Identifying Barriers to Low Impact Development and Green Infrastructure in the Albuquerque Area

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Abstract

Many municipalities are now implementing stormwater management techniques that integrate and utilize stormwater in urban design, while greatly reducing urban runoff and non-point source pollutants. These techniques, often referred to as Low Impact Development (LID) or Green Infrastructure (GI), include bio-swales, rain gardens, green roofs, porous pavement, and curb cuts, among many others. The United States Environmental Protection Agency (EPA) is strongly encouraging the implementation of LID and GI stormwater management programs; however, many of these techniques were developed in and are mainly used in Eastern or Pacific Northwest states. Given New Mexico's semi-arid climate, high intensity rainstorm events, and state water laws, the feasibility of using these techniques may be limited despite their successes in other regions.

The purpose of this study was to identify barriers to the widespread implementation of LID and GI in the Albuquerque region. This information was collected through a focus group with local professionals that included stormwater managers, drainage engineers, architects and landscape architects, water conservation managers, and developers, as LID/GI implementation requires a variety of experts.

A preference for certain LID/GI techniques emerged from the focus group activities and discussions, especially those techniques that were lower cost, well known, and water conservative. For example, rain barrels/cisterns, green parking, green streets and green detention facilities were among the top rated/recommended techniques, while living roofs, porous pavements and rain gardens received the lowest ratings and recommendations. Swales, urban tree cover, and planter boxes were rated or recommended mid- to low depending on the activity. For those techniques that rated well, there was a general consensus among the group in support of those techniques. For those that rated lower, there appeared to be a lack of knowledge about those techniques, or an uncertainty about their effectiveness, durability or implementation.
Focus group findings also indicate that although many barriers exist, most were similar to barriers faced in other communities and included institutional, financial, social, and

knowledge barriers, in addition to the physical barriers related to climate. While many of the barriers expressed are in fact real, others were perceived barriers based on opinion rather than fact. Institutional barriers included water rights and state water harvesting policies, current development standards and ordinances that do not include LID/GI, and the low price of municipal water making water harvesting not cost effective. Financial barriers included increased development costs with LID/GI, a lack of incentives to encourage implementation, and that stormwater program budgets are already limited, and LID/GI would only increase costs. Social barriers included the current disconnect between urban dwellers and their environment and their lack of support for waterway improvements, the current lack of political will to adopt LID/GI, and skepticism from engineer and developers related to LID/GI techniques. Knowledge barriers included that many in the area are unaware of LID/GI, that there is a lack of knowledge on how to design, construct, fund, and maintain these techniques, as well as major knowledge gaps related to how they function in an arid climate.

Based on the focus group findings and the literature on LID/GI, the author made six recommendations for overcoming barriers and for addressing semi-arid climate concerns. These recommendations included 1) promoting collaboration and communication, 2) conducting outreach and education, 3) identifying local knowledge and efforts, 4) utilizing outside knowledge, 5) taking the initiative to lead in this effort and 6) taking a multifaceted approach to implementing LID/GI.

Despite the many barriers that exist, LID/GI can be implemented in the Albuquerque area. Many of these barriers have been overcome in communities across the U.S. and they can be overcome in the Albuquerque area if support is gained and the proper actions are taken. Also, despite a few techniques not being the best choices for an arid climate, there are a variety of other techniques to choose from and proper design will be the solution for successful implementation in the Albuquerque area.

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List of Acronyms

ABCWUA: Albuquerque Bernalillo County Water Utility Authority

AMAFCA: Albuquerque Metropolitan Arroyo Flood Control Authority

BMP: Best Management Practice

CWA: Clean Water Act

EPA: Environmental Protection Agency

GI: Green Infrastructure

ISC: Interstate Stream Commission

LID: Low Impact Development

LIDC: Low Impact Development Center

MRG: Middle Rio Grande

MS4: Municipal Separate Storm Sewer System

NMDOT: New Mexico Department of Transportation

NPDES: National Pollution Discharge Elimination System

NRDC: Natural Resources Defense Council

OSE: Office of the State Engineer

SSCAFCA: Southern Sandoval County Arroyo Flood Control Authority

UA: Urbanized Area

Chapter 1: Introduction

"The health of our waters is the principal measure of how we live on the land." - Luna Leopold

Urbanization of Watersheds

When a watershed is developed or urbanized, the hydrology of that landscape is altered from its pre-development state. Generally with development there is a loss of native vegetation and groundcover, soils are compacted and eroded, natural drainage features are lost, and the percentage of impervious surfaces increases from the construction of buildings, parking lots, and roads. The major effects from these land use alterations include changes in: 1) total runoff, 2) peak flow characteristics, 3) water quality and 4) hydrologic amenities[1] (Leopold, 1968).

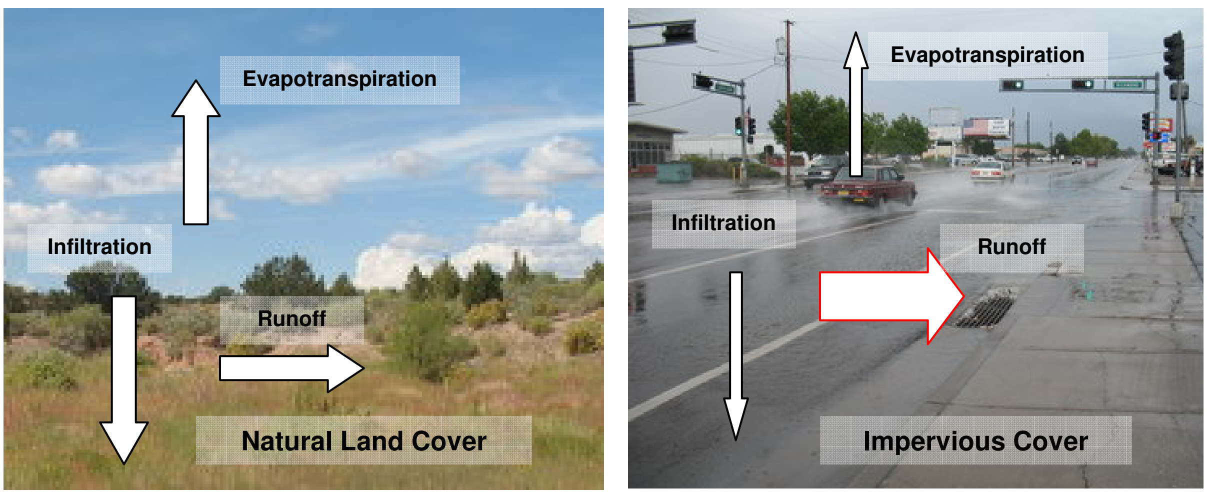

Figure 1: Changes in hydrologic characteristics due to urbanization. Arrows represent a general magnitude of change.

