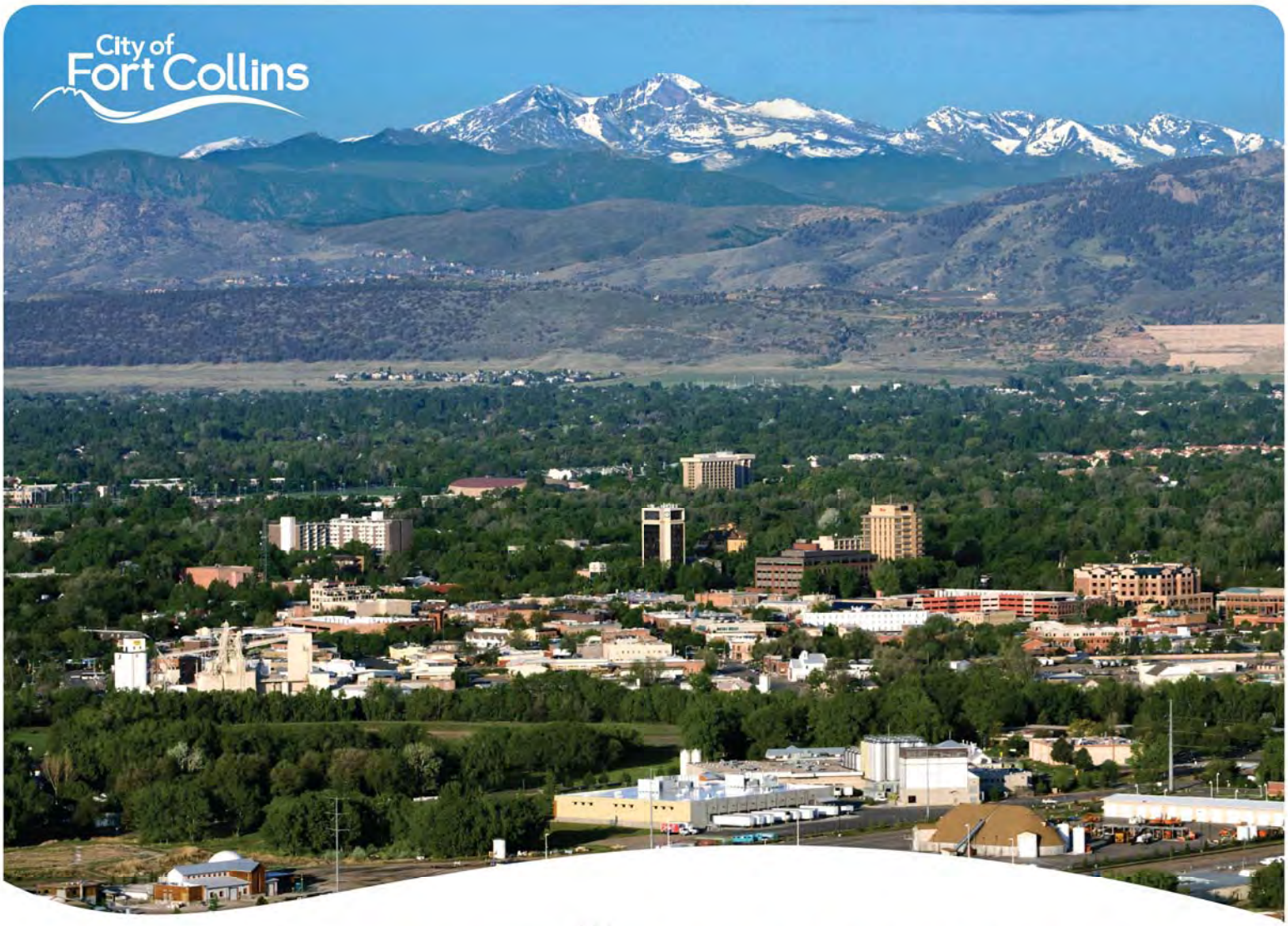

City Plan Fort Collins

STORMWATER REPORT

FEBRUARY 2011

innovate·sustain·connect

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TABLE OF CONTENTS

INTRODUCTION 5

PRINCIPLES & POLICIES 5

EXISTING STORMWATER MANAGEMENT REQUIREMENTS 7

CURRENT STORMWATER POLICIES & PRACTICES 7

INOVATIVE POLICIES & PRACTICES TO ADDRESS FUTURE CHALLENGES 9

FORT COLLINS LAND USE TYPES & STORMWATER CHALLENGES 10
- EXISTING DEVELOPMENT AREAS – CHALLENGES & OPPORTUNITIES
- REDEVELOPMENT AREAS
- NEW DEVELOPMENT

PROTOTYPES DESCRIBING INNOVATIONS IN STORMWATER MANAGEMENT 15
- TARGETED REDEVELOPMENT AREAS
- RETROFITTING STORMWATER SYSTEMS IN OLD TOWN
- NEW PLANNED DEVELOPMENTS
- INDUSTRIAL AREA
- COMMERCIAL REDEVELOPMENT
- URBAN STREET STORMWATER RETROFIT
- RESIDENTIAL DEVELOPMENT

WORKS CITED 31

APPENDIX 33
- STORMWATER TECHNICAL MEMORANDUM

INTRODUCTION

City Plan is the comprehensive plan for the City of Fort Collins that illustrates responsible development practices for the City over the next twenty-five plus years. However, because of the technical and complex nature of stormwater, the stormwater principles and policies in the Environmental Health chapter do not provide enough detail to adequately describe how solutions might be implemented. This report describes in greater detail how those principles and policies could be implemented, and how those Principles and policies can complement *City Plan*'s goals for multi-functional infrastructure and compact development.

The City of Fort Collins has been an innovator in stormwater management practices and policies for many years. The City's programs to restore urban streams, and the construction of the Udall Natural Area (to improve the water quality of stormwater), demonstrate a long-term commitment to environmentally responsible stormwater management. The City has also demonstrated its progressive approach to stormwater management by integrating stormwater facilities into parks, open space and trail networks. This report is designed to supplement *City Plan* by focusing on how the City can expand its current policies, and practices; and proposes innovations in stormwater management that support the broader goals of *City Plan*.

This report is divided into six sections. The first two sections reference the proposed principles and policies listed in *City Plan* and describe the City's existing stormwater management requirements. The third section describes the current policies and practices of the City's Stormwater Utility department, and the progress towards fully achieving those policies and practices. The fourth section describes the challenges that the City will face as patterns of growth, climate change, and modes of transportation evolve. The fifth identifies sub areas of the City, and each of these area's unique stormwater challenges and opportunities. The final section describes prototypes for managing stormwater in the areas of the City with the greatest potential to benefit from the implementation of new stormwater innovations.

PRINCIPLES AND POLICIES INFLUENCING STORMWATER MANAGEMENT

These Principles and Policies are taken from the larger *City Plan* document and are listed under the Environmental Health chapter.

Principle ENV 18: The City will minimize potentially hazardous conditions associated with flooding, recognize and manage for the preservation of floodplain values, adhere to all City mandated codes, policies, and goals, and comply with all State and Federally mandated laws and regulations related to the management of activities in floodprone areas.

Policy ENV 18.1 – Balance Environmental, Human and Economic Concerns
Recognize and manage floodplains with the intent to provide a balance between economic, environmental, and human (including safety) considerations within floodplain lands.

Policy ENV 18.2 – Manage Risks
Seek to minimize risk to life and property by structural and non-structural design or modification of actions in the floodplain where it is not otherwise practical to place structures and human activities outside of the floodplain.

Policy ENV 18.3 – Minimize Flood Damage
Recognize that maintenance, restoration and enhancement of the natural resources and the beneficial functions of floodplains is a concurrent goal with reducing human and wildlife vulnerability to flood damage.

Policy ENV 18.4 – Manage Floodplain
Require structures and facilities that are unavoidably located in the floodplain to be designed to be consistent with the intent of the standards and criteria of the City of Fort Collins and the National Flood Insurance Program.

Policy ENV 18.5 – Provide Education
Inform the public about the hazards of flooding, and develop and disseminate the most accurate information obtainable on local flood hazards. Educate the public about the natural and beneficial functions and uses of floodplains.

Policy ENV 18.6 – Modify Detention Requirements for Redevelopment
Modify detention requirements to allow for greater flexibility of options for meeting National Pollutant Discharge Elimination System (NPDES) rules and create mechanisms to satisfy detention requirements through a more holistic approach that includes Low Impact Development (LID) tools and satisfying such requirements on a sub watershed basis rather than exclusively on an individual parcel specific basis.

Principle ENV 19: The City will pursue opportunities to protect and restore the natural function of the community's urban watersheds and streams, as a key component of minimizing flood risk, reducing urban runoff pollution, and improving the ecological health of urban streams.

Policy ENV 19.1 – Employ a Watershed Approach to Stormwater Management
Design stormwater systems to minimize the introduction of human caused pollutants. Pursue educational programs and demonstration projects to enhance public understanding of pollution prevention efforts. Design tributary systems for water quality control, with appropriate use of buffer areas, grass swales, detention ponds, etc. Include receiving water habitat restoration and protection in stormwater master plans, in conjunction with habitat mapping efforts.

Policy ENV 19.2 – Pursue Low Impact Development
Pursue and implement Low Impact Development (LID) as an effective approach to address stormwater quality and impacts to streams by urbanization. Low Impact Development is a comprehensive land planning and engineering design approach with a goal of minimizing the impact of development on urban watersheds through the use of various techniques aimed at mimicking pre-development hydrology.

Principle ENV 20: The City will develop an integrated stormwater management program that addresses the impacts of urbanization on the City's urban watershed. As part of that program, the City will implement requirements and strategies for multi-functional stormwater facilities that support density goals for development and redevelopment at a sub-watershed level.

Policy ENV 20.1 – Develop Stormwater Master Plans
Develop master plans for future stormwater projects in order to minimize the impacts of urbanization. Master plans should consider the naturalization of stream corridors, piped conveyance, and other methods to provide a balanced benefit to the citizens of Fort Collins.

Policy ENV 20.2 – Follow Design Criteria for Stormwater Facilities
Utilize stormwater facility design criteria that follow national Best Management Practices (BMPs).

Policy ENV 20.3 – Utilize Public Lands
Utilize public lands, such as street rights-of-way, for the design of multi-functional stormwater facilities by maximizing the carrying capacity of streets with curb and gutter, and by modifying design standards to promote infiltration or detention where appropriate depending on area specifics. Emphasize the development of a linked surface stormwater system that reinforces the City's open lands policy and reduces the need for large stormwater pipes. (Also see the Transportation chapter mode choices section of the larger *City Plan* document.)

Policy ENV 20.4 – Develop Public/Private Partnerships
Employ public/private partnerships to optimize the balance between stormwater management and compact development. Take advantage of opportunities to combine stormwater management needs from both public and private lands.

EXISTING STORMWATER MANAGEMENT REQUIREMENTS

Stormwater Regulations:

Detention:

Currently each new development must provide stormwater detention for the 100 year storm event. However, if the site has been previously developed, that portion of the site that is covered by impervious surfaces may be "grandfathered." This limits the amount of detention for the 100 year storm event to the runoff from any new impervious areas added as a result of redevelopment. In addition, new developments are allowed an increase of 1,000 square feet of new impervious area in all drainage basins, without providing additional stormwater detention, except in the Old Town Drainage Basin. In the Old Town Drainage Basin 5,000 square feet of new impervious area is allowed without providing onsite detention.

Water Quality:

Presently every site must provide onsite water quality treatment for the stormwater generated from new impervious areas for the minor storm event (the first half inch of cumulative precipitation depth, which is considered a water quality storm event). The only exception to this regulation is the portion of the Old Town drainage basin whose runoff is treated by the regional water quality treatment facility located in the Udall Natural Area. In that portion of the Old Town basin onsite water quality treatment is encouraged but not required.

