a 5-year capacity (this system overflows during the 5-year storm);
- The remaining storm sewers in the watershed have a 5-year capacity;
- Surface flows on the streets in the watershed are less than one foot deep during the 100-year storm event, except at Colfax and Osage;
- There is excessive ponding, cross-street flow, and split flow at the intersection of Colfax Avenue (arterial roadway) and Osage Street; and
- Surface flows leave the watershed at numerous locations.

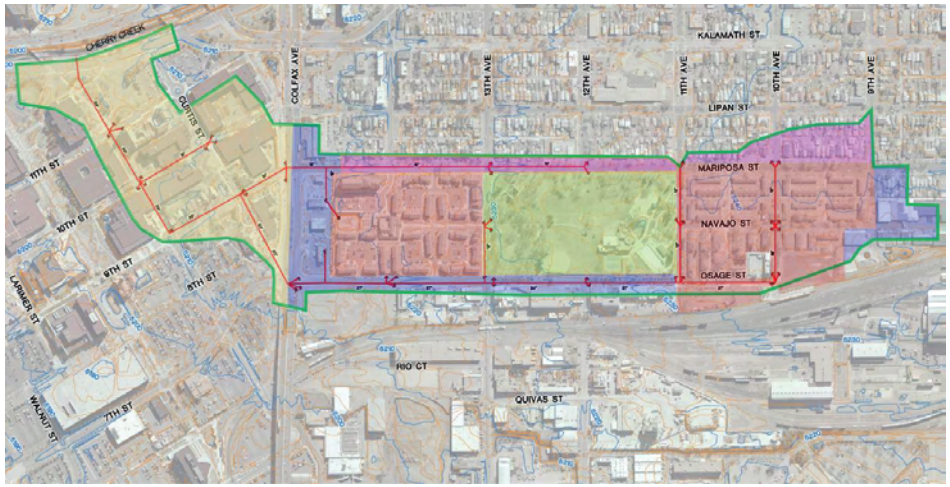
During the 100-year storm, stormwater surface flows leave the watershed and discharge to the south towards the RTD light rail line and Auraria Parkway. This occurs at the intersections of 10th and Osage, 13th and Osage, Colfax and Osage, and on the Auraria Campus at 9th and 10th Streets. At 10th and Osage, it is estimated surface flows will enter the RTD station in a 5-year storm event.

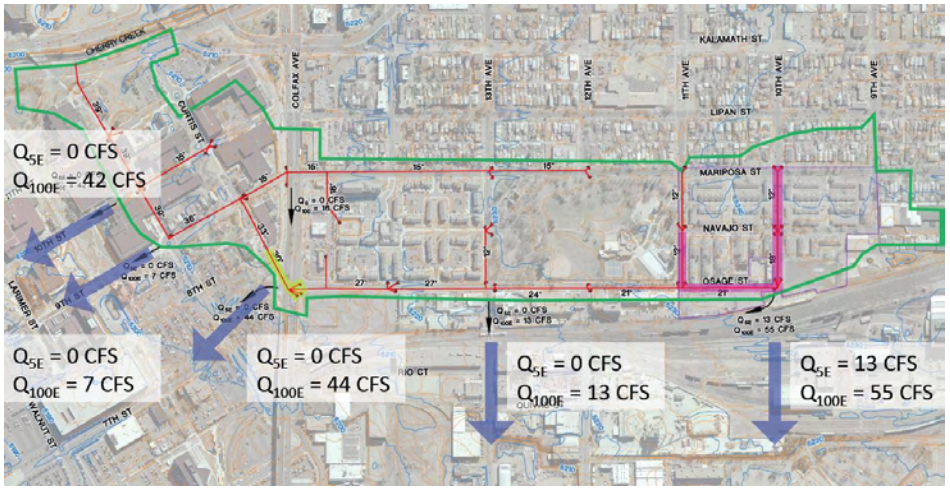
We have estimated that the existing Curtis Street Outfall Watershed contributes approximately 20 tons of pollutants, in the form of total suspended solids (TSS), to Cherry Creek every year. The existing South Lincoln site contributes almost 6 tons of TSS per year. This means that runoff from the SoLi site contributes almost one third of all TSS pollutants coming from the watershed and effective stormwater strategies at SoLi could provide significant improvements to water quality in Cherry Creek.

This analysis clearly shows that the La Alma / Lincoln Park stormwater system is not able to manage the 100-year storm, and in some areas the 5-year storm. When the watershed overflows, pollutants drain into Cherry Creek and eventually the South Platte River impacting water quality. Stormwater overflows in this watershed also impact transportation at the 10th and Osage light rail station, on Colfax, and on all roads where overflows occur. It will be important for the City and neighborhood stakeholders to address these issues by improving stormwater quantity and quality, increasing infrastructure, or a combination of both.

For a full copy of Vision Land Consultant's South Lincoln Redevelopment Project Stormwater Analysis go to the Appendix or the following link.

http://yrgsustainability.centraldesktop.com/denverscpcharrettesexternal/





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5. Conclusions and Recommendations

The South Lincoln Redevelopment Project has enormous potential to become a catalyst for innovative, cost effective, and sustainable stormwater solutions that could be applied throughout the City of Denver and the regional basin. The first phase of the project is already a pilot for several innovative low-impact design strategies and the future phases could provide the testing grounds for the full range of LID strategies that could be applied throughout the region. It is believed that these strategies could not only provide all of the stormwater needs required by the City at SoLi, but they could also provide benefits to other developers in the La Alma / Lincoln Park Neighborhood and Curtis Street Outfall Watershed as part of a comprehensive regional stormwater plan.