Urbanization leads to a loss of infiltrative and evapotranspirative function resulting in increased volumes of runoff, or stormwater, as illustrated above in Figure 1. The magnitude of hydrologic change that occurs is dependent on the type of development and percentage of effective impervious cover added, as well as the on the type of natural land cover that was converted (e.g. forest, grassland, desert). In some cases, development can lead to major differences between pre- and post-development hydrology. In addition to changes in hydrologic characteristics, the rate at which water moves throughout the watershed is also changed. The hydrograph in Figure 2 illustrates these changes, resulting

[1] Hydrologic amenities include natural drainage features and native landscapes, which have an aesthetic or recreational value.

in less time to peak flows with increased discharge volumes when compared to the non-urbanized flow regime. Also, urbanization affects base flows between storm events due to the loss in infiltrative capacity.

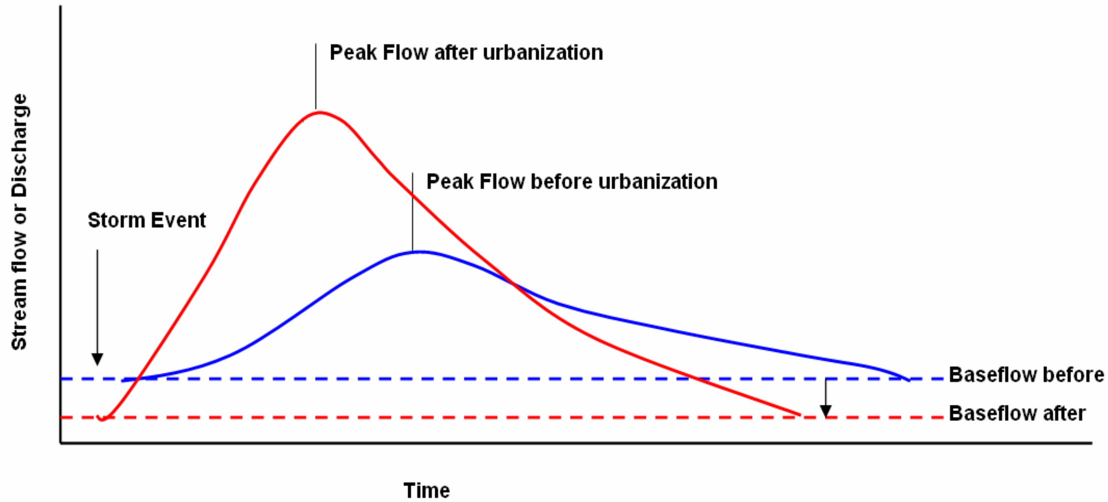

Figure 2: Effects of urbanization on peak flows and base flows. Adapted from Randolph, 2004.

These hydrologic changes to the landscape do not come without consequences, as stormwater runoff leads to flooding in the urban landscape if drainage conveyance systems are not adequate. When adequate drainage is provided, however, the consequences are often just shifted downstream resulting in stream bank erosion and loss of habitat. In addition, stormwater literally washes non-point source pollutants (see Figure 3) from the urban landscape into downstream water bodies, leading to degradation of receiving waters that may subsequently affect their suitability for water quality, recreation, or environmental protection.

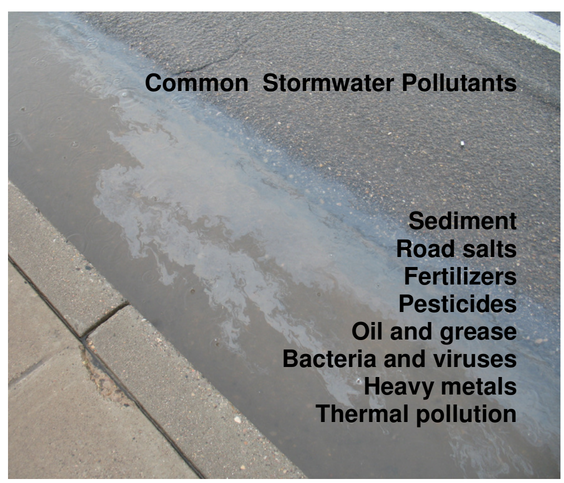

Figure 3: Common non-point source pollutants found in stormwater. Pollutant list: EPA, 2003.

These issues illustrate why the management of urban runoff is important in protecting the health of our nation's waters.

Urban Stormwater Management

Prior to the 1970's, the main focus of urban stormwater management was to provide adequate drainage and flood control. This was achieved by channeling water quickly to rivers and other water bodies along "grey" stormwater conveyance systems, such as gutters, streets, pipes, ditches and lined channels. Stormwater management then shifted towards reducing peak flows, and it was not until recently that stormwater quality was addressed through federal regulation.

In 1987 the National Pollution Discharge Elimination System (NPDES) was expanded under section 402p of the Clean Water Act (CWA) to encompass stormwater runoff as a regulated non-point source pollutant. In 1990 the U.S. Environmental Protection Agency (EPA) issued Phase I Stormwater Rules requiring NPDES permits for operators of Municipal Separate Stormwater Sewers (MS4s), or stormwater conveyance systems that serve populations over 100,000. In 1999, Phase II Stormwater Rules were issued for MS4s serving smaller populations. Under these permits, both Phase I and II MS4s are required to manage stormwater through 6 Minimum Control Measures[2], for which hundreds of Best Management Practices (BMPs)[3] or Stormwater Control Measures (SCMs) exist.

Best Management Practice (BMP)
Physical, structural, and/or managerial practices that, when used singly or in combination, reduce downstream quality and quantity impacts of stormwater. The term is synonymous with Stormwater Control Measure (SCM).

Figure 4: BMP definition. Source: NRC, 2009.

Despite NPDES permitting and the application of BMPs, many of the impairments from stormwater runoff have yet to be addressed. The EPA, in acknowledging this, requested the National Research Council Water Science and Technology Board to review the current stormwater discharge permitting under the CWA and make recommendations for improvement. The resulting publication, *Urban Stormwater Management in the United States*, provides

[2] The 6 minimum control measures include: 1) Public education and outreach, 2) Public participation and involvement, 3) Illicit discharge detection and elimination, 4) Construction site runoff control, 5) Post-construction runoff control, and 6) Pollution prevention and good housekeeping. Source: EPA, 2000.
[3] The National Menu of BMP's can be accesses on the EPA's website at: http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm

recommendations for improved monitoring and modeling, management approaches, and the permitting process itself. The following statement is made in relation to management approaches:

> *"…the emerging goal of stormwater management is to mimic, as much as possible, the hydrological and water quality processes of natural systems as rain travels from the roof to the stream through combined application of a series of practices throughout the entire development site and extending to the stream corridor."* (NRC, 2009, pg 436)

This illustrates the current shift away from conventional stormwater "disposal" to a more integrative approach throughout the entire urbanized watershed, where a variety of structural and non-structural BMPs can be implemented as a system to improve watershed health.