CURRENT STORMWATER POLICIES AND PRACTICES

The *21st Century Goals* report of 2007 identified four stormwater goals to be achieved by 2035. These goals include: restoring 21 miles of streams, removing 1,735 structures from the floodplain, maintaining a FEMA CRS class 4 rating and increasing the amount of developed land actively managed by Best Management Practices (BMP) to 100%. Since 2007 progress has been made on these goals. The City was recertified by FEMA in 2008 and retained its CRS class 4 rating. As of 2009 the City has restored 5.9 miles of stream corridors and approximately 20% of the developed property of the City is presently being treated by structural stormwater quality control measures or BMPs.

The McBride Water Report of 2009, *Fort Collins Best Management Practices Review*, identified three other existing goals concerning the ecological health of Fort Collins stream corridors. These include: minimizing the introduction of pollutants into the City's watersheds, treating the runoff and the pollutants carried by stormwater prior to reaching receiving waters, and protecting and restoring receiving water bodies and habitats. This ecological approach to stormwater is consistent with the Low Impact Development (LID) standards discussed in the McBride report.

Prior to the initiation of this planning process, the Stormwater Utilities Department has been active in implementing the following policies and practices:

Stream Corridors:

Promote the ecologic and biologic diversity in Fort Collins' stream corridors, and prevent erosion by establishing stream buffers, which allow streams to naturally meander.

- Erosion buffer limits were established in the Fossil Creek, Mail Creek, McClellands and Boxelder basins. Chapter 10 of City Code establishes regulations regulating protection of erosion buffer areas.
- At present all City urban stream corridor reaches have been inventoried and rated using ten physical and/or biological parameters. An urban stream health assessment study has been recently completed in order to evaluate what stream reaches can best be improved, and assess what policies or stream rehabilitation techniques might best benefit urban streams and waterways.

Public Outreach:

Continue to educate the community about flooding, water quality, stream health, emergency preparedness, and issues associated with irrigation ditches.

- Flood Awareness Week and other public outreach efforts are held annually.

- Flood risk determinations and drainage assessments are provided to citizens, business owners, property owners, real estate agents, insurance agents, engineers, surveyors, and mortgage companies on a daily basis.
- The City regularly offers training opportunities on topics related to floodplain management to citizens, professionals, businesses and special interest groups.
- In 2008, the Stormwater Utility Department published a flood warning video to educate the public.
- The Stormwater Utility Department has continued to participate in annual Emergency Preparedness Fairs, Open Houses and related public forums.

Water Quality:

Low Impact Development (LID) and Best Management Practices (BMP) techniques are utilized with the development or re-development of properties to reduce the impacts of storm runoff and where practical regional water quality facilities are utilized.

- The update of *City Plan* that is currently underway will assess LID and expanded BMPs techniques for potential inclusion. Three LID demonstration projects have been completed. A monitoring and sampling program at these LID sites has been initiated, and the City is currently collecting water quantity and quality data which will be used to determine the relative effectiveness of different technologies, to establish standard maintenance operating procedures, and to help determine a City-wide LID policy that best suits the City's climate, culture and available resources.

Walnut Street LID pervious paver test site

- The LID demonstration projects are also used as educational tools for the public to demonstrate what can be done on their own property to reduce and treat storm runoff.
- Three regional water quality facilities serving the Old Town area are in place. Two additional regional facilities serving the North College Avenue area have been planned and some of the property purchases completed. A monitoring and sampling program aimed at assessing the effectiveness of these regional water quality facilities has been established and is currently operational.

Flooding & Detention:

The Stormwater Utility Department will continue the City's emphasis on public safety by supporting the Flood Warning System's (FWS) data acquisition, data dissemination, public awareness and emergency preparedness elements, and continue to coordinate with state and federal partnering agencies (CWCB, FEMA, NWS, NOAA, CSU, State OEM, etc.) The Stormwater Utility Department will continue to encourage the ongoing use of FWS data by the research community to improve weather radar technology, evaluate stream morphology, monitor storm intensity surrounding flood events, manage flood response efforts, and provide public notification.

- In 2009, the Stormwater Utility Department improved the website's FWS maps to provide the public with better information during flooding situations.
- Floodplain mapping was updated in 2006 and Chapter 10 of City Code currently regulates encroachments in the floodplain.
- In 2011, the Poudre River floodplain regulations are slated for review and options will be considered.
- Stormwater master plans will be updated in 2011 and 2012 and will utilize the Triple Bottom Line (TBL) philosophy in identifying means to mitigate flooding hazards.
- Restrictions on the use of the LOMR-Fill process for the Poudre River Basin were adopted by City Council.
- City Council will consider revising the Poudre River floodway from 0.5-ft allowable rise to a performance based review and an evaluation of impact to surrounding properties.
- The Stormwater Utility Department will continue efforts that have reduced flooding in the City. The enforcement of floodplain regulations, design criteria and construction standards for new and re-

development and the construction of flood mitigation projects have all been effective in reducing flooding in Fort Collins.

Multi-use Facilities:

Stormwater facilities should be designed, constructed and maintained to fulfill multiple functions and values.

- Detention Pond Landscape Standards and Guidelines fulfilling multi-disciplinary goals have been established and are incorporated into the Land Use Code.

Triple Bottom Line:

The City will utilize the Triple Bottom Line (TBL) philosophy and approach in the design and construction of infrastructure improvements and in the maintenance of such improvements.

Stormwater Regulations:

The City will continue to provide for and promote the general health, safety and welfare of its citizens, as well as downstream water users. The City will also ensure that land use regulations, sub area plans, stormwater master plans, and floodplain regulations are consistent.

- The update of *City Plan* will ensure the consistency of City planning documents.

INNOVATIVE POLICIES AND PRACTICES TO ADDRESS FUTURE CHALLENGES

As part of the current *City Plan* planning process several additional goals have been identified which look at stormwater management as part of a regional linked stormwater system.

Address the competing community values of floodplain management, protection of life safety on public/private property with the potential for development and redevelopment:

Previous stormwater master plans have identified areas of the City that are within the 100 year floodplain. These areas represent a variety of land use types and different challenges. Older areas such as Old Town, with dense development and an undersized stormwater conveyance system, suffer from storm sewer backups that cause minor flooding. Spring Creek and the canals west of Colorado State University cause flooding in the surrounding residential neighborhoods and the commercial area along College Avenue. More serious flooding occurs along the Cache La Poudre River, affecting the commercial and industrial areas north of the river. Flooding is also of concern along Boxelder Creek, and west of Interstate 25 affecting the industrial areas along Interstate 25. Currently there are competing values between the goals of stream corridor preservation, flood protection, and development/redevelopment.

Anticipate higher standards not yet in place for flood mitigation and water quality:

- Large volumes of water released over longer periods of time to tend destabilize stream corridors and destroy habitat. Therefore, higher levels of flood mitigation for large and small storms may be required to achieve the higher levels of stream restoration desired by the City. Irrigation flows further contribute to the long term degradation of stream banks because of the high levels of consistent water flow.
- Climate change may increase the intensity of storm events resulting in an increase in flooding and ultimately an increase in the 100-year flood volume. The effect of possible future design flow increases on stormwater management planning should also be considered. In 1999, a Citizen task force studied rainfall records and recommended an increase in the rainfall design standard, which effectively increased the 100-year flood runoff rate and volume, and this recommendation was subsequently approved and adopted by the City Council. The new rainfall design standard resulted in new criteria for the design of stormwater facilities and floodplain mapping.
- Elements of urban runoff and treated effluent not previously considered to be a problem are now believed to cause significant damage to riparian and aquatic ecosystems. New methods and higher standards of water quality treatment may be required to achieve the levels of stream restoration desired by the City.

- Stream health and flooding problems extend beyond City boundaries. It is important to work with other jurisdictions that share Fort Collins watersheds and stream corridors to improve water quality and reduce flooding at a watershed level.
- The maintenance and monitoring of hundreds of small onsite BMP's would be very costly for landowners and the City over the long term. It is important to identify strategies to minimize long-term monitoring and maintenance costs for water quality facilities.

Promote strategies that encourage better integration of stormwater management into private development:

- Common practices by homeowners and businesses often inadvertently contribute to the degradation of water quality. Chemicals such as fertilizers, herbicides and pesticides can pollute storm runoff and if left untreated, negatively affect downstream water bodies and receiving waters. Education of private homeowners and businesses can be an effective means to protect water quality by minimizing the amount of chemicals released into watersheds.
- Compact development and the high value of land encourage higher densities, which may be inconsistent with current LID strategies for onsite water quality treatment. In higher density areas public and private partnerships should be established to create regional stormwater facilities to treat stormwater.
- Current studies show that many stormwater control measures may be ineffective over the long term because of a lack of proper maintenance or poor construction. Strategies need to be identified that improve the long term performance of water quality facilities and minimize the amount of maintenance needed.
- Clustering of development should be encouraged to preserve and create buffers along stream corridors. Land disturbance close to streams can have a harmful effect on water quality and stream health.

Factors outside of existing stormwater considerations that may be a factor in the future:

As Fort Collins continues to develop, the amount of impervious surface area will increase, resulting in larger stormwater volumes and more severe impacts to the community. Possible changes in state and federal regulations may require urban runoff volumes and rates to mimic natural pre-development storm flows to the extent possible. Extended drought, prohibitively high prices for new sources of potable water, and the high cost of upgrading infrastructure may require innovations in the use and management of all of the City's water resources, as well as strategies for upgrading infrastructure. Future changes in state water laws could present the opportunity to reuse or recycle stormwater effluent, resulting in smaller stormwater loads.

FORT COLLINS LAND USE TYPES AND STORMWATER CHALLENGES

Fort Collins, like most cities, is made up of a diverse mix of land use types, and eras of development. Each land-use type demonstrates unique land-use patterns and challenges related to stormwater management. For example, the gridded street network of Old Town, with thousands of small parcels and limited areas of open space, has significant flooding problems because of inadequately sized storm sewers built over a hundred years ago. By contrast, planned communities developed 20 to 30 years ago may have adequately sized storm sewer systems, have provided for stormwater detention, and preserved existing stream corridors, but may not have provided for treatment of stormwater for nonpoint source pollutants.

The purpose of this section is to describe the varied land use types that exist in the City, and identify challenges and opportunities for each type. The opportunities listed below illustrate how the stormwater principles and policies of *City Plan* can lead to new practices that protect the City's stormwater resources while supporting other innovations in land-use planning and multi-functional infrastructure.

EXISTING DEVELOPMENT AREAS - CHALLENGES & OPPORTUNITIES:

The following land-use types are illustrated in Figure 1, Map of Land Use Types

Pre- World War II (WWII) Residential Development

(*See* also *Stormwater Prototypes in the following section)*

Challenges:

- Older sewer systems that are significantly under designed can result in areas of shallow flooding.
- In the past, stream corridors were buried or diverted through pipes, with no consideration for stream health or water quality.
- Retrofitting of sewers by increasing the size of conventional pipe systems is extremely expensive, and does not address issues of water quality or stream health.
- The limited availability of parks and open space in these areas reduces the opportunity to integrate stormwater management facilities into these publicly owned lands.
- The desire to maintain and increase density on redeveloped sites is inconsistent with the desire to have onsite stormwater management. This requires reduced density, increasing development costs.

Opportunities:

- The wide streets, typical of these areas could allow for a surface stormwater system to be integrated in selected corridors as an alternative to a large piped system. The surface stormwater system could provide water quality treatment in addition to stormwater conveyance.

Post- WWII Residential Development

Challenges:

- A significant percentage of the City's land area was developed after World War II, much of which is large lot single-family residential. Until the 1980's little consideration was given to stormwater management and flooding. Improved stream health and the treatment of urban runoff has been a stated goal of the City only since 1995.

NE Siskiyou Street in Portland OR – retro-fit of an older residential area with a stormwater bump-out

Opportunities:

- Current practices of retrofitting stream corridors to provide detention and water quality treatment at a district or regional scale should be expanded.
- Local streets and other public rights of way can be modified to incorporate water quality treatment facilities. Such facilities might include bump-outs and curb cuts.

Commercial Development

(See also Stormwater Prototypes in the following section)

Challenges:

- A significant percentage of new commercial development occurs on a parcel-by-parcel basis, making it difficult to manage stormwater in a consolidated detention and treatment facility.
- Onsite systems to treat and detain stormwater are difficult to maintain and monitor.