One of the major barriers to developing a regional stormwater plan is the lack of communication, coordination, and collaboration between major stakeholders and regulatory agencies in the neighborhood. It is also difficult for individual developers to collaborate on a shared regional solution when they are working on various projects with different funding sources and schedules. To overcome these barriers, key stakeholders such as the Denver Housing Authority, the Auraria Higher Education Center, Denver Parks and Recreation, Regional Transportation District, the City of Denver Public Works, and Urban Drainage and Flood Control will need to create a new vehicle for communicating and collaborating on stormwater projects within the region.

Two actions that are critical for achieving this goal are:

- Fund and complete a regional stormwater engineering study that identifies the opportunities for cost effective and sustainable regional stormwater solutions
- Create a “convening body” that enables active communication and collaboration between these key stakeholders.

If this study and convening body are created as an outcome of the Stormwater / Green Infrastructure Charrette, it would be a major success and significant change in the way that stormwater issues are currently addressed in the City of Denver.

Ultimately, this report is not intended as a concise summary of the presentations and discussions that happened at the Stormwater / Green Infrastructure Charrette. It is, in essence, a call to action; a reflection of the opinions and recommendations of the many charrette participants and consultants involved in this project who think it is time to change the way we think about, coordinate, and implement stormwater and green infrastructure solutions in the City of Denver.

5.1 Funding and Incentive Opportunities

DHA will need to acquire additional funding to implement many of the strategies outline in this report. The following funding sources were identified to help support these strategies.

- Urban Drainage and Flood Control District
- Environmental Protection Agency
- State Revolving Funds and Clean Water Act 319 grants
- Developer Stormwater Fees
- Better Denver Bond Program

5.2 Strategic Partnerships

DHA will need to develop active working relationships with the following strategic partners in order to successfully implement the stormwater/green infrastructure strategies recommended in this report.

Housing and Urban Development (HUD) – HUD can provide support for programs that support LID stormwater strategies and implementation.

Denver Public Works (DPW) – Denver Public Works plays a critical role in the development, approval, and ongoing management of regional stormwater management solutions in the SoLi development and La Alma / Lincoln Park neighborhood.

Denver Community Planning and Development (CPD) – Denver CPD has developed a comprehensive neighborhood plan for La Alma / Lincoln Park and will need to be involved in many of the major decisions moving forward.

Regional Transportation District (RTD) – RTD is affected by stormwater overflows and will need to be involved in stormwater management strategies and solutions in the neighborhood.

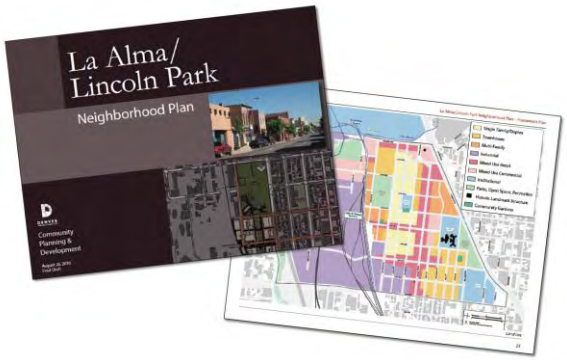
Colorado Department of Transportation (CDOT) – CDOT will need to be involved if the comprehensive neighborhood stormwater plan impacts traffic flows through the La Alma / Lincoln Park neighborhood.

La Alma /Lincoln Park Neighborhood Association (LPNA formerly known as La Alma / Lincoln Park Planning Group (LLPPG)) – Many of the programs and infrastructure developments included in this report will not be successful without engaging and developing support within the LALP resident community.

Auraria Higher Education Campus (AHEC) – AHEC covers roughly one third of the land area in the Curtis Street Outfall Watershed and is currently developing new projects in the area.

Urban Drainage and Flood Control District (UD) – Urban Drainage and Flood Control District oversees comprehensive stormwater management strategies for areas in and around the City of Denver.

Denver Parks and Recreation (DPR) – DPR owns and maintains Lincoln Park which covers a large land area in the middle of the Curtis Street Outfall Watershed.



6. Appendix

6.1 Charrette Agenda, Presentations, and Handouts

The agenda, a PDF of the PowerPoint presentations, and all handouts for the Stormwater / Green Infrastructure Charrette have been posted on a public website for participants and the general public to access. Go to the following website to access those documents.

http://yrgsustainability.centraldesktop.com/denverscpcharrettesexternal/

6.2 Charrette Photos

Go to the following link to see photos taken during the Stormwater / Green Infrastructure Charrette.

http://picasaweb.google.com/yrgconsultants/PSCCharrettes?feat=directlink

6.3 Charrette Notes

The following pages contain all of the notes that were recorded on flip charts and taken during the discussions and working groups in the Stormwater / Green Infrastructure.

Charrette Notes:

EPA Stormwater Charrette Notes (Transcribed):

South Lincoln Redevelopment
Stormwater/Green Infrastructure Charrette: December 6 & 7

Charrette Notes: Flip Chart **Notes /** Discussion **Notes**

Stormwater/Green Infrastructure Charrette Goal:
To identify current efforts, barriers, and opportunities to creating a comprehensive stormwater/green infrastructure solution within the DHA site and develop an implementation plan to increase interagency collaboration on these issues in the regional watershed.

Day 1:

What metric is used if discussing 'success' for stormwater management?:
- Effective imperviousness; how much of the total project area can absorb run off
- Meets regulatory requirements and adds value (measurable financial value) to site (e.coli issues, sedimentation issues, etc.)
- Watershed/WQ issues – amount of water leaving site, rate / quantity; quality
- Don't adversely affect those down stream
- Lasts a long time, robust and durable
- Reduction of utilities, how will this impact reducing utility and ongoing maintenance?
- Profitability / marketability to other investments in neighborhood
- Finding solution that fit the site – not a one size fits all solution

Considerations:
- How do we approach with 'this is overarching umbrella strategy?'
- How do we incorporate strategies in a phased manner on site? How do phases 2, 3, 4,etc move forward in overarching plan?
- How can 1099 present a successful test case?