Figure 5: Green vs. grey infrastructure approaches to stormwater management.

A class of BMPs growing in popularity are those that integrate stormwater into the urban landscape, specifically techniques and approaches that harvest, infiltrate, or evapotranspirate stormwater. These "Green Infrastructure" techniques and approaches, also referred to as Low Impact Development, are designed to slow, capture and treat the first flush of stormwater directly on site, thereby reducing urban runoff and non-point source pollutants.

Purpose of Study

This study aims to 1) identify the barriers, both perceived and real, to the widespread implementation of Low Impact Development (LID) and Green Infrastructure (GI) in the Albuquerque area and 2) make recommendations for overcoming these barriers. Examining LID/GI for the Albuquerque area is important for a number of reasons:

- The United States Environmental Protection Agency (EPA) is *strongly* encouraging Municipal Separate Storm Sewer System (MS4) permittees nationwide to include LID/GI approaches and techniques as a part of their stormwater management plan.
- Many developers, planners, and stormwater managers in the Albuquerque region are concerned that they will soon be required to use LID/GI as part of their federally mandated stormwater management plans, however, a variety of barriers may make implementation difficult.
- LID/GI techniques and approaches were often developed in, or are most extensively used in, wet humid climates, and there is limited performance knowledge and application of these techniques in semi-arid climates.
- The implementation of LID/GI could not only address stormwater quantity and quality issues, but could also provide a non-potable water source, create green community spaces, improve air quality, and reduce the urban heat island effect.

Low Impact Development and Green Infrastructure are discussed in detail in Chapter 2. The main method of data collection occurred through a facilitated focus group, which is discussed in detail in Chapter 3. The findings from the focus group are summarized in Chapter 4, and an analysis and discussion of those findings are in Chapter 5. Recommendations for further research and overcoming barriers appear in Chapter 6.

As per the request of some focus group participants, most photos used throughout this paper are all local LID/GI examples, or examples from similar climates.[4]

Stormwater Management in the Albuquerque Area

Located in the heart of the Middle Rio Grande (MRG) watershed, the greater Albuquerque area is the most populated region in the State of New Mexico with over 500,000 residents. As this watershed was developed, the native landscape was replaced with buildings, roads and other impervious surfaces and many natural drainage channels, or arroyos, were lined with concrete. While on average the area receives less than 10 inches of precipitation annually, large amounts of runoff are generated during rain

[4] Many participants expressed concern over the lack of local or semi-arid LID/GI examples in publications.

storms, especially during the monsoonal rain season which frequently brings precipitation in the form of intense thunderstorms.

Figure 6: The North Diversion channel after a rain event.

Like most urbanized areas, the focus of stormwater management in Albuquerque has been on the rapid removal of stormwater through straightened and frequently lined channels, with little consideration given to its impact on the Rio Grande. Because of this approach stormwater has impaired the quality of this river. For example, the MRG-Albuquerque reach was listed on the 2008-2010 State of New Mexico Clean Water Act §303(d) list of impaired water bodies, with fecal coliform identified as a pollutant of concern (MRGARWG, 2008). Fecal coliforms are often used as a measure of health for watersheds, as their transport to waterways often indicates the presence of other pollutants, and a variety studies (NMED, 2002; PWI, 2008) have examined the presence of this pollutant in the Middle Rio Grande.

A water quality sampling program began in 1992 for the Albuquerque metropolitan area, under a cooperative agreement between the U.S Geological Survey (USGS), the Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA) and the City of Albuquerque. Since that time, the water quality sampling has been included as part of the urban stormwater data collection program, which also includes the collection of stream flow and rainfall data for the area. For example, a 2006 USGS report (Kelly et al.) presents this data collected from October 1, 2003 to September 30, 2004. This information is important for land use planning, estimating stormwater runoff for the region, and quantifying water quality impairments from urban runoff.

To address stormwater quality and urban watershed health, a variety of local efforts have been undertaken. For example, the *Middle Rio Grande-Albuquerque Reach Watershed Restoration Action Strategy* (MRGARWG, 2008) offers a phased approach to reduce non-point source stormwater pollutants by 2016. Also, the Stormwater Team[5] has a public outreach program for stormwater pollution prevention, which includes the "Scoop the Poop" program to control pet waste pollutants. Innovative efforts have also been underway to control pollutants once they have reached arroyos and stormwater channels. Water harvesting initiatives are present in the Albuquerque area, but they are focused on water conservation goals and are not linked to stormwater management and pollution control.[6]

Stormwater Entities and Study Area

For the purposes of this study, the Albuquerque area was defined by the 2000 US Census Urbanized Area (UA) delineation, as this is the boundary used by the EPA to identify MS4 stormwater entities, or those required to file for NPDES permits (EPA, 2000). The Albuquerque UA (see Appendix A) is located in both Sandoval and Valencia Counties and includes the City of Albuquerque, Rio Rancho, smaller municipalities, pueblo lands, and unincorporated areas.

<u>Phase I</u>

- The City of Albuquerque, with co-permittees:
  - AMAFCA
  - NMDOT
  - UNM

<u>Phase II</u>

- Bernalillo County
- The Town of Bernalillo
- The Village of Corrales
- Kirtland Air Force Base
- Los Ranchos de Albuquerque
- NMDOT District 3
- The City of Rio Rancho
- Sandoval County
- SSCAFCA

Figure 7: MS4 stormwater entities in the Albuquerque UA based on permit types.

MS4 stormwater entities in the Albuquerque area are represented by NPDES permit[7] in Figure 7. Since New Mexico does not have primacy over their NPDES permit program, the EPA is the regulatory authority for stormwater permits in New Mexico. Also, NPDES permitting for stormwater is relatively new to the

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[5] The Stormwater Quality Team partners include: The City of Albuquerque, Bernalillo County, Albuquerque Metropolitan Flood Control Authority, Southern Sandoval County Flood Control Authority, Ciudad Soil and Water Conservation District, New Mexico Department of Transportation, and the University of New Mexico. More information can be found at www.keeptheriogrande.org

[6] For example, some of the ABCWUA water conservation campaigns indirectly promote "on site" stormwater management, although it is not specifically stated. http://www.abcwua.org

[7] Phase I stormwater permits are for MS4s serving populations greater than 100,000. Phase II stormwater permits are for MS4s serving smaller populations that are located within an urbanized area boundary.