Opportunities:

- Stormwater districts can manage stormwater from several parcels, allowing for better management and monitoring.
- Property owners could partner with the City or other public agencies when possible to integrate facilities into open space areas.

Multi-Family Development

Challenges:

- Significant numbers of multi-family residential projects were developed after WWII, before stormwater regulations were put into place.
- Newer multi-family developments may not have incorporated water quality treatment as part of stormwater management improvements.

Opportunities:

- The city could educate and incentivize landowners to retrofit landscape areas into stormwater gardens and similar onsite treatment facilities. This would reduce potable water use and landscape maintenance as well as providing onsite runoff treatment.

REDEVELOPMENT AREAS:

Large Redevelopment Sites:

Challenges and Opportunities:

See Stormwater Prototypes in the following section

Small Redevelopment Sites:

Challenges:

- Redevelopment of small parcels may be one of the more difficult challenges in that the City's goal of maximizing density may be inconsistent with the need to manage stormwater onsite. Onsite stormwater management typically reduces the developable area of the site, or significantly increases development costs.
- To increase density, underground stormwater vaults are often built to maximize developable area above ground. These stormwater facilities are expensive, and difficult to maintain and monitor.
- Redeveloped sites are only required to provide water quality treatment and detention for storm volumes generated by impervious area added to the site. Detention for runoff from existing impervious areas is not required, which does not help to reduce downstream flooding caused by insufficient detention.

Opportunities:

- Stormwater districts could be created in areas with a predominance of small parcels to manage stormwater from several parcels in a consolidated stormwater facility, allowing for better management and monitoring.
- The City could require detention for existing impervious areas, especially where flooding is a problem.
- Property owners could partner with the City or other public agencies when possible to integrate facilities into parks or open space areas.
- Redevelopment could offer an opportunity to use more innovative stormwater quality treatment techniques, such as LID, which were not in use at the time of original development.

NEW DEVELOPMENT

Planned Community Development

Challenges and Opportunities:

See Stormwater Prototypes in the following sections

Small Incremental Development

Challenges:

- Construction of individual onsite stormwater facilities discourages compact development, and requires higher levels of monitoring and maintenance.

Opportunities:

- The City could encourage the formulation of stormwater districts to manage stormwater from several parcels, allowing for better management and monitoring.
- Property owners could partner with the City or other public agencies when possible to integrate facilities into open space areas.
- May be able to use underground detention storage to increase developable surface area.

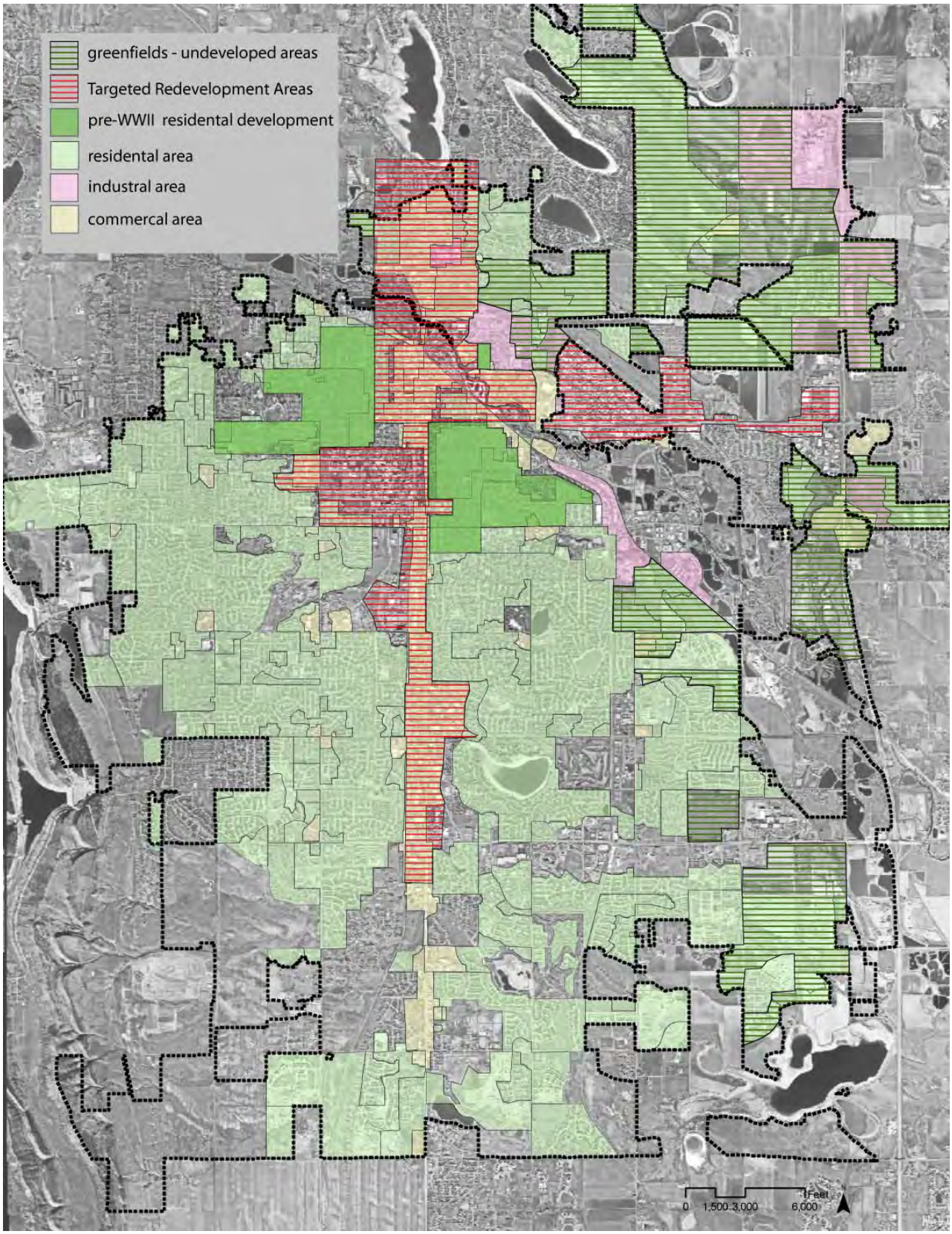


Figure 1 – Map of Land Use Types – Each land use type has different stormwater challenges and opportunities. These are discussed in the previous section "Fort Collins Land Use Types & Stormwater Challenges." The prototypes shown in the following section, titled "Prototypes Describing Innovations in Stormwater Management," have been chosen from those areas of the City that are most likely to be development or redevelopment in the near future. This includes Targeted Redevelopment Areas and those areas that are undeveloped, often called "greenfields."

PROTOTYPES DESCRIBING INNOVATIONS IN STORMWATER MANAGEMENT

Prototypes have been developed for those areas of the City with the greatest opportunity to resolve potential conflicts between compact development and onsite detention. These areas are thought to have the greatest development activity, and in areas where flooding and water quality problems may require innovative and creative approaches.

Although sites selected in the following prototypes can be easily identified as to their specific ownership and location, the intent is to develop prototypical solutions that are generally applicable to many sites in the City. It is not the intent of these prototypes to make specific recommendations for the selected sites, rather to indicate general approaches.

Prototypical areas for the following development types have been selected:

Targeted Redevelopment Areas:

The greatest potential for innovations in stormwater management can be realized in those areas of the City where significant new development or redevelopment is anticipated to occur, where flooding problems currently exist, and where significant investment is anticipated to upgrade the City's stormwater system. The areas studied include:

- Industrial Areas – Air Park Village
- Commercial Development – College Ave. & Drake Rd.
- Old Town – Magnolia St.

Retrofitting Stormwater Systems in Old Town:

Flooding and water quality in the historic downtown and adjacent neighborhoods pose some of the most significant challenges because of density and the extent of existing developed impervious area. Significant investments in upgrading the stormwater system are anticipated under the City's current stormwater master plan in order to mitigate flooding problems. Prototypes in this area would address both flooding and water quality issues, and explore multiple benefit approaches in lieu of or in concert with the construction of stormwater pipes.

New Planned Developments:

Undeveloped areas, especially those that are of a large scale and include significant open space, provide the opportunity for large consolidated multi-purpose stormwater facilities. These can provide recreational opportunities, in the form of parks and open space.

INDUSTRIAL AREA

Prototypical Industrial Redevelopment – Air Park Village

Introduction

Industrial development, both new development and redevelopment, present some of the more challenging issues related to stormwater management. High percentages of impervious areas and higher levels of nonpoint source pollutants are typically associated with this land-use type.

Challenges:

Industrial areas often occupy low-lying areas in and along the Poudre River corridor, which can be prone to flooding. The site illustrated below is bisected by an existing stream, and habitat areas.