Current Public Works process:
- Concerned with maintenance, safety, aesthetics and functionality
- Maintenance of retention at DHA Site is ok because it is tied in well – developing a green job core

Maintenance requirements / Issues:
- Remove sedimentation in each of the basins on a regular basis
- Regular fixing and upkeep
- Utilities are required under some of these strategies (e.g. porous paving) and need to be taken care of (e.g. Denver water may lie new line with porous paving, and then later put asphalt over porous paving)
- It is expensive to make grates flush (however east coast has been able to implement better strategies and design that allows them to not be as expensive)
- Regular trash removal

Day 1: Guiding Questions for Brainstorming Groups (5 Groups):

1. How does stormwater landing on the site and streets within the DHA development at 10th and Osage *impact* the following agencies? (DHA, RTD, Public Works, EPA, Urban Drainage, Auraria Campus, Denver Water)
2. What current *efforts* are in place within these agencies to address stormwater in this neighborhood?
3. Do you have long-range *plans* that include attention to this area?
4. How do these agencies currently *work together* around stormwater issues?
5. What *funding* is in place to support stormwater improvements in this neighborhood? If this funding is allocated for specific improvements, *what* are they?
6. What are the regulatory and procedural *obstacle*s to implementing a comprehensive stormwater strategy on this site?
7. What other *barriers* will limit or prevent a comprehensive stormwater solution within this development?

Day 1: Group 1

1. Impacts
   - EPA – environmental standards; water quality
   - City – Liability, transportation, aging infrastructure, storm capacity
   - DHA – Access and safety; liability; funding; ongoing maintenance
   - Auraria – Capacity; funding; maintenance; short-term fix

2. Current Efforts
   - EPA – Collaboration with Fed. Family and local organizations; exploring the "what if"
   - City – Streamlining permit process; Better Denver Bond projects; Long-term goals
   - DHA – Healthy development measurement; 6 "livability principles"
   - Auraria – project evaluation of current system; fostering spirit of collaboration

3. Plans
   - Yes.

4. Current Cooperation
   - City – regional detention solution with private partner opt-in/pay-in
   - Auraria – Maintenance and students doing projects; urban drainage funds

5. Funding
   - EPA – creative connecting for grants
   - DHA – allocation for "greening"
   - Auraria – dealing with land limits; project by project

6/7. Obstacles/Barriers
- Federal/State/Local ordinances
- Water rights issue
- Theory vs. practice (competing interests; liability)
- Maintenance responsibility
- Cost effectiveness
- Short term funds for long term goals

Day 1: Group 2

1. Impacts
   - DHA – address site drainage; BMP maintenance
   - RTD – flooding operations
   - EPA – support sustainable community(ies) initiative; funding opportunities
   - Auraria – limited impacts
   - Urban Drainage – potential increased impact to downstream facilities
   - Denver Water – irrigation/water harvesting; future potential
   - City – manage infrastructure; BMPs; site plan review; inspect and enforce

2. Current Efforts
   - DHA – Phase 1 1099 Osage project and Master Plan initiatives
   - RTD – Discussing potential partnership w/ DHA to address station area flooding
   - Denver Public Works -- Phase 1 1099 Osage project and future plan review; development services
   - EPA – project involvement and monitoring
   - Denver Water and AHEC – public involvement

3. Long-range Plans
   - City – Master Plan
   - DHA – Master Plan for site
   - EPA/Urban Drainage – use as potential neighborhood redevelopment model
   - AHEC – future nearby athletic fields

4. Current Cooperation?
   - (see drawing on flip chart Day 1: Group 2 p. 2)

5. Funding
   - Urban Drainage

6. Regulatory and Procedural Obstacles
   - Water Rights?
   - Soils (in certain areas)
   - ADA accessibility/connectivity
   - Development standards/procedures
   - Safety and health (i.e. fire truck accessibility, etc.)
   - Cost and maintenance
   - MS4 requirements (City and RTD)

7. Other Barriers
   - Agency culture
   - Funding

Day 1: Group 3

1. Impacts
   DHA – developers who must comply with regulations
   RTD – overflows stop train traffic
   Public Works – improvements can shift and lower capital costs of storm sewer upgrades
   EPA – Water quality/human health impacts of flooding
   Urban Drainage – Maintenance and improvement
   Auraria – Save money on vaults
   Denver Water – Conservation measures can impact water rights/usage; Future rate impacts

2. Current Efforts
   "There seems to be efforts underway *within* silos but not between."
   RTD – study initiated to solve flooding problem
   City/Wastewater – Capital Improvement Plan (CIP)
   Auraria – Individual schools building solutions to flooding
   DHA – Implementing site solutions for 1099 Osage project

"Timing of projects among these groups is a problem"
- Metropolitan State College of Denver is building vaults now
- RTD feels a sense of urgency
- DHA's timeframe is longer

"Less expensive 'temporary' solutions might accommodate these timing problems."
"The 'efficiency' of vaults to private developers who buy/own expensive urban land. What are other potential options? – Chicago's 'Green Alleys'."

3. Long-Range Plans (See #2)

4. Current Cooperation?
   Generally, agencies are not working together.
   But they are all here today (at the charrette).

5. Funding
   "Even if you can show that a regional solution is cheaper than one silo's solution:"
   - Who handles the money?
   - Who oversees the projects?
   - Who monitors the projects?