Albuquerque area. For example, the City of Albuquerque received their first NPDES stormwater permit in 2003 by the EPA, and they are currently waiting for their revised permit to be issued. While some Phase II stormwater entities are in the process of filing their Notice of Intent and Stormwater Management Plans, others have submitted and are waiting to receive permits from the EPA. Information on the three major stormwater entities in the Albuquerque area is detailed below. Also, a very detailed map of the region showing all drainage facilities and maintenance responsibilities for each entity is available online through AMAFCA's website[8].

- **City of Albuquerque**: Stormwater is managed through the City's Department of Municipal Development, Storm Drainage Design Section of the Engineering Division. Their first Notice of Intent was submitted to the EPA in 1991, but their stormwater permit was not issued to the city until 2003. The City is a NPDES co-permittee with AMAFCA, UNM, and NMDOT. Currently, the city does not have a stormwater ordinance or Stormwater Quality Management Plan (SWQMP). Although a variety of LID/GI examples exist in the Albuquerque area, LID/GI language is not included in the first NPDES permit. LID/GI language was not included in the second permit submitted to the EPA, however EPA revisions have added LID/GI to the permit, which is still in its draft stage[9]. There is little to no LID/GI included in the current Development Process Manual.

  Bernalillo County: Stormwater is managed through the County's Public Works Division. The County's Notice of Intent and Stormwater Quality Management Plan (SWQMP) were submitted to the EPA on April 1st, 2007. The permit has not been issued yet, as an Endangered Species Consultation is required before the permit can be approved. The county has a stormwater ordinance and SWQMP. While some LID/GI examples exist in Bernalillo County, LID/GI is not specifically stated in the SWQMP. The County's current Water Conservation Ordinance does not specifically state LID/GI. Drafts of a revised Water Conservation Ordinance however, which is currently under revision, does include LID/GI components for both residential and smaller commercial properties as recommended techniques to meet gallon per day conservation requirements.

- **AMAFCA**: The Albuquerque Metropolitan Arroyo Flood Control Authority owns and maintains approximately 85 miles of drainage channels and structures, in addition to 35 flood control dams[10]. AMAFCA is a co-permittee with the City of Albuquerque's NPDES stormwater permit. The North and South Diversion Channels, which are maintained AMAFCA, are two of the main flood control channels in the metropolitan region. Although many AMAFCA channels and

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[8] Drainage facilities map available at: http://www.amafca.org/images/maintmap.pdf
[9] Personal communication, Roland Pentila and Kathy Verhage, City of Albuquerque. 10/28/09
[10] http://www.amafca.org/

> flood control structures are traditional in their approach (e.g. concrete lined), AMAFCA also maintains non-traditional channels, incorporates multiple use or recreation in the drainage right of way, and takes innovative approaches to address stormwater quality.

Despite the presence of the NPDES stormwater permitting program in the Albuquerque UA, as well as local efforts and innovations to address stormwater quality and promote water harvesting, the impairment of the Middle Rio Grande from urban runoff has not been resolved. In an effort to increase the overall health of the Middle Rio Grande watershed, many in the Albuquerque area are interested in making the transition from grey to green infrastructure approaches. Unfortunately there are a variety of barriers and uncertainties may stand in the way. The following quote from a local project manager and engineer illustrates this point:

> *"As a design professional I am encouraged by the interest in Low Impact Development and Green Infrastructure here in the arid southwest. To that end I receive countless announcements, emails and professional resource information about LID design methodologies and trends. However, I find that the vast majority of the information and "how to" guidelines do not lend themselves to our arid conditions here in New Mexico and the Southwest. There is a dire need for both practical and academic research to develop applications that suit our specific conditions."*[11]
>
> -L. Brad Sumrall, P.E, Senior Project Manager at Bohannan Huston

There is in fact a dire need for more information and research related to LID/GI in the Albuquerque area, and this is just one of the many barriers that will emerge from this project.

[11] Personal communication, 11/7/09.

Chapter 2: Low Impact Development and Green Infrastructure

Low Impact Development and Green Infrastructure have been used over the past few decades for stormwater management and the interest continues to grow across the US. In some areas LID/GI is the new status quo of stormwater management, with conventional approaches being secondary or complimentary to these innovative techniques. Below is a timeline of some significant events and publications related to LID/GI, illustrating the increased interest and push towards these stormwater management practices.

> *With LID, every urban landscape or infrastructure feature (roof, streets, parking, sidewalks, and green space) can be designed to be multifunctional, incorporating detention, retention, filtration, or runoff use.*
> - Prince George's County Maryland, 1999

- **Early 1990's:** LID Pioneered by Prince George's County Maryland
- **June 1998:** Low Impact Development Center, Inc was founded
- **October 2000:** LID Literature Review published by the EPA and LIDC (2000)
- **July 2003:** *The Practice of Low Impact Development* is released by the U.S. Department of Housing and Urban Development (2003)
- **April 2007:** *Green Infrastructure Statement of Intent* is signed by the EPA and four partners [12]
- **July 2007**: The EPA's online GI Resource Center was established
- **August 2007**: EPA issued a memo encouraging the incorporation of GI in stormwater permits and enforcement (see Appendix B)
- **January 2008:** The *Green Infrastructure Action Strategy* (EPA, 2008) was created as a set of actions to follow up on the 2007 *GI Statement of Intent*.

It's important to highlight the growing interest in LID/GI over the past few decades as 1) these techniques are not just a passing trend and skeptics need to realize the role of LID/GI in stormwater management, and 2) MS4s in urbanized areas that have not started implementing LID/GI should be aware of it, as they may be required to in the future as part of their NPDES permits. The timeline above also shows the initial interest in LID in the 1990's, followed by the growing interest in GI in the later 2000's.

[12] Partners include: The National Association of Clean Water Agencies, Natural Resources Defense Council, Low Impact Development Center, Association of State and Interstate Water Pollution Control Administrators

Definitions, Techniques and Benefits

What's the difference between LID and GI, and how are they different from Water Sensitive Urban Design? The answer to that question depends on who you ask and some distinctions can be made. Often the terms are used interchangeably.