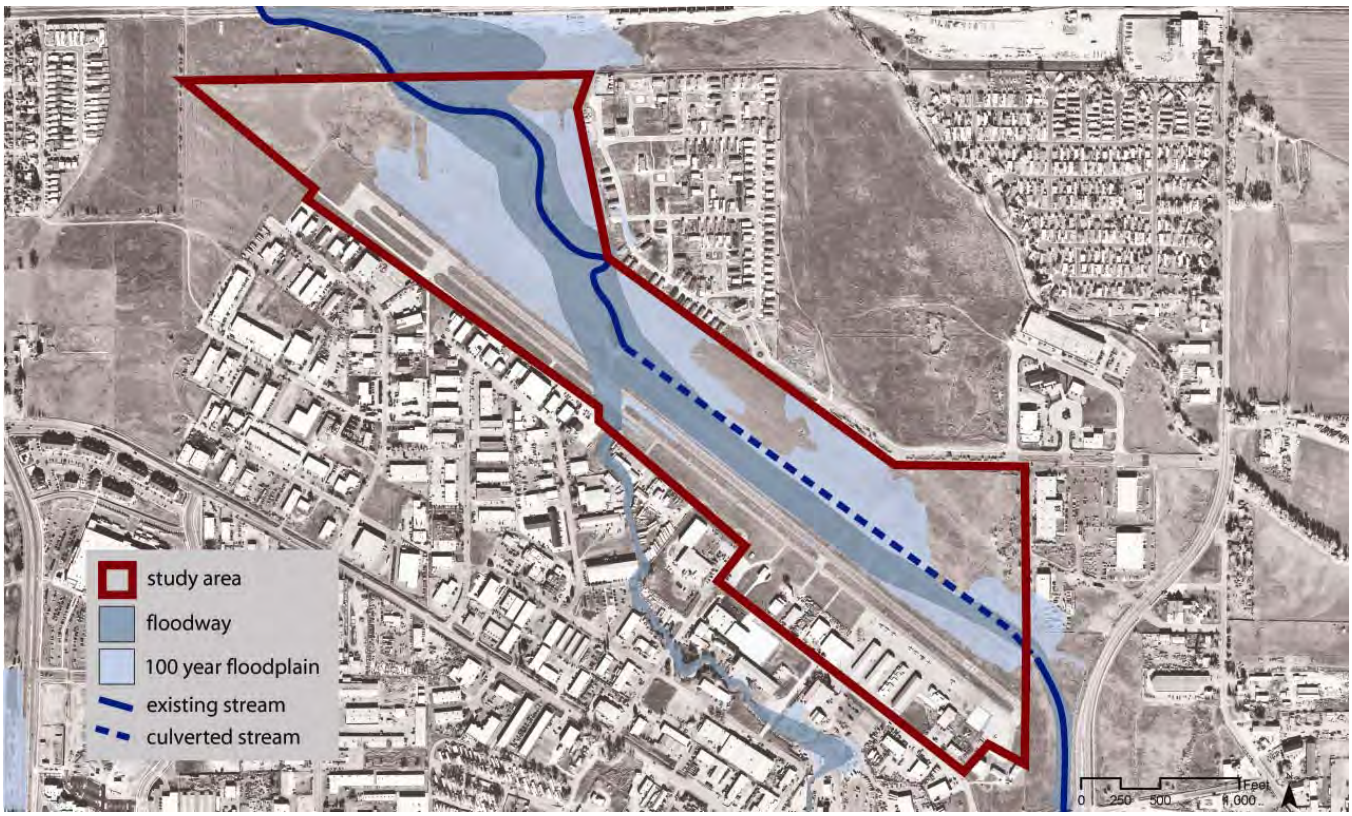


Figure 2 – Existing Conditions -Prototypical Industrial Redevelopment Site

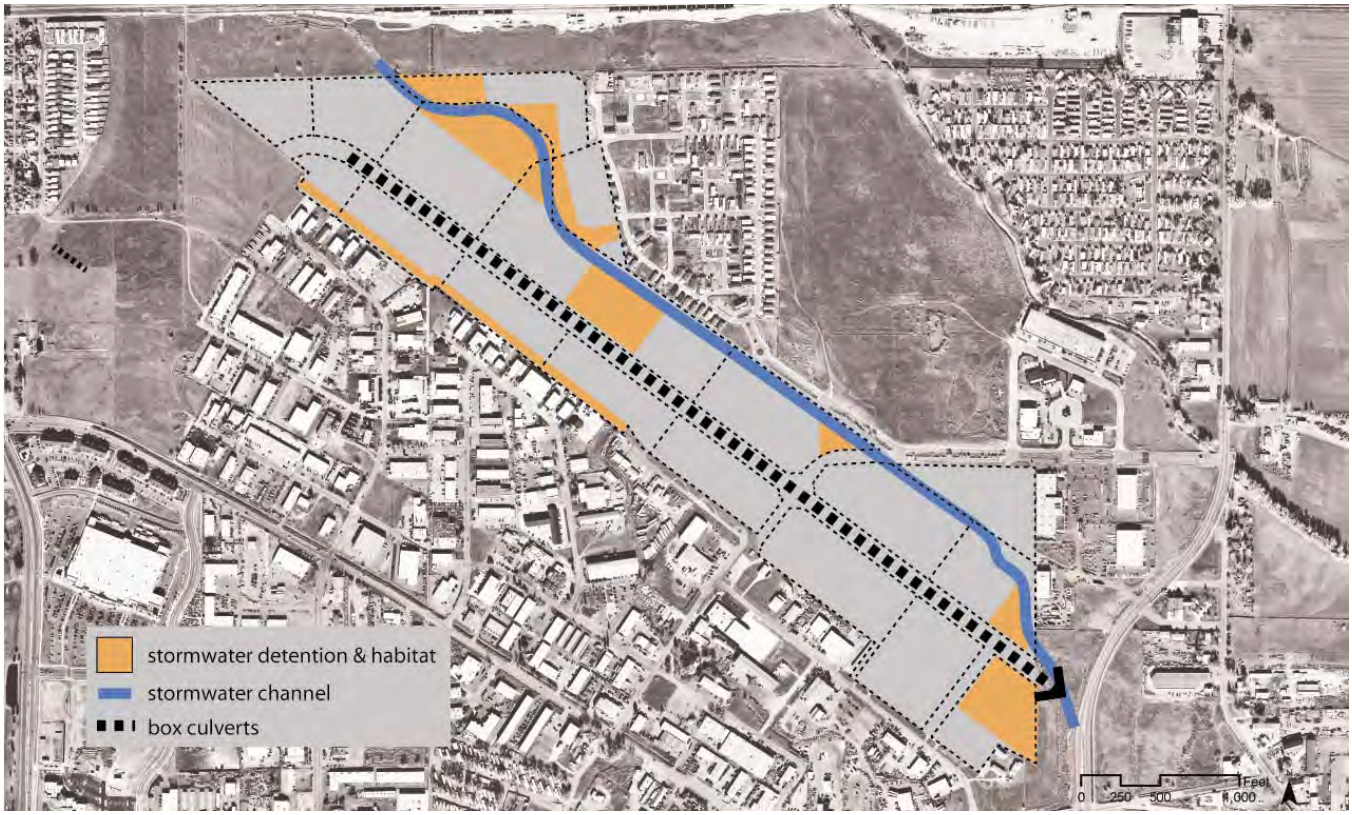
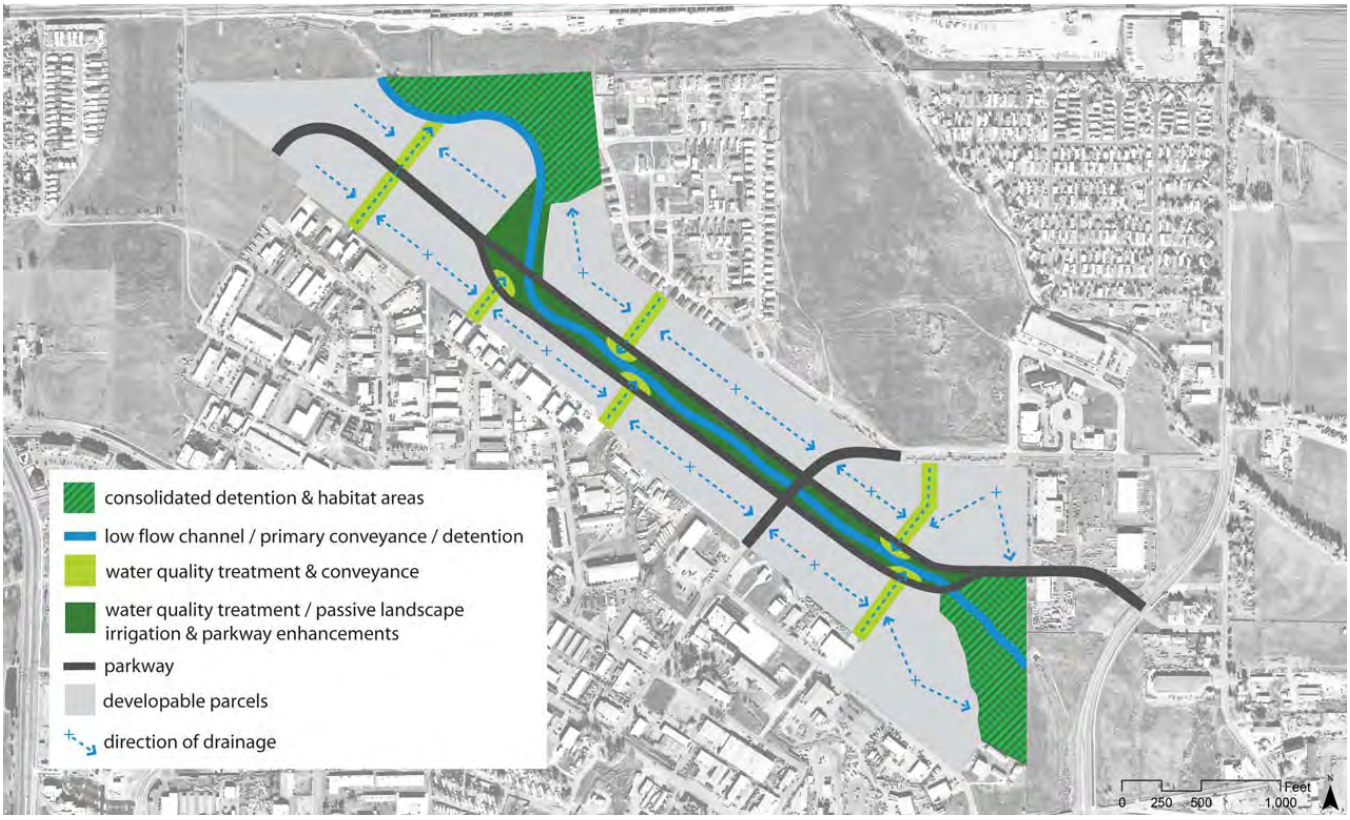


Figure 3 – Typical Approach to Stormwater System Design – A stormwater management concept proposed for this industrial site proposes a large open surface channel at the northern edge of the site, with several detention ponds. Large concrete box culverts beneath the proposed parkway provide drainage and conveyance for the central and southern portions of the site. Habitat areas and the open channel help to buffer residential areas while providing habitat and stormwater detention.



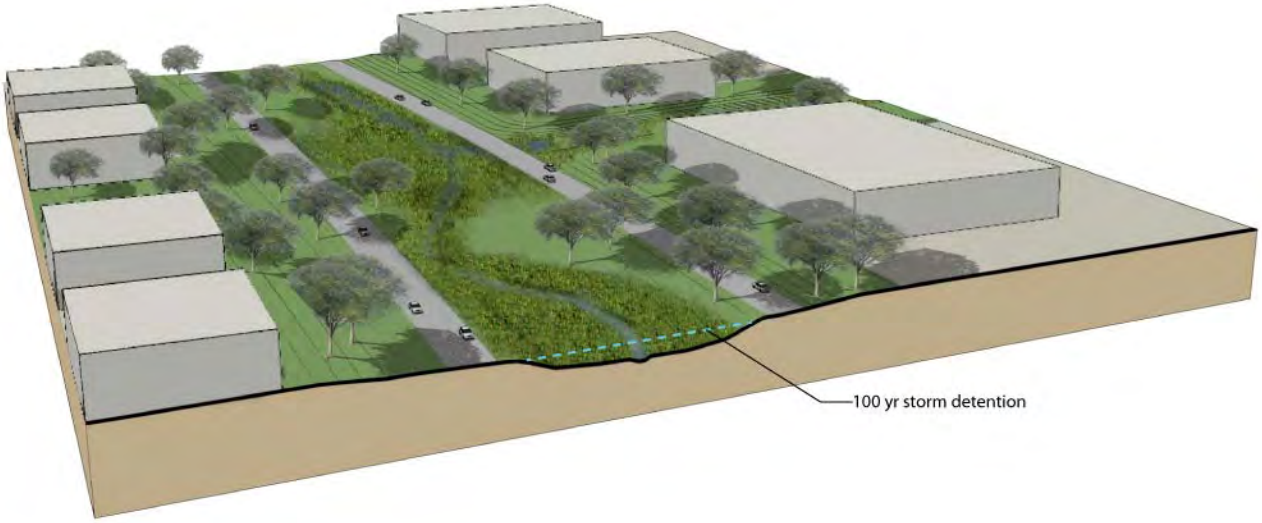


Figure 4 – An Alternative Approach – Plan (above) / Axon (below)

An alternative to standard practice described in Figure 3 includes consolidation of multiple surface stormwater channels into a central channel in the proposed median. The central channel gives identity to the development, reduces land area required for conveyance, and incorporates water quality treatment and detention into the combined channel. The central channel also helps to link and extend existing wildlife habitat areas located in the northwest and southeast corners of the development. A series of "green fingers" provide consolidated water quality treatment and positive drainage for individual sites, although, small pipes may be required to drain the back edges of many sites. Detention areas are located to complement and extend existing habitat areas. Most importantly, this plan proposes a surface stormwater system that should eliminate the need to construct large box culverts that parallel the large open stormwater channel at the northern edge of the project as shown in Figure 3.

COMMERCIAL REDEVELOPMENT

Prototypical Design for a Commercial Redevelopment – College Avenue & Drake Road

Introduction

Significant portions of commercial districts in the center of the City, especially along College Avenue, are anticipated to redevelop as existing patterns of use become outmoded. An important goal of areas targeted for redevelopment is compact development. Onsite stormwater facilities can typically occupy 5-10% of a sites land area reducing the potential for compact development. The following prototypes explore strategies that can increase developable area while addressing the need to meet stormwater requirements.

For the Commercial Redevelopment prototype five alternatives were explored ranging from using the existing City standards for a 100% impervious site (no detention required and individual water quality areas) to implementing higher "Greenfield" standards (100-year detention and water quality required). Several approaches to site layout were explored ranging from standard practice, which requires each developer to be responsible for their stormwater management, to where stormwater is managed in a consolidated facility.

Assumptions:

The existing site is 100% impervious.