6. Obstacles/Barriers
   "We lack a leader for unifying the stakeholder agencies."

Day 1: Group 4

1. Impacts
   EPA – Ecoli, TMDL
   City – Flooding @ RTD, Storm Capacity, Maintenance
   DHA – Access and Safety, Liability, Maintenance
   Auraria – Capacity, maintenance
   RTD -- Flooding

2. Current Efforts
   RTD – Flooding study in place
   City – CIP: City's plan vs Public Works plan
   Auraria – has buildings in design and construction phases with detention basins
   DHA – 1099 and Master Plan → formalized

"There is a great need for plans to work together"

3. Plans
   First development gets to use stormwater capacity.
   City has stormwater plan but this area is not a priority project.
   Formalization of stormwater strategies from 1099 into Master Plan, outcome from this charrette.

4. Current Cooperation
   Happens at the site level → There is a need for looking at the bigger picture.
   There is a need for an on going forum → needs specific project, specific goal

5. Funding
   Need upfront capital for a comprehensive/regional solution
   - May have interim solution?
   - Participation of other agencies

6. Obstacles/Barriers
   Water law
   Funding
   Integration of agency agendas

Day 1: Group 5

1. Impacts
    - DHA – 10th and Osage station flood; no flooding for structures (density; project cost; design); undersized systems
    - Public Works – Capital improvement needs; partnerships needed for maintenance; money is needed for this basin
    - PW/Urban Drainage/developers – New BMPs from update; the nontraditional may be tested
    - EPA – water quality, stormwater regulations

"Which agency is responsible for looking at the big picture?"

2. Current Efforts
    - DHA – Start w/ Phase 1 1099 Osage project; design Master Plan
    - PW – no efforts, nothing in the 6 year plan
    - EPA – pay for charrettes, water quality improvements for S. Platte/Cherry Creek

3. Long-Range Plans
    - DHA – will have to do flood control in a more constrained way because the agency is undersized
    - PW – don't put too much effort on the 6 yr plan.

"A financial partnership will have to be made to do it right – fix upstream sites."

4. Current Cooperation
    - Site solutions vs Regional Improvements (no funding): Agencies must work together on site solutions
    - Agencies can identify regional solutions through design criteria
    - Interim measures/options impact the fee structure (upfront $$)

5. Funding
    - No regional project money
    - Development paid site by site
    - Future Bonds?
    - Next Building HOPE VI

6. Obstacles/Barriers
    - Water Law
    - Grand Partnering
    - Money
    - Timing
    - Multi-jurisdictional problems

Day 1: Breakout Notes and Further Questions:

-What mechanisms exist for outside organizations to work with the city around stormwater issues and coordinated funding?

- Are there bonding structures to fund a comprehensive 30-40 year solution?
- Where do you find the land?
- How do you set up a fee structure to pay for a Comprehensive Plan?
- Is there tension between having BMPs and Active Zones? (Currently, BMPs do not count as open space)

-The solution for water quality will likely focus on a 2-year storm. This is different than focusing on flooding and there is a clear need for focus and balance here

- We are also in need of a forum where we can discuss these issues
- We need to develop incentives to encourage developers and agencies to participate in this forum (highlight the risks of not participating)
- Timing is a huge funding issue
- How do we encourage participation in a regional solution? How do you illustrate financial benefits of participation?

Current Cooperation:

- "Flooding can be service issue for RTD"
- RTD right-of-way (ROW) could be shared
- RTD can contribute money or land
- Auraria downgradient – looking at building vaults
- LaFarge as a possible partner
- Maintenance issues for Denver Water for pervious pavements
- State role – funding pieces of watershed planning education and outreach, projects
- Opportunity to redefine urban priorities
    - Habitat for Humanity has tried to implement SW BMPs (eg porous concrete)

Obstacles:

- Denver Parks – historic park
- Approval of innovative BMPs by City
- SW fee structure
- Preference for traditional SW measures
- Disconnect between funding sources and cycles
- Unknown cost of maintenance for new BMPs how to bring together everyone for planning
- Planning scales are different as well as timeframes and levels of urgency
- How to pay for long term incremental improvements that are part of a long term goal

Day 2:

Day 1 RECAP (big issues and ideas):

- There are different schedules / timeframe for everyone involved. Particular set of issues (DHA, Auraria, the city) puts SW process / implementation on different timeframe, but all are invested in working with the city
    - Individual players have common problems but are all on individual schedules. Need coordination of funding and planning, however these are difficult to align
- Investment: city doesn't look at investment in terms of capital improvements, works in very limited perspective; a political issue.
    - In order to get to sustainable solution, need to get the money in at the right cycles, bonding, etc.
- Don't want to mix water quality with early needs for flood control:
    - Distinction between water quality short term needs vs flooding needs
    - Bigger pipe does not benefit people downstream – water quality is integral to flooding issues
- Current DHA Master Plan has budgeted to facilitate all rules and guidelines for DHA's site, but does not consider regional approach

Vision Land Analysis Discussion

- Can rooftop detention include a water quality component? (sand filters, etc.?).
    - maintenance may be an issue, and it's not a design standard so would have to overcome these hurdles for implementation
- Grass buffer and swale costs only includes capital costs, does not include land value so cost could potentially be much higher
- Detention volumes include 22-23 acre site, not only development site of 17 acres
- Have there been revisions to policies within cities to incorporate maintenance and regulation requirements. What would this take to do in Denver?
    - pilot program…
- A challenge in this area will be the soil conditions – soils vary in type and depth dramatically across the site (clay ranges from 5-45%).
- Master Plan needs support from city for ROW improvements
- Proposed strategies are only meeting the city's SW requirements, not going above and beyond (not all meet LEED or Enterprise criteria)
- Cost of last step "is not feasible for individual developer" – way too much money
- If any of these steps are implemented, it will benefit neighboring lands as well
    - Because of this, how would neighboring lands' plans change and be modified?
    - How is this done with the varying project timeframes?