The term Green Infrastructure, as defined by the EPA[13], simply refers to a class of stormwater BMPs or practices that slow, capture, treat, infiltrate and/or store runoff at its source, and includes both structural (stormwater capture and treatment) and non-structural (preservation of open space) approaches. GI can be applied at the site, neighborhood, or regional scale, and examples of each are listed in Table 1.

Site Application	Neighborhood Application	Regional or Watershed Application
- Green Roofs - Cisterns and Rain barrels - Planter Boxes - Rain Gardens - Permeable Pavements - Swales	- Green Parking - Green Streets and Highways - Pocket Wetlands - Green Detention Facilities	- Urban Forestry - Preservation of open spaces and natural drainage features

Table 1: Green Infrastructure applications at various scales of application. Source: EPA Green Infrastructure website, http://www.epa.gov/greeninfrastructure/.

The term Low Impact Development usually refers to *development approaches and principles* that utilize GI techniques to create functional drainage systems. LID approaches and principles include (PGCM, 1999; LIDC, 2002):

- Minimizing land disturbance during development
- Incorporating and preserving natural features in the development
- Decentralizing stormwater management and treating it at the source, through the use of GI and other techniques
- Reducing and disconnecting impervious surfaces in the development
- Understanding and mimicking pre-development hydrology

LID will often have a public education component as well, as the GI techniques or other decentralized management systems are usually located on private property.

[13] How the EPA defines GI: *"… for the purposes of EPA's efforts to implement the Green Infrastructure Statement of Intent, EPA intends the term "green infrastructure" to generally refer to systems and practices that use or mimic natural processes to infiltrate, evapotranspirate, or reuse stormwater or runoff on the site where it is generated.*" Source: http://www.epa.gov/nps/lid/

Watershed Sensitive Urban Design, which was developed in Australia, is similar to LID. For the purposes of this paper, the terms Low Impact Development and Green Infrastructure will be used, as those are the terms generally used in the U.S. to refer to these innovative stormwater management techniques and approaches. Also, since GI is a key component of LID, and the terms are used interchangeably by some; both will be used in this paper.

Regardless of the terminology used, LID and GI offer a variety of benefits that conventional stormwater approaches do not. The hydrograph in Figure 8 illustrates the objective of LID/GI to mimic pre-development hydrology, while conventional approaches do not mimic volumetric discharge over the timescale even when peak discharge is matched. In addition to reducing the volume and velocity of runoff, LID/GI capture pollutants and treats runoff on site, which is difficult to achieve with conventional approaches.

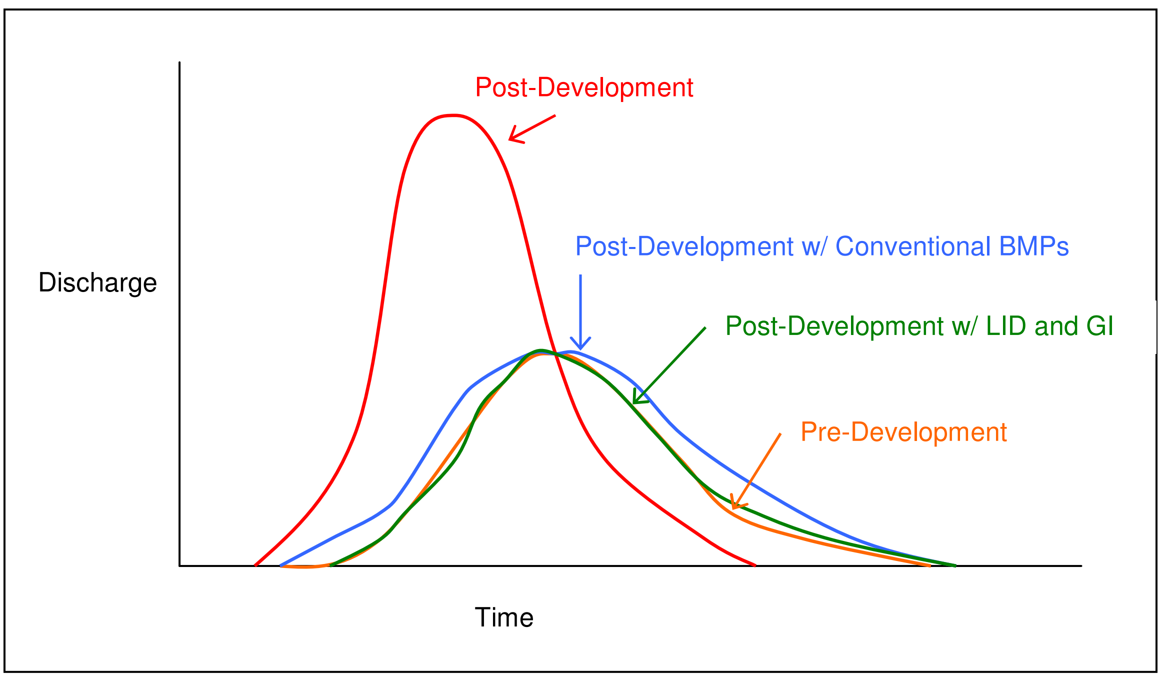

Figure 8: Hydrograph comparing LID/GI with conventional BMP approaches. Hydrograph modified from: LIDC, 2007.

While both conventional approaches and LID/GI offer flood control protection, LID and GI offer the following additional benefits that conventional approaches do not:[14]

- Green community spaces
- Wildlife habitat
- Carbon sequestration
- Traffic calming
- Groundwater recharge
- Water quality protection
- Reduced urban heat island effect and energy demands
- Increased urban aesthetics
- Improved human health
- Increased property values

Figure 9: Traffic calming round-about that also harvests street runoff. Source: Brad Lancaster, www.harvestingrainwater.com

The above list, combined with LID/GI's ability to reduce stormwater related impacts on waterways, is why many municipalities, regions, and states are making the transition from "grey" to "green".

Barriers to LID and GI Implementation

Although the interest and application of LID and GI have grown extensively over the past few decades, most communities find that they have to overcome a variety of barriers to achieve widespread implementation. In many cases, the first step communities take is identifying the various physical, social, institutional, economic and knowledge barriers they must overcome, generally through interviews, surveys, or workshops. Whether real or perceived, the barriers found offer not only a starting point from which to move forward, but in some cases the initial investigation jumpstarts the LID/GI conversation in those communities.

The following case studies provide summaries of barriers found in Colorado, Oregon, and the Chesapeake Bay area.