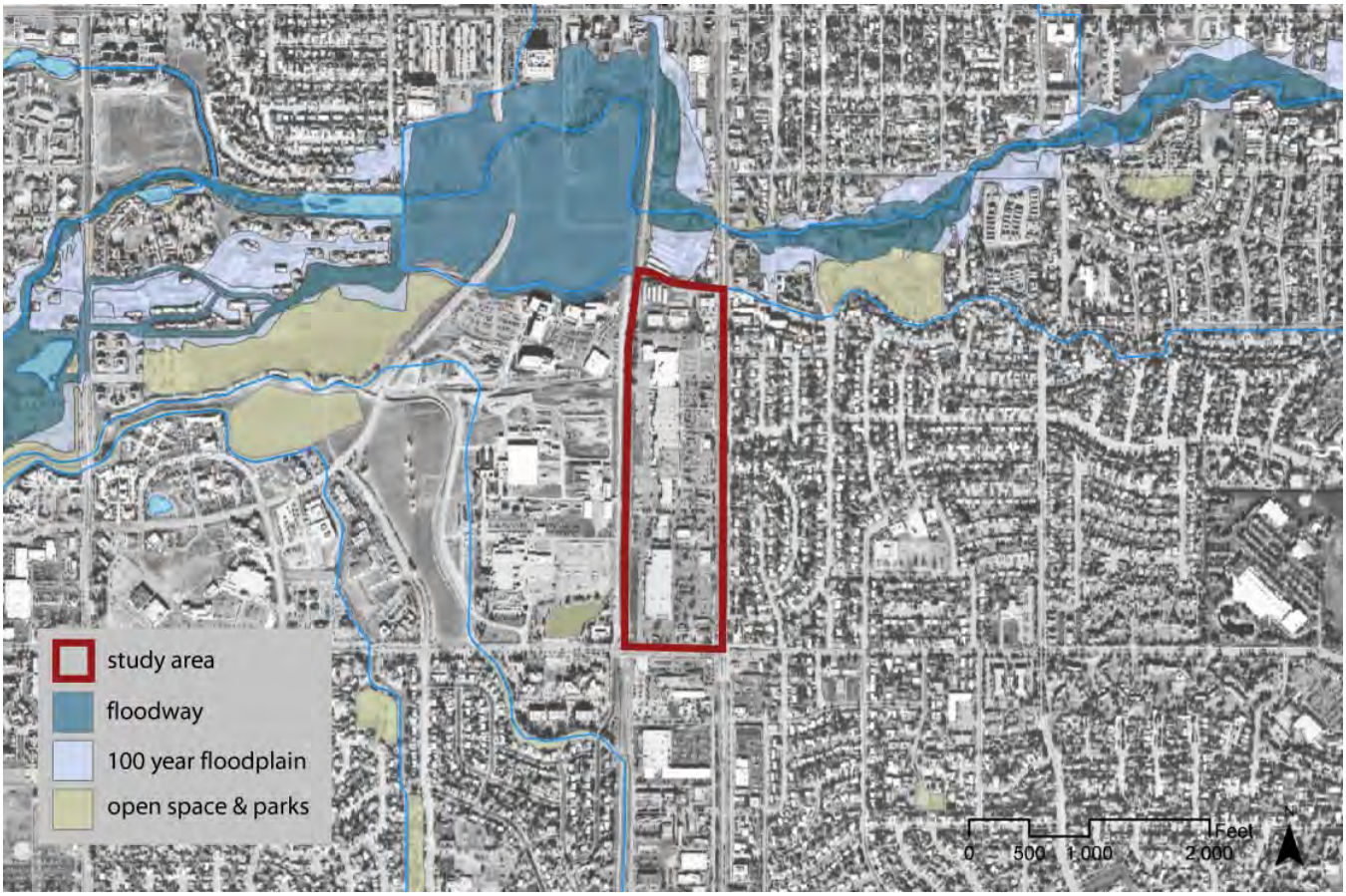


Figure 5 – Existing Conditions Prototypical Commercial Redevelopment Site

Individual Water Quality Treatment Areas to Meet Current Redevelopment Standards

Current requirements for stormwater management-limited to providing water quality treatment-are illustrated in this prototype. Dispersed onsite stormwater facilities that can be anticipated under this option tend to reduce densities, and create development patterns typically found in more suburban environments.

This option shows the stormwater facility requirements under the existing stormwater regulations for a site that has 100% existing impervious surfaces and where each developer is responsible for their own stormwater treatment.

Opportunities:

- Each landowner is responsible for constructing and maintaining a facility for treating their stormwater.

Challenges:

- If each owner treats their stormwater onsite, the amount of land area that could be developed is reduced, limiting the compact development potential of the site.
- Stormwater detention is not required which requires the need to mitigate downstream flooding caused in part by runoff from the site.
- Because each landowner is required to maintain their own stormwater treatment facility, the long term effectiveness of the water quality treatment areas is not ensured.
- There is a direct and immediate cost incurred for the owner to construct and maintain individual stormwater treatment areas.

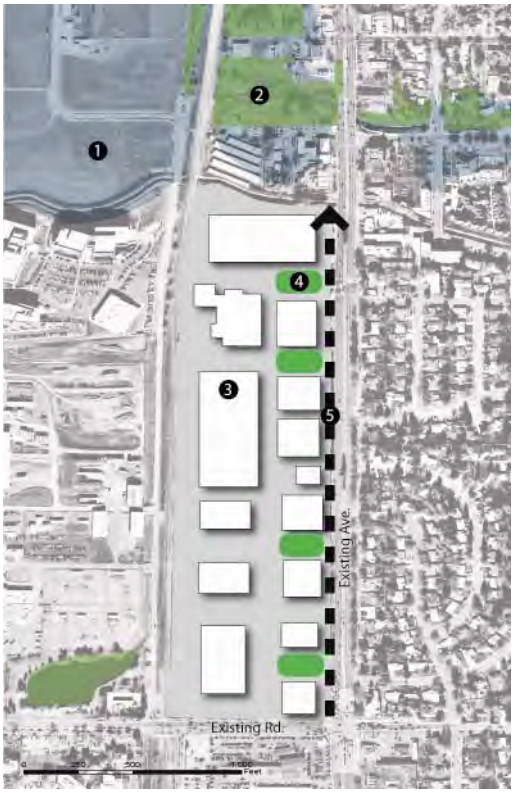


Figure 6 – 1) Floodplain, 2) Publicly Owned Land, 3) Redevelopment, 4) Water Quality Treatment Area / Stormwater Park, 5) Large Stormwater Pipe

Figure 7 – Tanner Springs Park, Pearl District, Portland OR – Is an example of a park that also functions as a consolidated stormwater treatment & detention facility in a mixed-use, medium to high density infill development area.

Consolidated District Scale Water Quality to Meet Current Redevelopment Standards

This prototype provides a consolidated offsite water quality treatment facility with no detention for the 100 year storm. This prototype requires the establishment of a stormwater district and acquisition of property within an existing floodplain. These requirements are offset by maximizing the development potential of the redevelopment area, and the enhanced open-space of the adjacent stream corridor.

This option shows the existing stormwater regulations for a site that has 100% existing impervious surfaces and where the developers join together with the City to create a regional facility. The prototype also shows the use of a surface stormwater channel, reducing the need for pipes, and providing for limited water quality treatment.

Opportunities:

- 100% of the site is available for redevelopment.
- The consolidated facility could be placed in the existing floodplain, freeing up more desirable land for denser development.
- A larger consolidated stomwater treatment facility allows for the possibility of multiple uses of the treatment area: i.e. the water quality treatment area could double as a park, or wildlife habitat, and bring flood-prone areas into public or semi-public ownership.
- A consolidated stormwater approach allows the City to monitor one large facility rather than multiple small facilities to assure proper operation.
- Developers could pay into a stormwater funding agreement spreading the cost of constructing and maintaining a stormwater treatment facility over a period of years rather than as an upfront cost.

Challenges:

- No stormwater detention is required if the site can drain to a major stream ahead of the peak runoff flow to that stream, which then necessitates the City to mitigate downstream flooding caused by existing runoff from the site.
- The City might need to construct the consolidated facility before development occurs and before fees are collected.

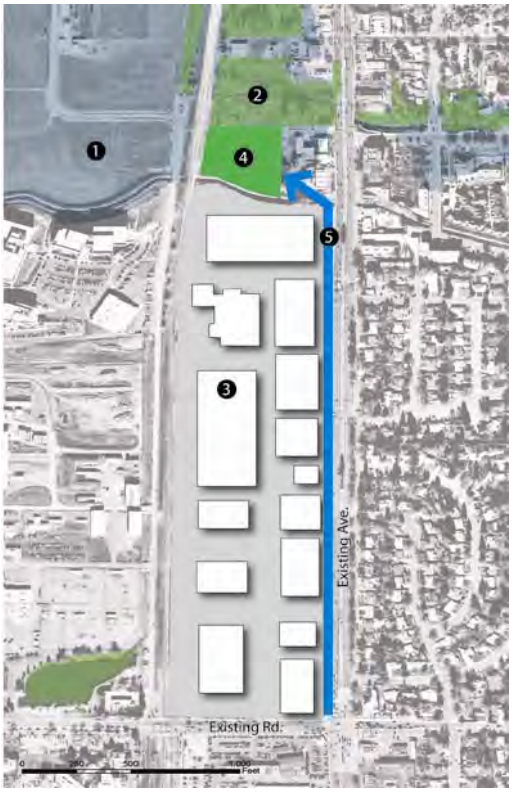


Figure 8 – 1) Floodplain, 2) Publicly Owned Land, 3) Redevelopment, 4) Water Quality Treatment Area / Stormwater Park, 5) Stormwater Channel

Stormwater Detention & Water Quality to Meet Current New Development "Greenfield" Standards

This prototype provides for both stormwater detention and water quality treatment, as is currently required for new development. The dispersed pattern of development, and a greater reduction in developable land described in this option is anticipated.

This option shows a higher level of treatment & detention requirements where, in addition to the treatment of stormwater runoff, developers are required to meet a higher "Greenfield" standard and detain the 100 year storm event. The prototype also shows the use of a stormwater channel reducing the need for pipes and providing some treatment. Figure 9 is the same as Figure 9a except the stormwater channel could move to the center of the development functioning more as an amenity and enhancing the street character (*see also Urban Street Stormwater Retrofit*).

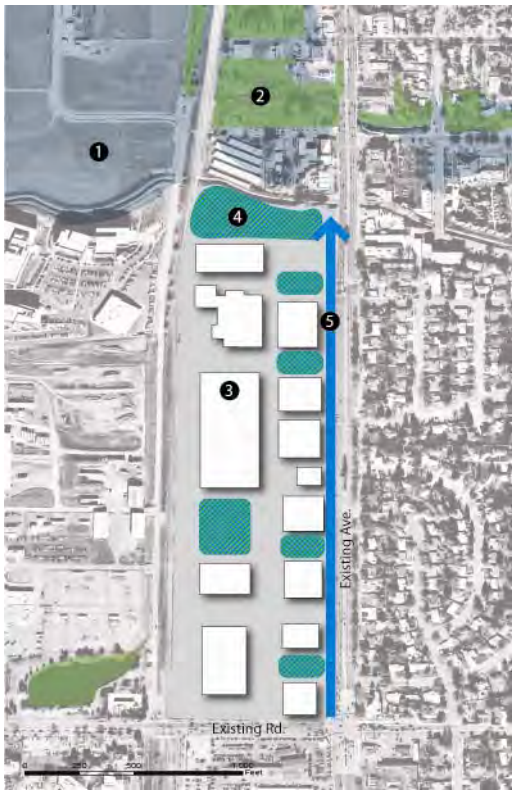


Figure 9

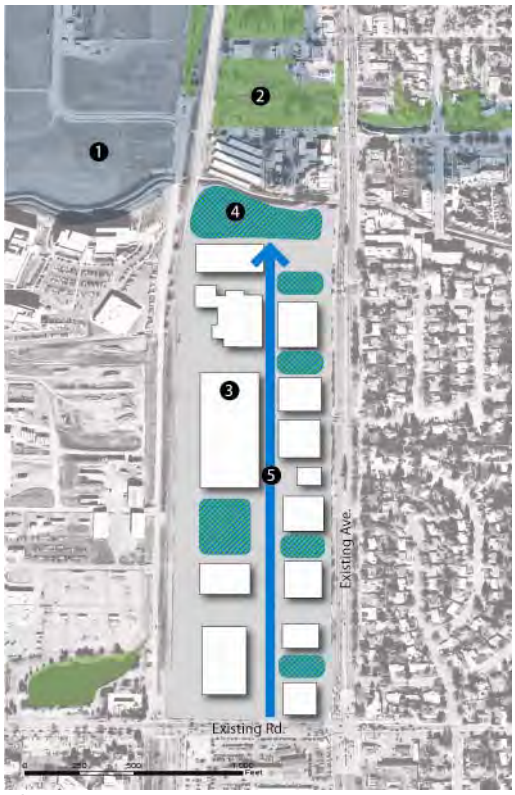


Figure 9a

1) Floodplain, 2) Publicly Owned Land, 3) Redevelopment, 4) Water Quality Treatment & Detention Facility / Stormwater Park, 5) Stormwater Channel

Opportunities:

- Although each landowner is responsible for treating and detaining their stormwater onsite, landowners could consolidate treatment and detention ponds in order to create onsite stormwater parks (see figures 7 & 14).
- Increased onsite detention may also alleviate some downstream flooding. However, caution must be used in calculating this runoff as the timing of the decreased release rates may then match that of the stream and increase the peak flow rate of the stream.