Vision Land Analysis Discussion (Cont.)

- Don't want to implement strategies of lost opportunity costs – have ponds instead of functional landscape features
- Next level of analysis would look at how grading works, how to phase strategies, etc.
- RTD would be more interested in regional solutions
- How do we ensure strategies are going to work as well as existing conditions (and ideally better)?
- After Colfax, have to deal with major overflow
- At Auraria, can this all be dealt with on site?
- Where are we going to get economies of scale?
- Main concern is not 5 or 10 year storms, its 100 year storms: build these strategies into infrastructure (i.e. storage in roads, etc.).
    - Try to separate extreme events around / out and may come up with better cost solution

4 Working Groups:

1. Funding/Policies
2. Coordination and Planning
3. Operations and Maintenance
4. Technical Implementation

4 Brainstorming Tasks / For Each Recommendation:

1. Identify Principles
2. Recommend Step-by-step Implementation Strategies
3. Identify Elements of Success
4. Identify Resources

Day 2: Funding Group

-What would the funding opportunity be with a regional approach?
-20 year life cycle for operations and maintenance
-Who funds capital?
  - RTD
  - Auraria
  - DHA
  - Smaller Developers

-An incentive program
-Temporary detention approach
-Water harvesting over 8 years
-Proportional share
-EPA provides $2 Million/annually to state water quality division for non-point source projects (competitive process once a year)
-Create stormwater utility
-Bond issue
-State revolving loan funds ($30 Million)

FUNDING GROUP REPORT OUT

- Main focus: Identify the need ("ask") and figure out proposal to request this
- What resources would be available to help fund this? (approach by site or basin-wide?) = BASIN WIDE
  - Need to start with **joint engineering study** that would explore alternatives to help flooding issue – RTD, Auraria, DHA, smaller developers –this would identify solutions, priorities, requirements, funding/cost requirements, etc.
    - This would look at WQ and flood control
    - This study could be a next step to Vision Land's analysis, cost benefit analysis, showing different solutions beyond just DHA site. How does DHA tie into Auraria and surrounding areas?
  - **Research grants available** from state WQ nonpoint source or state revolving fund
    - There is a pool of money received from EPA (section 319, nonpoint source) – annual grant cycle (can be tricky in urban corridor - No precedent in the urban corridor in CO). Close to $2 million available every year, half of which is pretty flexible to use on state-wide demo projects/info & education projects esp with LID strategies (typically work on a lot of mining and ag sites; want to link with land use planning related to water quality)
    - State revolving fund: Wastewater utility is common recipient, could maybe fund engineering study
  - Issuing bonds? (depends on source of issuing agency) – this would pay for capital costs of implementing the solution (whatever this would be)
  - Once study completed, look at everyone's portion required to fund the ultimate goal and meet requirements, and determine what share of the cost everyone would owe
- City and county of Denver has requirements to meet 5 year storm event. This is not met in this area.
- Possible Resource:
  - Identify a temporary or short term solution (i.e. detention area that can be taken out when funding becomes available) – this could buy some time for the project
  - Fund the study while fund temp solution
- Elements of Success
  - Fixing the problem, Getting it done

Day 2: Coordination and Planning Group

- RTD – issues at 10th and Osage and Colfax and Osage
- DHA will help 10th and Osage, but not Colfax and Osage
- Expand analysis and depth of other parts of drainage basin
- DHA's work lowers priority for RTD to do additional work
- In need of a convener with institutional knowledge, capacity, clout: ie, Urban Drainage, City of Denver
- Potential to create a stormwater metro district(s)?
-Link districts to area of change or station areas
-Ability to fund/tax
-Boundaries and participants
-Put stormwater tax into district fund instead of a general fund
-Solve issues cooperatively to lower the stormwater fee
-Resources – Funding to support stormwater district convener
-Principle – coordinate large-scale stormwater management
-Implementation – convener; prioritize plans for each basin

Elements of success – A coordinated plan
-Principle – review Capital Improvement Plan (CIP) criteria to refine project priority and stormwater master plan priorities
-Stormwater money as seed money for coordinated effort
- City as convener for continued work on site (stormwater/wastewater)
- New partners – 13th and Osage; Colfax and Osage
- *Define boundaries of project area*
- *Engage Auraria with their detention issues*
- *City convene by January*
- EPA/HUD/DOT/RTD co-convene with City
- EPA support as resource
- Technical design

Meeting #1: Collaboration and funding for technical study; define boundaries and scope

COORDINATION AND PLANNING REPORT OUT

- Only a few are defining the watershed. Fewer partners are better.
- How do we move forward with planning?
    - **Have a convener** because some entity needs to take the responsibility (i.e. the City, EPA?) to help coordinate and organize these efforts, and act as technical review point of contact
    - Timeframe is very important here. Need interim agreement because everyone is under tight timeframe
    - Need to have a technical study to definitively look at alternatives (park, Auraria ball fields, looking at water quality, etc.)
- What's the nature of a district?
    - Areas of change, new zoning codes, station areas = any areas that have large investments
    - Be able to be flexible and aware where there are pockets of development; understand their issues and acknowledge overall solutions
    - Difficulty is that there is no 'hammer' to get this done – there needs to be a public entity
    - Where are the boundaries?: keep it within the basin (however, auraria's ball fields are in another basin…)
- **The goal of the convener is to establish a technical study;** plan to have a **meeting in January** to get people talking and looking at what needs to be discussed, what agencies should participate and develop an agreement to collaboratively work together. Once this agreement is in place, identify who has funding, what the partnerships and resources are, and the next steps.