[14] List compiled from EPA's online GI resource center: http://www.epa.gov/greeninfrastructure/

Colorado

Publication: *Breaking Down the Barriers to Low-Impact Development in Colorado*

Date: December 2008

Sponsoring Agency: Keep it Clean Partnership (KICP)

Region/communities: The City of Boulder, Erie, Longmont, Louisville, and Superior and Boulder Counties

Summary of study: A questionnaire was developed based on barriers that were identified through interviews. The questionnaire was then distributed to municipal staff, engineers, and developers in the KICP watersheds to help assess each of the barriers. As part of the study, a checklist to identify potential opportunities for LID was also developed and applied to proposed developments. Conceptual strategies for addressing the LID barriers were also established.

Major findings: The questionnaire consisted of over 30 potential barriers for respondents to rate. Based on the group average, the top 5 barriers were 1) perceived design, construction, and maintenance costs, 2) mixed messages from different governmental departments, 3) maintenance and durability concerns, 4) no clear economic incentive for using LID and 5) LID not integrated early enough in the planning process.

Report available online at: http://www.keepitcleanpartnership.org/

Oregon

Publication: *Barriers and Opportunities for Low Impact Development: Case Studies from Three Oregon Communities*

Date: 2008

Sponsoring Agencies: Oregon Sea Grant Extension, Oregon Department of Land Conservation and Development, Oregon State University, NOAA

Region/communities: Portland metro area, Grants Pass, Brookings

Summary of study: Needs assessment workshops were conducted with local decision makers and residents in the three communities. The workshops addressed LID barriers, the needs or resources to address these issues, and the audiences that efforts should be directed towards.

Major findings: Major barriers found in all 3 communities were 1) lack of basic understanding of planning and the impacts of growth, 2) the need for active leadership, 3) the need for technical information and assistance, 3) funding, economics, and incentives and 4) rapid large scale urbanization.

Report available online at: http://seagrant.oregonstate.edu/sgpubs/onlinepubs/w06002.pdf

Chesapeake Bay

Publication: *Impediments to Low Impact Development and Environmental Sensitive Design*

Date: December 2002

Sponsoring Agencies: Chesapeake Bay Program and Virginia Tech's Institute for Innovative Governance

Region/communities: Fredericksburg, Virginia; New Carrollton, Maryland; Carlisle, Pennsylvania

Summary of study: Workshops were conducted in each community with representation from government agencies, various organizations, and the development community. Based on the findings, recommended actions were established.

Major findings: The most important barriers or impediments found were 1) the need for pilot projects, evaluation of LID and its function within the larger system, 3) the need for science/technical based LID education, 4) model principles and standards, 5) clear designation of who coordinates LID efforts, 5) establishment of pre-qualifying procedure for consultants and developers, 6) lack and knowledge on LID efficiency rates and 7) the need to demonstrate that builders and developers can still make a profit with LID.

Report available online at: http://www.chesapeake.org/stac/Pubs/ILIDFinalReport.PDF

The above case studies provide some insights about barriers that many communities face for the widespread implementation of LID and GI. Although similar barriers are seen across studies, such as a lack of incentives, each has a unique set of barriers or needs that are specific to those communities. This is due to a variety of local factors including the political climate, the amount of public support, the level of current funding, climate variations, hydrologic and watershed characteristics and how far along these communities are in the LID/GI implementation process. As barriers can vary greatly by location or region, identifying and evaluating barriers locally provides an important tool that enables discussion and actions towards overcoming those issues.

Although the Albuquerque area can learn a great deal from the barriers and recommended actions found in other communities, we also have a unique situation that needs to be examined in the local context, especially for our climate. The author tried to find studies from an arid climate in the southwest where barriers to implementation were examined, but was not successful in finding LID/GI barrier studies from climates similar the Albuquerque. The Colorado case study came close, as that region is considered semi-arid; however, that region does receive double the rainfall of the Albuquerque area. Also, in the Colorado example the semi-arid climate was only listed as a barrier, and did not provide insights into why.

Chapter 3: Methodology

Low Impact Development and Green Infrastructure are being implemented successfully in a variety of cities across the US and abroad, offering viable alternatives for managing and reducing storm water flows and its associated non-point source pollution. The driving question behind this research was "What barriers exist that impede or prevent the widespread implementation of Low Impact Development and Green Infrastructure in the Albuquerque area?" When this research was in its initial development stages[15], a focus group was considered as a potential, yet minor, method to help answer that question. Over time, however, it became clear that a focus group would instead serve as the key method of data collection. This realization came about due to the following reasons:

- The literature on LID/GI in semi-arid climates was found to be limited, especially on the feasibility of these techniques in our climate.
- Through interviews with local professionals, concerns were also expressed for non-climate barriers such as budget shortfalls, state water laws, and maintenance concerns, which need to be further identified and discussed in a local context.
- There was limited conversation about LID/GI taking place in our region, especially between agencies and departments, and a focus group could help to stimulate that conversation or determine if it is even needed.

Given the lack of information on LID/GI in arid climates and the variety of concerns, support, and skepticism expressed during initial interviews, a facilitated focus group seemed a useful option for gaining an understanding of the barriers to LID/GI implementation in our region.

In addition to the focus group, the author also conducted interviews to help shape the design of the focus group, as well as to gain an understanding of current stormwater management and LID/GI practices in the Albuquerque area. The participant selection and focus group design are discussed in the following sections.

[15] Initial research began in the fall of 2008.

Participant Selection

The author first identified members of the Mid-Rio Grande Stormwater Quality Team as participants for the focus group, and through interviews with several of the team members, other potential participants were identified. Participants in this initial list, however, mainly represented the public sector and many participants were engineers. As LID/GI implementation involves experts in a variety of fields, additional participants were recruited from the private sector, including architects, landscape architects, and developers.

The agencies and businesses represented at the focus group are listed in Figure 10, and a detailed list of the 17 participants can be found in Appendix C.

Focus Group Participants
- Albuquerque Bernalillo County Water Utility Authority
- Bernalillo County Public Works Division
- City of Albuquerque
- Ciudad Soil and Water Conservation District
- Dekker/Perich/Sabatini
- Environmental Dynamics, Inc
- High Desert Investment Corporation
- Kayeman Custom Homes
- New Mexico Department of Transportation
- NM Green Build Council
- Sites Southwest
- Southern Sandoval County Arroyo Flood Control Authority
- Tierra West, LLC
- University of New Mexico
- Xeriscape Council of New Mexico

Figure 10: List of focus group participants affiliations. Representatives from AMAFCA, Rio Rancho, and the OSE were invited, but were unable to attend.