Challenges:

- Each owner must treat and detain their stormwater onsite, which reduces the amount of developable land area.
- Because each landowner is required to maintain their stormwater treatment area the effectiveness of the water quality treatment areas is not ensured.
- Higher land costs encourage the use of vaults and related underground detention facilities, greatly increasing site development costs.

Consolidated District Scale Stormwater Detention

This prototype requires the establishment of a stormwater district, and acquisition of properties currently in the floodplain to provide for consolidated detention and treatment. The need to establish a district and acquire additional property is offset by a significant increase in developable land, more urban development patterns, and incorporation of "stormwater parks," for water quality treatment, into the development.

This option shows a higher level of treatment and detention where, in addition to the treatment of stormwater runoff, developers are also required to meet a higher "Greenfield" standard and detain the 100 year storm event. The prototype also shows the use of a consolidated stormwater detention facility and a stormwater channel which reduces the need for pipes and provides some water quality treatment.

Opportunities:

- More developable land is available in the redeveloped area.
- A consolidated stormwater approach allows the City to more easily monitor the facility to make sure it is operating correctly.
- The consolidated detention facility could be placed in the floodplain, freeing up more desirable land for denser development.
- As a public facility financing could be arranged through bonding, payable over a longer period of time.
- Stormwater treatment and detention areas could double as a park providing an amenity to adjoining developments. (*see figure 7 & 14*)
- Requiring the detention of a 100 year storm runoff from an existing impervious site might reduce the potential of downstream flooding. However, caution must be used in calculating this runoff as the timing of the decreased release rates may then match that of the stream and increase the peak flow rate of the stream.

Challenges:

- The City might need to construct the consolidated facility before development occurs and before fees are collected.
- Treatment would still occur on developable property reducing the development density that the site could achieve.

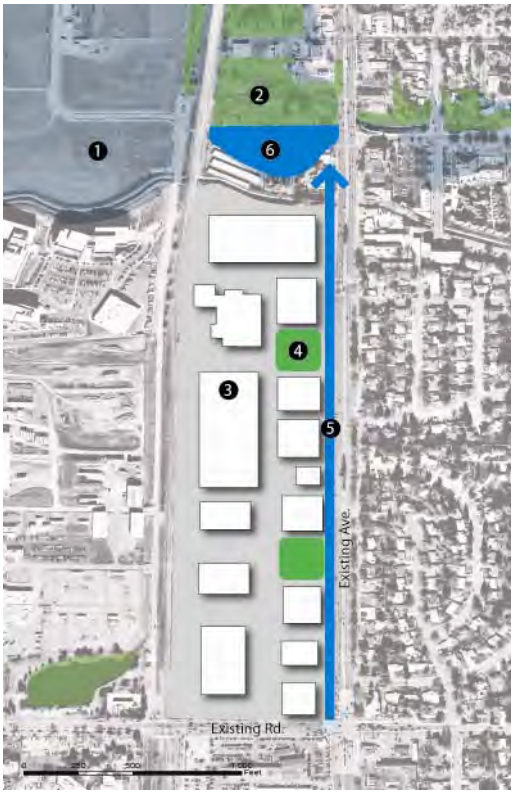


Figure 10 – 1) Floodplain, 2) Publicly Owned Land, 3) Redevelopment, 4) Water Quality Treatment Area / Stormwater Park, 5) Stormwater Channel, 6) Stormwater Detention.

Consolidated District Scale Stormwater Detention & Treatment

This prototype requires the establishment of a stormwater district and acquisition of property within an existing floodplain. These requirements are offset by maximizing the development potential of the redevelopment area, and enhance the open-space values of the adjacent stream corridor.

This option shows a higher level of treatment and detention, where in addition to the treatment of stormwater runoff the developers are required to meet higher "Greenfield" standards and detain the 100 year storm event. In this option developers and the City could join together to create a regional facility that both treats and detains the storm runoff from the site. This regional facility could be located in a low value/offsite facility allowing for maximum onsite development. The prototype also shows the use of a stormwater channel reducing the need for pipes.

Opportunities:

- 100% of the site is available for redevelopment.
- The consolidated detention facility could be placed in the existing floodplain freeing up more desirable land for denser development.
- A consolidated stomwater treatment and detention facility allows for the possibility for multiple uses of the treatment area: ie.: the treatment area could double as a park, habitat or open space.
- A consolidated stormwater approach allows the City to more easily monitor the facility to make sure it is operating correctly.
- Developers could pay into a stormwater agreement spreading the cost of constructing a stormwater treatment facility over a period of years rather than as an upfront cost.
- Requiring the detention of a 100 year storm runoff from an existing impervious site might help to reduce the potential of downstream flooding. However, caution must be used in calculating this runoff as the timing of the decreased release rates may then match that of the stream and increase the peak flow rate of the stream.

Challenges:

- The City might need to construct the consolidated facility before development occurs and before fees are collected.

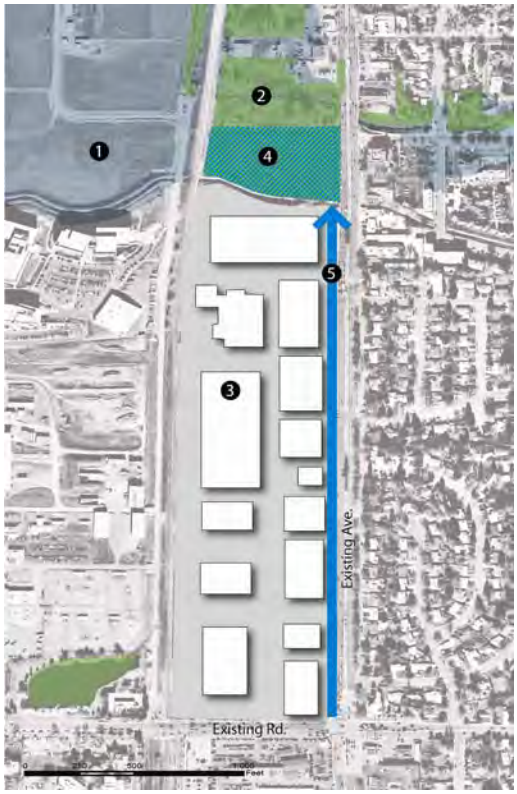


Figure 11 – 1) Floodplain, 2) Publicly Owned Land, 3) Redevelopment, 4) Water Quality Treatment & Detention Facility / Stormwater Park, 5) Stormwater Channel

Commercial Redevelopment Typical Sections & Axon

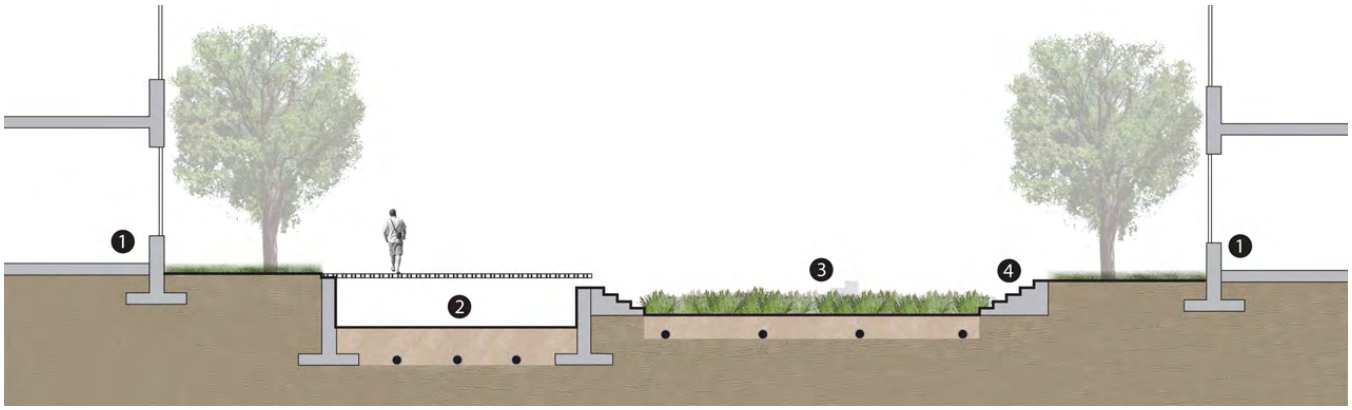


Figure 12 – Stormwater park typical cross-section 1) Proposed multi-story mixed use development, 2) Stormwater treatment beneath multi-use deck, 3) Stormwater bio filter and park landscape, 4) Multi-use landscape edge.

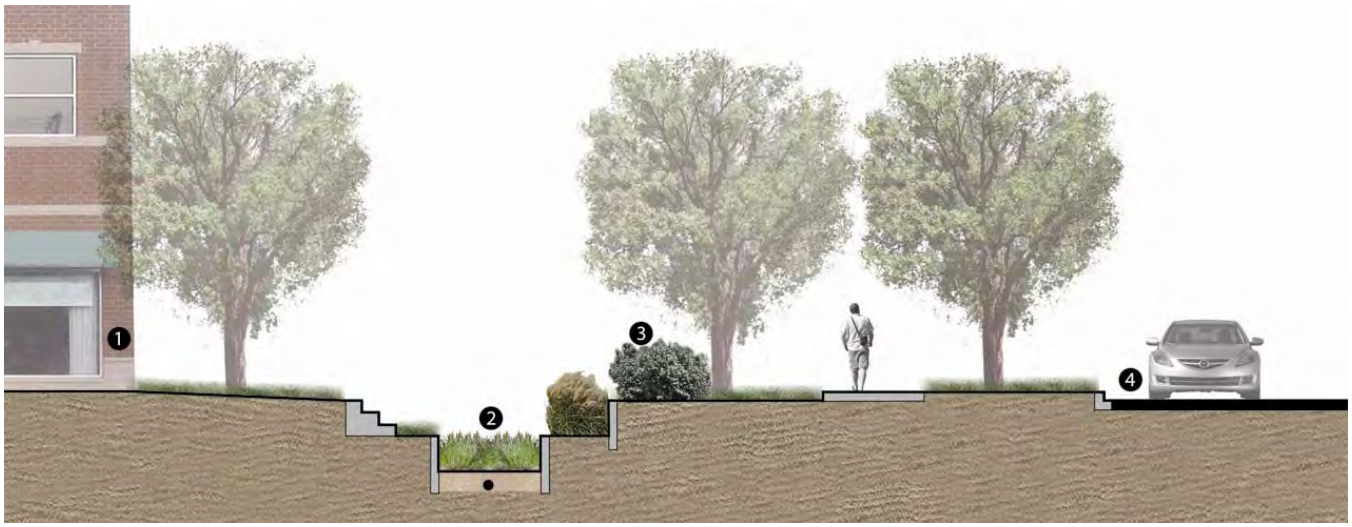


Figure 13 – A surface stormwater conveyance channel could replace the large storm pipe typically constructed for projects of this scope and density. 1) Multi-story mixed use development, 2) Storm conveyance and water quality treatment channel, 3) Buffer landscape, 4) Arterial street