Day 2: Operations and Maintenance Group

-Depends on design selected
-Owner is responsible for maintenance
-Green Infrastructure O&M cost maybe higher than conventional O&M
-DHA has to do/conduct maintenance as per regulatory requirements
-Use "outside" contractors to do O&M
-Green Team
-City does maintenance at a higher, inflated cost
-DHA hires a green team director
-Study other successful "green jobs" programs
-Possible partnerships with existing green jobs providers (e.g., community colleges, consultants)
-Green team director to evaluate scope of O&M at Lincoln Park Project
-Work with city to determine scope of work of BMPs in place
-DHA Housing management program Section 3
-Recommendation: "City Plays Nice"

OPERATIONS AND MAINTENANCE REPORT OUT

- Suggestions:
    - Site specific design
    - Owner is responsible for maintenance
    - Options to take care of strategies are to: look at existing housing management, outside contractors or the city at a much higher cost
    - Have a current tax law or assess an extra cost / sf to be for maintenance (there is current storm drainage fee)
    - Green team: hire a director to see what demands are across portfolio and begin a program; identify who partners may be; what resources are available? (DHA has section 3 requirement)
    - Will City have to have a work force to discuss LID strategies and implementation?
        - Yes, as it gets more complicated. Currently there is not a maintenance / ops team that deals with the green strategies
    - Some cities stormwater groups offer training for maintenance and construction workers
        - Denver is going to need to do this – right now, will do this for construction activities only
        - **Look at Portland's Green Street stewardship program as example**

Day 2: Technical Implementation Group

-Regional solutions
-Right of Way (ROW) PLD's w/ 100 year
-Hybrid System
-Separating Water quality and quantity and 100-yr (parking and streets)

TECHNICAL IMPLEMENTATION REPORT OUT

- Regional solutions: biggest restriction on site is 10th & Osage sewer. In order to increase conveyance here, can upsize pipe to west and manage additional capacity; add improvements in ROW (focused on flood control). Also look at how Colfax is influenced and impacted.
    - Identified site on park to manage 25-100yr flooding AND storage opportunity in Auraria sports complex – however, time and money are the main issues. Alternative is sub-regional approach to manage water on-site only
        - Historic park has some issues / reqs. Neighborhood is dense so park is being used quite a bit.
            - Need to assure maintenance and usability (however, this is going to only be used once every 5 years)
            - sensitive issue to use parks, need to be very specific on what parks are going to be used for and what they need
        - What is depth? Driven by invert of pipe more than by the depth
    - Putting in LIDs in ROW: manage water quantity volumes for 100-year storms (see Jay's Image) and water quality treatment.
        - Concept is approved, but not in the ROW (detention is not approved in ROW, but precedent is other parts of the country)
        - What is depth? Driven by invert of pipe more than by the depth needed
    - Consider using rooftop detention for site – use water for reuse, New Mexico is doing this and can do this. Colorado can pursue through pilot projects.
- How do we manage risks? This needs to be further evaluated and determined, look at:
    - Need to evaluate risks related to fire trucks, safety, parking requirements, transportation / pedestrians, building in the ROW, etc.
    - Look at what is happening / what is happening in these areas? Are there risks? What has been done and what is happening? (i.e. trip hazards, how does snow impact the proposed solution?)
        - Consider if EPA can do this research
        - Larry's example of New Hampshire porous pavement ok with snow
- Consider a hybrid system

Resources / Tools:

- Urban Drainage Stormwater tool
- Volume 3 water quality manual just been released (posted last week)
- Sustainable sites initiative

Overall Next Steps:

- Convener meeting in January
- Joint engineering study
- Research grant opportunities that can help fund engineering study
- Set up meeting with Fire Dept
- Look at precedent
    - Portland's Green Street stewardship program (green team)
    - East coast case studies / costs on implementing flush grates with success and low cost
    - Larry's example of New Hampshire porous pavement – proved to be ok with snow

6.4 Charrette Attendees:

First Name	Last Name	Organization
Tamara	Allen	Water Quality Control Division
Eric	Barendsen	Department of Energy
Terry	Baus	Denver Public Works
Devon	Bertram	YRG sustainability
Andy	Blackmun	Habitat for Humanity Metro Denver
Cindy	Bosco	Greenprint Denver
Matthew	Brady	--
Kenneth	Brewer	Denver Development Services
Brad	Buchanan	BYG Group
Devon	Buckels	City and County of Denver Parks and Recreation
Amy	Clark	EPA Region 8
Cindy	Cody	EPA Region 8
Kimball	Crangle	Denver Housing Authority (DHA)
Michelle	DeLaria	CO Dept of Public Health and the Environment
Greg	Dorolek	Wenk & Associates
Stacey	Eriksen	EPA Region 8
John	Ewy	RTD
Saeed	Farahmandi	Denver Community Planning and Development
Rebecca	Fox	SRA International
Kristin	Fritz	Denver Community Planning & Development
Jim	Godwin	Vision Land
Narada	Golden	YRG sustainability
Karen	Good	Denver Public Works
Nicole	Harwell	RTD
Guadalupe	Herrera	HUD