Focus Group Design

To address the larger research question, a focus group was designed to answer the following questions:

- Which techniques, if any, are most feasible in our climate?
- What barriers and limitations are faced locally for implementing LID/GI?
- What is the level of local interest in examining or implementing LID/GI, especially from stormwater managers, engineers, builders, landscape architects and other related professions?

The focus group was designed and facilitated by the author, in collaboration with Tim Karpoff, professional facilitator and consultant, of Karpoff and Associates.

Given the difficulty of bringing busy professionals together, a 2.5 hour focus group addenda seemed most feasible, especially when lunch was provided. Due to the short time frame, the number of participants, and the amount of information that needed to be gathered to answer the questions listed above, the following focus group agenda was established:

- Activity # 1: Determining Feasibility for our Climate
- Discussion # 1: Feasibility for our Climate
- Lunch
- Discussion #2: Barriers for Implementation
- Activity # 2: Recommended Techniques for our Region

Each activity and discussion is detailed below. To prepare participants for the focus group, an information packet was sent out prior to the event, which summarized the various techniques to be evaluated. A similar summary sheet was provided at the focus group as well (see Appendix D).

Activity # 1: Determining Feasibility for our Climate

For the first activity, participants were asked to individually rate the technical feasibility or performance of 10 techniques[16] (see Figure 11) for achieving stormwater goals in our climate, while ignoring external barriers. Stormwater goals were defined as flood control, non-point source pollution reduction, and maintenance of natural hydrology. External barriers (or barriers independent of climate) included topics such as budget shortfalls, development code conflicts, and/or lack of political will. The rating scale was from 1 to 5, with 1 being most feasible for our climate, and 5 being the least feasible.

10 Technique Categories Evaluated in Focus Group

1) Increased Urban Tree Cover
2) Green or "living" roofs
3) Rain barrels and cisterns
4) Infiltration or flow-through planter boxes
5) Rain Gardens (bioretention)
6) Swales & other earthen structures
7) Green parking
8) Porous pavements
9) Green streets
10) Green detention facilities

Figure 11: List of GI techniques examine during the focus group.

[16] These 10 Green Infrastructure techniques (or BMP's) were chosen, as they infiltrate, evapotranspirate, or capture stormwater on site, and may function differently depending on climate and precipitation. These 10 techniques are also key components of LID site design. LID however, also employs techniques such as reduced road widths, disconnection of impervious surfaces, and preservation of natural drainage features, which are not necessarily influenced by climate and were therefore not included.

Each participant first recorded their ratings on a worksheet (See appendix E), which also provided space for participants to leave comments for each of the techniques. Each participant then transferred their ratings to charts on the wall, so the group as a whole could view the results.

Discussion #1: Feasibility for our Climate

In a large group setting, participants were asked to discuss:

- Which techniques were rated best and worst overall
- What patterns they saw emerge from the activity
- Their views on particular techniques, and why they rated them as such
- Concerns, questions, or uncertainties about specific techniques or their applicability in our climate

The facilitators recorded comments on flip charts, which were then displayed around the room. The discussion was audio recorded.

Discussion # 2: Barriers and Limitations for Implementation

In this large group discussion, participants were asked to discuss the non-climate barriers and limitations they face for implementing LID/GI in our region. Again the facilitators recorded and displayed comments, and the discussion was audio recorded.

Activity # 2: Recommended Techniques for our Region

In the final activity, focus group participants were told to pretend that they were part of an advisory committee tasked with recommending LID/GI techniques for stormwater management in our region. Each participant was allowed 4 votes, of which they could give all votes to 1 technique or divide the votes among up to 4 techniques. The votes were recorded on the same posters as Activity # 1, to allow for a comparison between the results.

The focus group was then concluded with a brief discussion on the patterns and themes that emerged from the 2 activities and discussions. To collect anonymous feedback on the focus group session, participants were sent an online survey to complete within 2 weeks after the event.

Chapter 4: Focus Group Findings

The findings from the focus group, held on August 26, 2009, are summarized in the following sections. In addition to the activities, discussions, and post-focus group survey, the written responses from participant's worksheets are also summarized.

Activity # 1: Determining Feasibility for our Climate

		Number of responses per rating				
Technique	**Average Rating**	**1**	**2**	**3**	**4**	**5**
Rain barrels or cisterns	1.2	14	2	1	0	0
Green parking	1.2	14	2	1	0	0
Green detention facilities	1.4	13	3	0	1	0
Green streets	1.5	9	8	0	0	0
Swales and other earthen structures	1.6	10	5	1	1	0
Infiltration & flow-through planter boxes	1.9	7	5	2	3	0
Increased Urban Tree Cover	2.3	4	6	5	2	0
Rain Gardens (bioretention)	2.4	4	5	5	3	0
Porous pavements	2.6	3	5	5	3	1
Green or "living" roofs	3.3	1	3	4	8	1

Table 2: Results and findings from focus group Activity 1, rating of climate feasibility. See rating scale in Figure 12.

This technique or approach…

1: would perform well in our arid region
2: would most likely perform well in our arid region
3: may perform well here
4: would most likely not perform well in our arid region
5: would not perform well in our arid

Note: The lower the score, the higher the performance or feasibility based on climate.

Figure 12: Rating scale used for Activity # 1.

The findings from the group are summarized above in Table 2, listed in order of highest to lowest performance for our climate. Averaged across the group, rain barrels/cisterns and green parking received the best ratings, while green/living roofs came in last for feasibility in our climate. Six of the ten techniques averaged ratings between a 1 and a 2 (performing well in our climate), and no techniques averaged higher than a 3.3. It is also important to note the number of responses per rating, or how the 17 participants rated each technique. For example, it appears there is a general consensus on how rain barrels/cisterns would perform here, while there is little consensus on porous pavements.

Discussion # 1: Feasibility for our Climate

Some of the key climate related themes to emerge from this discussion included:

- **Yes, we can do LID/GI in the Albuquerque area.** The ratings showed that the majority of participants thought cisterns/rain barrels, green parking, green streets, green detention facilities, swales, and flow through planter boxes would perform well (score of 1 or 2) in the Albuquerque metro area. Many comments were also made that all techniques *were* feasible, if designed for our climate and used in the correct applications, and that many of them were already being used here, although not extensively. Support was also stated for removing runoff from hardened to pervious surfaces whenever possible.
- **Debate over green roofs and porous pavement.** There was much debate over the feasibility of green roofs and porous pavement in our region, both of which scored less feasible for our climate. A recurring concern for green roofs was the amount of water needed for irrigation, whether potable or non-potable. Of the many varieties of porous pavement that exist, there was discussion on how some would function here while others would not, requiring an evaluation of each type.
- **Vegetation and water.** Many of the techniques rated less feasible are typically designed with dense green vegetation in humid climates, which would require supplemental irrigation to achieve here. There was discussion over how these techniques need to be adapted and designed to our rainfall and vegetation, and that they may in fact function differently. Many participants also emphasized that the techniques should support, not go against water conservation measures.
- **Lack of information or knowledge.** For certain techniques in our region/climate, such as porous pavements, many felt there was a lack of solid information available on how the techniques perform here. Also, not all participants were aware of local examples of these techniques that already exist as they are not well known or publicized.