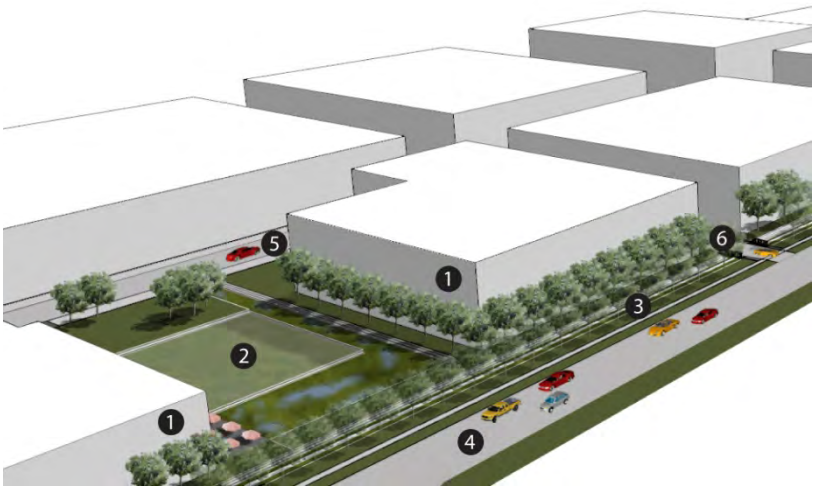


Figure 14 – Aerial view of Commercial Redevelopment Site incorporating Stormwater Park & surface conveyance Channel fronting on an arterial street –1) Multi-story mixed use development, 2) Stormwater bio filter and park landscape, 3) Storm conveyance and water quality treatment channel, 4) Arterial street, 5) Internal street, 6) Stormwater channel crossing

URBAN STREET STORMWATER RETROFIT

Prototypical Design for a Urban Street Stormwater Retrofit — Magnolia Street

Introduction

Significant areas of historic neighborhoods of Fort Collins are flood prone due to the limitations of the existing storm sewer system in the area.

This retrofit proposes an open stormwater channel that runs down the center of the street, which would provide water quality treatment and some in street detention and minor flood conveyance. This system could be (and in some places needs to be) augmented by a piped system. The channel could also be replicated on other nearby streets increasing the level of protection.

Assumptions:

Existing underground utilities can be avoided or rerouted.

Opportunities:

- Streetscape character improves: more trees, multiple transportation modes and less asphalt.
- Water quality treatment would be possible where presently no treatment occurs.
- Potentially additional flood protection in Old Town.
- Less pavement for the City to maintain
- Uses land that the City already owns

Challenges:

- Increased maintenance costs (sediment and debris would need to periodically be removed from the system) and landscaping and revetment would need to be maintained. There may also be increased cost for channel stabilization.
- Determination of maintenance responsibilities.
- Left turns out of driveways would, in most cases, not be possible.
- Could conflict with existing buried utilities (unknown at this point), which may increase installation cost or make this option impractical.

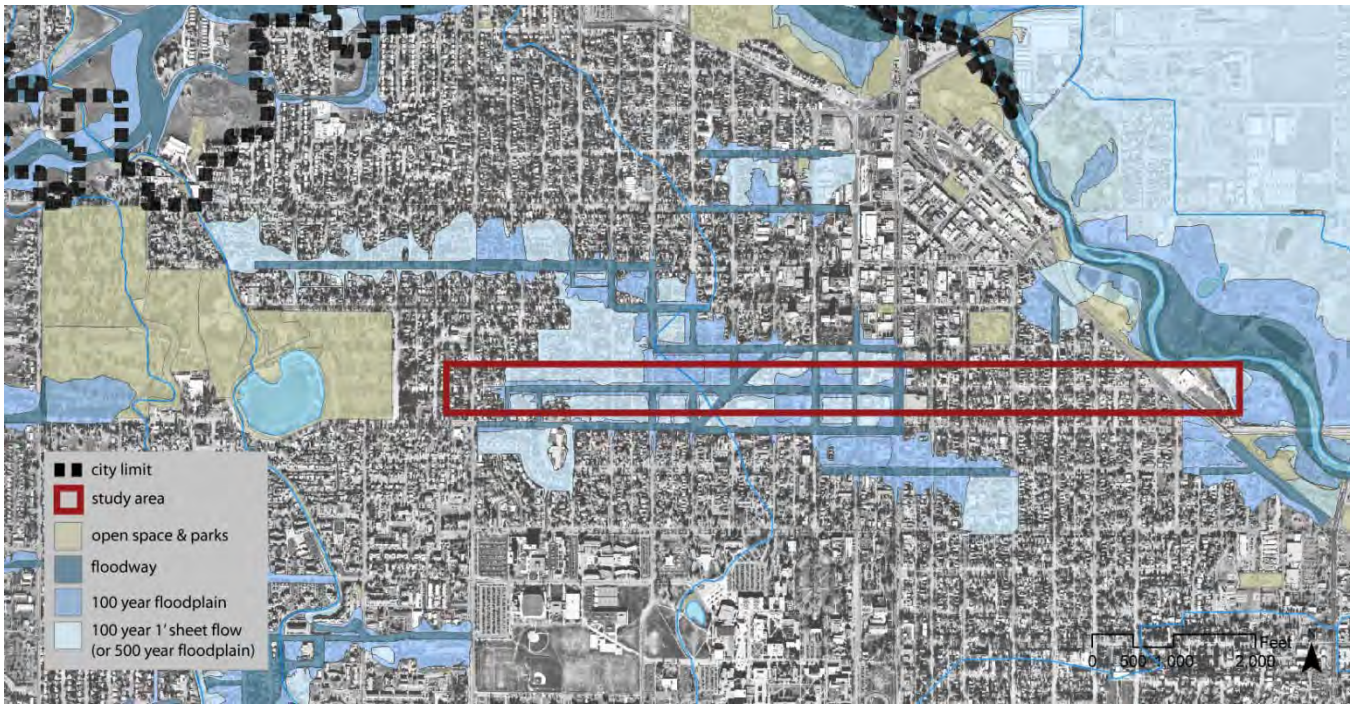


Figure 15 – Existing Conditions Old Town

Figure 16 – Stormwater Channel Plan, 1) Stormwater Channel, 2) Storm Sewer Pipe, 3) Stormwater Channel & Supplemental Pipe, 4) 100 year floodplain, 5) Park or Open Space.

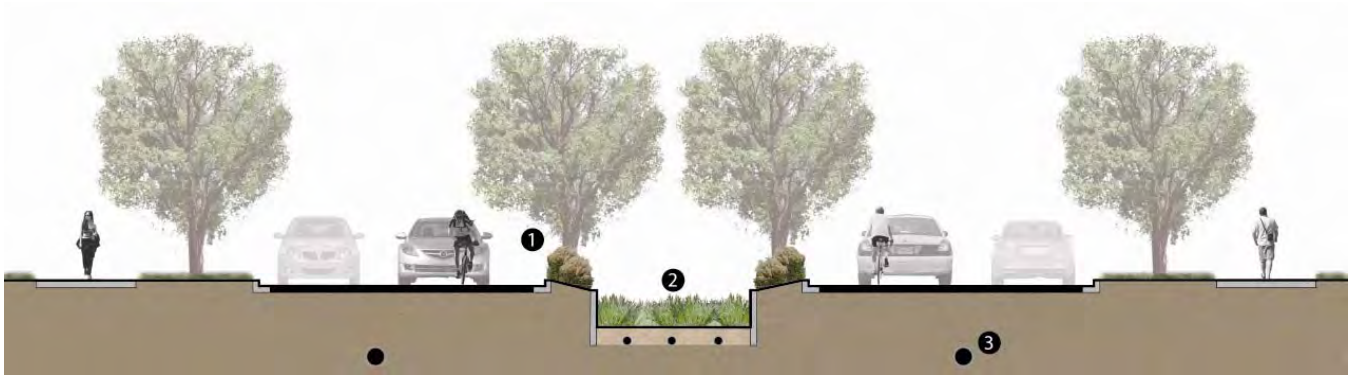


Figure 17 – Stormwater Channel Typical Section, 1) Landscape Buffer, 2) Stormwater Treatment & Conveyance Channel (instead of a larger pipe), 3) Smaller Storm Sewer Pipe

Figure 18 – Before & After Stormwater Channel Perspectives

RESIDENTIAL DEVELOPMENT

Prototypical New Planned Development – North County Road 9e & East County Road 50

Introduction

Large scale residential developments provide opportunities for stormwater infrastructure to be integrated with parks and open space as part of a comprehensive site design. Combined park and stormwater infrastructure frees up developable land, allows for passive landscape irrigation and provides an amenity to residents.

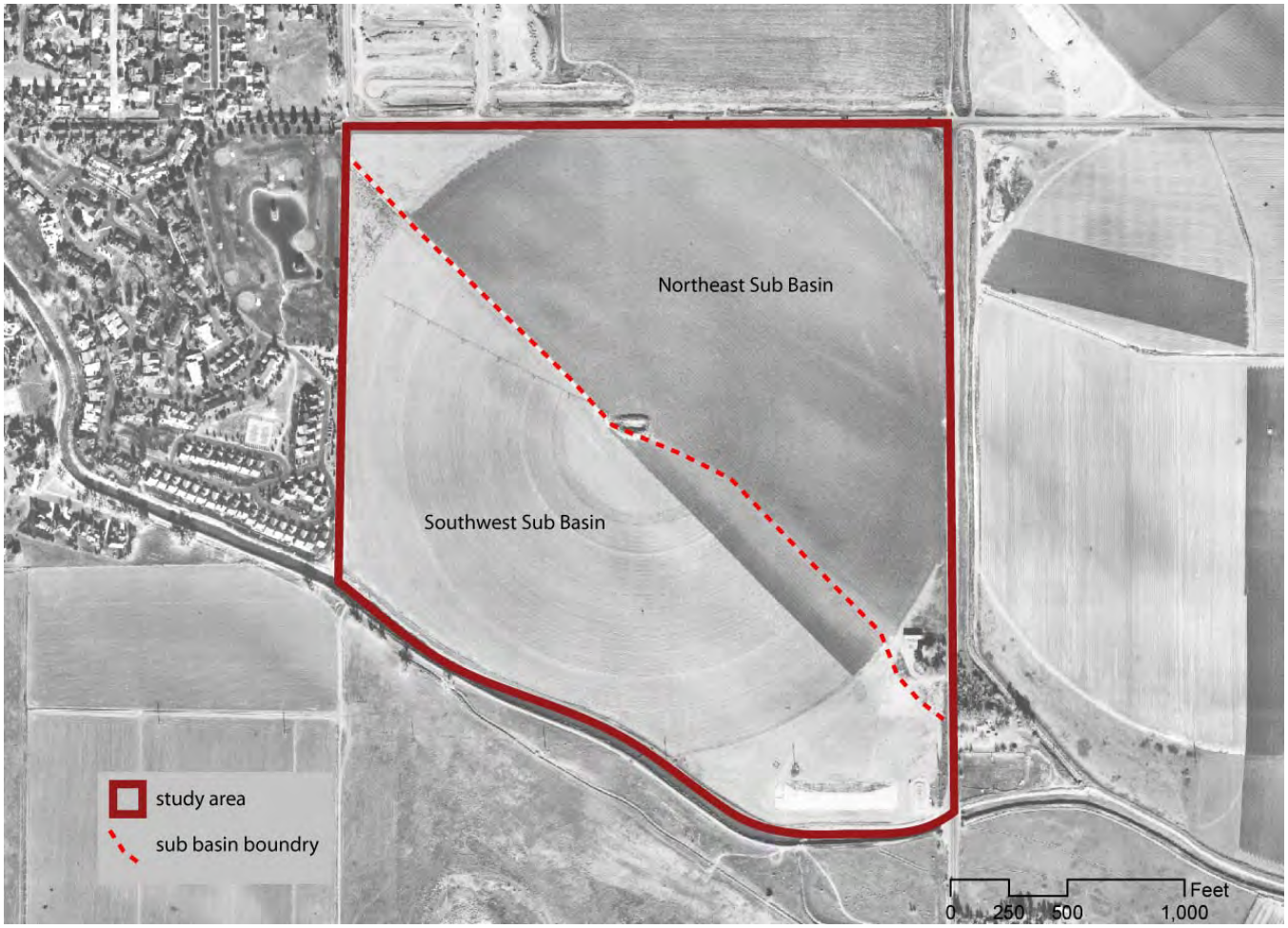


Figure 19 – Existing Conditions Greenfield Residential Site

Opportunities:

- The community site plan can be organized around an integrated storm water and open space network.
- Open space amenities of neighborhood parks and trails can be designed to integrate with, and support stormwater system elements.
- Elements of the storm water system itself can be designed to passively irrigate landscape areas to support park landscapes.
- When properly designed, subsurface storm water piping can be minimized.
- Retention and infiltration of minor storms can be more easily accomplished given the land areas typical of open space in low density planned suburban communities.