First Name	Last Name	Organization
Jack	Hidinger	EPA Region 8
Kenneth	Hoagland	Community Capital Corp
Abigail	Holmquist	Denver Water
Peter	Hynes	South Lincoln Steering Committee
Jill	Jennings	Auraria Higher Education Center
Elaine	Lai	EPA Region 8
Charles	Lawton	EPA
Jon	Novick	Denver Dept of Env Health
Chris	Olson	CSU
Jody	Ostendorf	EPA Region 8
Christopher	Parr	Denver Housing Authority (DHA)
Jay	Peters	Vision Land
Holly	Piza	Urban Drainage and Flood Control
Susan	Powers	Urban Ventures
Josh	Radoff	YRG sustainability
Tim	Rehder	EPA Region 8
Larry	Roesner	Colorado State University
Karl	Schemling	Denver Development Services
John	Shonsey	RTD
Eddie	Sierra	EPA Region 8
Brian	Smith	EPA
Alan	Sorrel	Denver Development Services
Ryan	Tobin	Denver Housing Authority (DHA)
Bill	Wenk	Wenk & Associates
Len	Wright	UC Boulder

6.5 Acronyms List:

Acronym	
AHEC	Auraria Higher Education Campus
BMP	Best Management Practice
CCoD	City and County of Denver
CDOT	Colorado Department of Transportation
CPD	Denver Community Planning and Development
DHA	Denver Housing Authority
DOT	Department of Transportation
DPR	Denver Parks and Recreation
DPW	Denver Public Works
EPA	Environmental Protection Agency
HUD	U.S. Department of Housing and Urban Development
LA / LP	La Alma / Lincoln Park
LID	Low Impact Design
LPNA	La Alma Lincoln Park Neighborhood Association
OBLR	EPA Office of Brownfields and Land Revitalization
PICP	Permeable Interlocking Concrete Pavers
PLD	Porous Landscape Detention
ROW	Right-of-Way
RTD	Regional Transportation District
SoLi	South Lincoln Redevelopment Project
TSS	Total Suspended Solids
UD	Urban Drainage and Flood Control District
VLC	Vision Land Consultants, Inc.

6.6 Vision Land Report

MEMORANDUM

To: Rebecca Fox, SRA International, Inc.
Narada Golden, YRG Consultants, Inc.

From: Jay Peters, PE, Vision Land Consultants, Inc.

Date: January 24, 2011

Re: South Lincoln Redevelopment - EPA Charrette
Summary of Stormwater Analysis for Report

This technical memorandum provides the analysis write-up for the stormwater charrette report as presented in the draft report outline dated 12/10/10 by YRG.

3.0 Vision Land Analysis

This section presents the stormwater analysis for the South Lincoln Redevelopment Site and the Curtis Street Outfall Watershed. Discussed are the South Lincoln and Curtis Street watersheds, the hydrology and hydraulics, results of the analysis, potential LID strategies at South Lincoln, the benefits of stormwater improvements at South Lincoln, and regional improvements that address the identified problem areas.

3.1 Regional Watershed Analysis

Vision Land Consultants, Inc. (VLC) conducted a hydrologic and hydraulic analysis as well as a pollutant loading analysis for both the South Lincoln Redevelopment site and the Curtis Street Outfall Watershed. The background and results of the analysis are discussed below.

3.1.1 South Lincoln Watershed

The Denver Housing Authority is planning to redevelop the South Lincoln Public Housing Site. The site is located in the La Alma/Lincoln Park neighborhood south of downtown Denver near the Buckhorn Exchange Restaurant. The site currently consists of 270 public housing townhome units on 15.1 acres. Also within the site are the RTD light rail station, a commercial site, parking lots both paved and earthen, and the Buckhorn Exchange Restaurant.

South Lincoln lies within a local sub-watershed that is 28 acres in size at the project outfall at 11th and Osage. There are off-site flows from the east that enter the site from a 5 acre area, as well a 2 acre area from the south. The watershed is 100% developed, consisting of single family houses to the east, some commercial development to the south, and the DHA multi-family units.

The stormwater infrastructure serving the South Lincoln Site is limited to 12- to 21-inch diameter vitrified clay pipe storm sewers. There are currently no water quality treatment or detention basins that serve the site. The site has mild slopes to the west at an average of 1.5%. There is a low point at the intersection of 10th and Osage, preventing overland flow to the north when the storm sewer capacities are exceeded. Runoff in excess of the storm sewer capacities flows to the west into the RTD light Rail Station. 8 soil borings were taken at South Lincoln. Soils are predominately clayey sands falling within hydrologic soil groups B and C. The clay content of the soil varies from 5 to 45%, with an average of 35%.

3.1.2 Curtis Street Outfall Watershed

The site is located within the upper reach of the Curtis Street Watershed which outfalls to Cherry Creek. The watershed is served by a storm sewer system ranging in size of 12-inches to 39-iches at the outfall to Cherry Creek. The area of the watershed is 101 acres at the outfall to Cherry Creek. The watershed has a variety of land uses, including parks, single family residential, multi-family residential, commercial, industrial, retail, and institutional. The watershed includes the RTD

light rail station at 10th and Osage, the North Lincoln Park Public Housing site, the RTD light rail line along Colfax, and the Auraria Campus at the lower reach of the watershed. The North Lincoln Park site is served by a detention basin and 18-inch outfall pipe.

3.1.3 Hydrologic and Hydraulic Model Development

VLC used the Environmental Protection Agency Stormwater Management Model (EPA SWMM) to evaluate the hydrology and hydraulics of the Curtis Street Outfall Watershed. The hydraulics were evaluated using the unsteady flow (dynamic wave) method to account for varying backwater conditions over time, evaluate existing detention basins, determine pipe and street conveyance capacities, and determine divided flows within the watershed. We evaluated the watershed for the 5- and 100-year design storm events.

3.1.4 Analysis Results

The results of the analysis indicate the following:

- The 21-inch storm sewer in Osage Street from 10th to 11th Avenue, and the storm sewer in 10th Avenue between Mariposa and Osage have less than a 5-year capacity;
- The remaining storm sewers in the watershed have a 5-year capacity;
- Surface flows on the streets in the watershed are less than one foot deep during the 100-year storm event, except at Colfax and Osage;
- There is excessive ponding, cross-street flow, and split flow at the intersection Colfax Avenue (arterial roadway)and Osage Street; and
- Surface flows leave the watershed at numerous locations.

During the 100-year storm event, stormwater surface flows leave the watershed and discharge to the south towards the RTD light rail line and Auraria Parkway. This occurs at the intersections of 10th and Osage, 13th and Osage, Colfax and Osage, and on the Auraria Campus at 9th and 10th Streets. At 10th and Osage, it is estimated surface flows will enter the RTD light rail station for the 5-year storm event.

We have estimated that the existing Curtis Street Outfall Watershed contributes approximately 20 tons per year of total suspended solids to Cherry Creek. The existing South Lincoln site contributes almost 6 tons per year.

3.2 Proposed Plan for South Lincoln

The stormwater system will be improved as part of the South Lincoln Redevelopment. The improvements will be designed to meet current CCD criteria and standards. There are opportunities to address both local and regional problems on a watershed based approach which may be more cost effective.

The project consists of new multi-story buildings, townhomes, parking lots, alleys, improved roadways, plaza areas, and green space/park areas. The site will have about 82% imperviousness. The table below summarizes the land use areas at South Lincoln.

Summary of Land Uses		
Type	**Area (acres)**	**Percent of Total**
Pervious	3.98	18
Streets	4.43	20
Sidewalks, Plaza Areas	3.90	18
Alleys and Parking Lots	2.63	12
Townhomes	1.94	9
Large Buildings	3.55	16
Areas not Improved	1.45	7
Total	21.88	100

The planned redevelopment will increase the density of the site with mixed use including retail, commercial, multi-story residential buildings, and townhomes. The redevelopment will occur over about a 22 acre site including improving the local infrastructure such as roadways, water, sewer, and stormwater management facilities. The redevelopment does not include the Buckhorn Exchange Restaurant or the commercial property on the southwest Corner. The current plan for the project includes 23 buildings, ranging from townhomes to mid-rise buildings three to eight stories in height. Roadways within, and adjacent to, the project site will be improved to meet CCD public works standards.

3.2.1 Strategies

As part of this project, VLC evaluated the implementation of low impact development stormwater management strategies on the South Lincoln Site. LID that could be implemented on the site are:

- Porous Landscape Detention or grass buffers and swales within the green space areas and tree lawns in the roadway right-of-way;
- Rooftop detention on the multi-story buildings;
- Green Roofs on the multi-story buildings;
- Porous pavement in the alleys and parking lots; and
- Porous pavement in the plaza areas.

These strategies can have multi-use objectives, including active use areas within green space areas, and manage stormwater for both quality and quantity. The function of each type of LID strategy is summarized in the table below.

LID Functions			
LID Type	**Function**		**Cost Comparison***
	Water Quality	**100-Year Detention**	
Porous Landscape Detention	✓	✓	Moderate
Grass Buffers and Swales	✓		Low
Porous Pavement	✓	✓	Moderate
Rooftop Detention		✓	Very Low
Green Roofs	✓		High

*For capital costs only, and does not include land values

3.2.2 Local and regional Improvements

VLC estimated the needed detention volumes to meet CCD stormwater management criteria. The detention volumes for the site are:

WQCV: 0.8 AF

100-Year: 2.5 AF

Total: 3.3 AF

We analyzed different scenarios using LID concepts for managing stormwater, and the resulting detention volumes necessary within the pervious areas of the development project, which are summarized in the table below.

Volume and Depths for LID Scenarios		
Description	**Volume in Pervious Areas (AF)**	**Depth in Pervious Areas (ft)**
Detention in Pervious Areas Only	3.3	0.8
Rooftop Detention	2.7	0.7
Rooftop Detention, Pervious Pavement in Parking Lots and Alleys	2	0.5
Rooftop Detention, Pervious Pavement, 50% Plaza areas with PICP	1.7	0.4
Rooftop Detention, Pervious Pavement, 50% PICP, Green Roofs	1.5	0.4

Providing water quality treatment and 100-year detention on the South Lincoln Redevelopment site will result in significant improvements to the performance of the off-site storm system. Improvements include significantly reducing the frequency of surface discharges into the RTD light rail station, and the frequency of split flows to the west at 13th Avenue. Total suspended solids leaving the site could be reduced by 4 tons per year.

VLC also developed conceptual cost estimates for managing stormwater on the South Lincoln site to compare traditional stormwater management facilities to LID strategies. The costs are comparable, and are listed below.

Traditional Management: $2.46M

LID Strategies: $2.65M

The traditional management costs assumes detention in underground vaults. Both estimates are for capital costs only, and do not include land costs.

VLC evaluated other potential regional improvements that would alleviate problems within watershed. The improvements included:

- About 2 acre-feet of detention immediately upstream of Colfax Avenue at Osage Street would provide a 100-year level of service to Colfax Avenue and eliminate the split flow to the west.
- About 1 acre-foot of detention on the Auraria Campus would alleviate the split flows to the west and provide a 100-year level of service to the storm sewer system.
- Implementing 3.3 acre-feet of detention on the South Lincoln site in a regional approach rather than on an individual site specific approach, will eliminate the overflows into the RTD light rail station and the split flow west down 13th street for events up to and including the 100-year event.
- Mariposa and Osage Streets from 9th Avenue to Colfax Avenue have wider tree lawns that could more easily allow for the implementation of PLDs within the right-of-way to further address water quality and flooding issues within the watershed.

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