Challenges:

- Major and minor maintenance activities related to maintenance of storm water and park facilities are often neglected by homeowners associations.

Figure 20 – Greenfield Residential Site

Northeast Sub Basin:

In this area treatment and detention is integrated into open space areas which could include small pocket parks, trails, and natural areas. Stormwater treatment is also located partially within detention areas, resulting in larger areas of wetlands and riparian areas.

Southwest Sub Basin:

This sub basin locates stormwater quality treatment at the edges of the open spaces-separate from the detention using porous landscape detention and curb cuts. The scheme also routes the low flow channel more to the edge of the open space areas, allowing for multiple use of the bottom of detention areas. This allows for more usable recreation space within the detention pond. "Green fingers" surface convey flows where a pipe might previously have been installed, reducing pipe sizes to minimums or eliminating them entirely. Grass swales attenuate flows and provide pedestrian connections to parks. In the lower right corner, a curb cut might be used to passively irrigate the street edge.

Figure 21 – multiuse extended detention

Figure 22 – Porous Landscape Detention (PLD) with sediment trap

Figure 23 – detention pond with a natural edge

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APPENDIX

INTERWEST CONSULTING GROUP

TECHNICAL MEMORANDUM

TO: City of Fort Collins Stormwater Department

FROM: Robert Almirall, P.E.

DATE: January 20, 2011

SUBJECT: Plan Fort Collins
Stormwater Prototype Technical Analysis

The following memo outlines our assumptions and calculations when examining the four different stormwater prototypes: Industrial, Commercial, Urban Street, and Residential. These are described in more detail in the Stormwater Appendix.

Industrial Prototype:
The purpose of this study is to provide a conceptual alternative to a typical stormwater configuration on an industrial site. This concept provides an alternative to using multiple and parallel conveyance systems. For the purposes of this study, the development of the industrial area known as Air Park Village has been used as an example. Specific site details such as soil types and downstream conveyance constraints were not considered as part of this high level alternative analysis.

Air Park Village is an approximately 168 acre site with an existing impervious area of 22 percent. The existing 2-yr release rate for the site was calculated to be 59 cfs. The proposed improvements would increase the impervious area to approximately 80 percent and the proposed 2-yr flow to 136 cfs. The allowable 2-yr release rate for the site would remain at 59 cfs based on the assumption that the existing improvements would be considered "grandfathered" as the historic runoff.

Following City of Fort Collins stormwater guidelines and using a SWMM model, the required detention storage volume for the site would be 20.0 ac-ft. and the required water quality capture volume would be 5.5 ac-ft.

The alternative approach shown on Figure 4 of the Appendix, describes the use of a consolidated open channel conveyance system that incorporates the detention and water quality capture volumes required to meet current city code criteria.

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TEL. 970.674.3300 – FAX 970.674.3303

Commercial Prototype:
The purpose of this study is to provide conceptual alternatives ranging from development under current city code criteria to an enhanced stormwater management system for a master planned commercial development. Alternatives included the use of one large detention/water quality pond to treat and release stormwater runoff from a commercial site to the use of a series of open channels and smaller multi-function water quality areas. For the purposes of this study, the redevelopment of the commercial area at College Ave and Drake Ave has been used as an example. Again, specific site details were not considered as part of this high level alternative analysis.

The commercial site at College and Drake is approximately 52 acres and is already fully developed. Under current code, no additional detention would be required if the site were to redevelop. However, additional concepts were evaluated based on enhanced design criteria for the site as are described in the Stormwater Appendix.

For part of the analysis, it was assumed that the existing site would not be grandfathered in respect to the current level of development, and the historic site had 0 percent impervious (runoff coefficient C=0.2). In this case the 2-yr historic release rate for the site was calculated to be 6.3 cfs. After re-development, the site would have an impervious area of approximately 87 percent (runoff coefficient C=0.87). Following City of Fort Collins stormwater guidelines and using the FAA method, the required storage volume for the site was calculated to be 15 ac-ft. The required water quality capture volume was calculated to be 1.3 ac-ft.

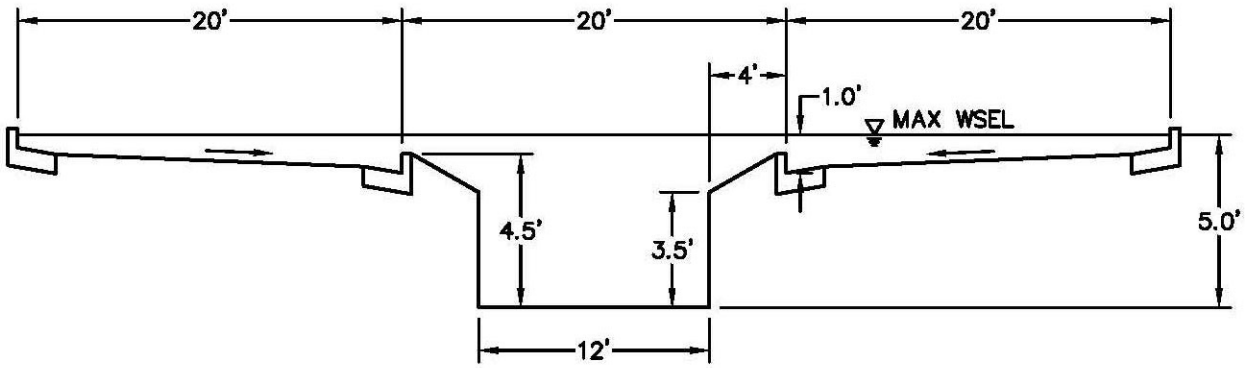
The required volumes were provided to Wenk and Associates and distributed in various combinations for the alternatives outlined in the Appendix. A separate analysis of the existing stormwater conveyance systems was not performed for the purpose of this exercise.

Urban Street Prototype:
The purpose of this study is to provide a conceptual alternative to large underground pipes used to collect and convey stormwater runoff. In particular, we wanted to analyze the use of existing wide streets (mainly in the Old Town area) to develop surface conveyance systems. For the purposes of this study, a portion of Magnolia Street has been used as an example. The City previously commissioned the Old Town Basin Master Plan for the corridor that recommended the installation of a large storm pipe network. In lieu of a single large pipe used for conveyance, it is proposed to use a combination of an open channel, box culverts and smaller diameter pipes to convey the stormwater runoff from tributary basins to the ultimate outfall.

A conceptual cross section of the conveyance channel can be seen in Figure 1. In order to complete the improvements, the entire street would need to be completely rebuilt from curb to curb, although following the master plan recommendations a significant portion of the roadway would also be impacted by the installation of the large diameter pipes. The channel would be in the middle of the road serving as an inverted median with twenty foot wide lanes in each direction to be used as travel lanes and parallel parking. For the purposes of this study it is assumed that the channel (Magnolia Street) has a slope of 0.5%. The channel itself is assumed to be an earthen bottom channel with a Manning's roughness coefficient of 0.030 with vertical sides (possibly decorative block) having a coefficient of 0.022. In larger storm events as water spills over the median curb and into the drive aisle a Manning's roughness coefficient of 0.013 was used for the street section. An earthen bottom

channel can have the added benefit of providing water quality enhancements that are not possible with a closed pipe network

Figure 1: Typical Section



Based on general City of Fort Collins utility maps, it is assumed that the street improvements along Magnolia will not require extensive utility relocations as the majority of the water and sewer lines do not appear to run along the middle of the roadway. However, it is anticipated that there would be utility relocations at all intersections. In order to convey the stormwater through each intersection a series of shallow box culverts would need to be installed. The construction of the box culverts would most likely conflict with existing utilities running north and south. There are also concerns regarding the hydraulic function of the box culverts at each intersection. A more detailed analysis would be required to calculate how the structure at each intersection would function under the different storm frequencies.

In order to approximate the size of the facilities, the flows established in the Old Town Basin Master Plan were used. The study area along Magnolia Street can be broken into three segments using cross streets as a reference. The first segment is from Shields to Canyon. Per the Master Plan the maximum flow during the 100-yr event that is conveyed to Magnolia Street is 547 cfs and the pipes proposed ranged from 72" – 90". The maximum capacity of the 4.5 foot channel and the street section is 691 cfs without exceeding the 6 inches above top back of curb for the median (which is acceptable practice for design when analyzing the 100-yr storm event per the City of Fort Collins Stormwater Manual). Therefore, all of the runoff in this segment can be conveyed in the open channel. Refer to Table 1 for a capacity chart of the proposed channel and street section.

The second segment is from Canyon to Remington. The Master Plan states that the maximum flow during the 100-yr event that is conveyed in this section is 945 cfs which would be conveyed in a 102" pipe. Since the maximum capacity of a 4.5 foot deep channel and street section is 691 cfs, an additional 66-inch pipe at a slope of 0.5% would need to be added to the conveyance system. This pipe would have a capacity of 240 cfs giving the total system a capacity of 931 cfs.

The third and final segment along Magnolia Street is from Remington to Riverside. It is unclear in the Master Plan how much water is directed to this segment of Magnolia Street. For the purpose of this study it was assumed that the 100-yr event produced 1200 cfs in this segment and the master plan recommended a 114" pipe for this segment. In order to convey this amount of water the channel will again have to be supplemented with a conveyance pipe. In this segment a 90-inch RCP

at 0.5% would be required to convey all of the runoff. The pipe capacity (544 cfs) combined with the street capacity (691 cfs) would adequately convey the 100-yr event.

Table 1: 4.5 Foot Deep Channel (figure 1)

Water Depth (ft)	Flow (cfs)	Velocity (ft/sec)
3.50	275	6.56
4.50	454	6.97
5.00*	691	7.29

**Maximum depth above top back of curb of the median is assumed to be 6 inches in order to minimize the flooding depth along the outside of the roadway for emergency vehicle passage. However, additional flow depths are possible with this configuration.*

It is recognized that the velocities in the channel are in the erosive range and that additional erosion protection methods along the bottom might need to be employed. However, we believe that this cursory analysis supports the concept of utilizing excess public right-of-way to develop "Green Streets" that can supplement of even replace the need for underground conveyance systems.

Residential Prototype:

The purpose of this study is to provide a conceptual alternative to the use of singular detention/water quality ponds to treat and release stormwater runoff from a residential development. For the purposes of this study, the development of a Greenfield residential area containing both multi-family and single family homes was used.

The prototype site has an area of 160 acres that is split into two drainage basins by a ridge line. Basin A is approximately 74 acres and is the northeast sub basin. Basin B is approximately 86 acres and is the southwest sub basin. Both basins have a historic impervious area of 2 percent. The 2-yr historic flow for Basin A is 20.5 cfs and the 2-yr historic flow for Basin B is 21.7 cfs. The proposed development of the site will increase the impervious area to approximately 60 percent for both basins.

Following City of Fort Collins stormwater guidelines and using the FAA method, the required storage volume for Basin A would be 8.6 ac-ft and the required storage volume for Basin B would be 10.4 ac-ft. The required water quality capture volume for Basin A would be 1.8 ac-ft and the water quality capture volume for Basin B would be 2.0 ac-ft.

The alternative exhibit shown on figure 20 of the Appendix indicates how these required volumes might be distributed in different ways for each of the basins to better integrate the land uses and the stormwater features.