Some non-climate barriers and limitations were brought up during Discussion # 1, however they are being reported below in Discussion # 2 for summary purposes.

Discussion #2: Barriers and Limitations for Implementation

The second group discussion focused on the external barriers and limitations for implementing LID/GI in the Albuquerque metro area. The key themes that emerged are summarized below.

Economics and Funding

- **Increased development costs.** Concern over a lack of support or pressure from the development community if these techniques increase costs over traditional systems. Both developers and homebuyers can not justify increased costs, especially in the current economy.
- **Lack of cost-benefit analyses.** There is concern that cost-benefit analyses are not being done for these techniques, or if they are that the costs don't justify the benefits.
- **Incorrect pricing of water.** Concern that municipal water is priced too low, making rainwater/stormwater harvesting techniques not economically viable. The return on investment is too low for many citizens in our region.
- **Staffing and program costs.** Concern over funding for increased maintenance demands, training and labor costs, and purchases of specialized equipment.
- **Lack of incentives.** Incentives are needed, such as tax credits or impact fees, to encourage the implementation of these techniques, especially if they are voluntary and not required.

Education and Knowledge

- **Many are unaware of LID/GI.** There is concern that many builders, engineers, architects, planners, and other professionals are unaware of these techniques, their benefits, and how to design, construct, or maintain them properly.
- **What's a watershed?** Concern over a fundamental disconnect between urban dwellers and their environment, in that many do not realize they live in a

watershed and have an impact on it. There was concern over this leading to a lack of public support for projects to improve our waterways.

Willingness to Change

- **Lack of trust in new technologies.** There is concern that engineers work "20 years in the past" and the building industry is using 50 year old technology, making them slow to adopt or trust in new advances.
- **Lack of political will.** Concern that there is a lack of political will to adopt new stormwater technologies and methods.
- **Current development standards.** Concern that innovation is difficult as it requires changing development standards, such as the Development Process Manual, and that these changes can take a lot of time.

Lack of Connections

- **Water and stormwater management.** Concern over a lack of connections between municipal water and stormwater management programs.
- **Between various agencies and departments.** Many of these techniques require of variety of expertise, ranging from soil experts to planners and engineers, and that these professionals need to work together and share knowledge.

Institutional Constraints

- **Office of the State Engineer.** Concern over no official OSE statement or policy regarding water harvesting, and that the ownership of stormwater may not be clear.

In addition to the barriers and limitations discussed, a few recommendations were also made for overcoming them:

- **Education is the key.** Many felt that educating the public as well as developers, contractors, and a variety of other professionals was necessary to gain support and acceptance of these techniques and to overcome issues related to design, maintenance and funding.

- **Collaboration and integration.** Integrated design teams were suggested - from design to construction, maintenance and operation, to ensure the success of these techniques in the short and long term, as a variety of expertise is required. Collaboration between various groups and agencies in the metro area was also suggested.
- **We should be acting now.** Although the economy is down, it was suggested that this is a prime opportunity to develop these techniques for our region, so they can be implemented when construction and development pick up again.

Activity # 2: Recommended Techniques

In the final activity, focus group participants were told to pretend that they were part of an advisory committee tasked with recommending LID/GI techniques for stormwater management in our region. Each participant was allowed **only 4 votes**[17], of which they could give all votes to 1 technique or divide the votes among up to 4 techniques. The results are illustrated below in Figure 2, with green parking, rain barrels/cisterns, and green streets receiving the highest number of votes, and green roofs and rain gardens coming in last with zero votes each.

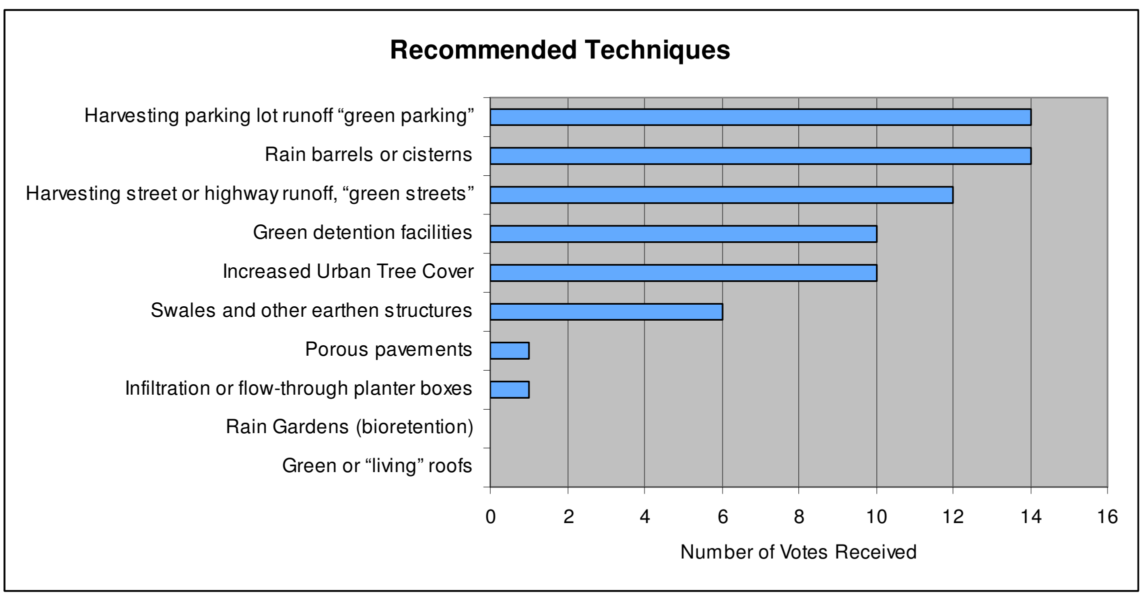

Figure 2. Results and findings from Activity 2.

Written Responses from Focus Group

The focus group worksheet provided participants with a way to make written comments related to the 10 categories of techniques. This allowed participants to make note of the ideas they wanted to share in group discussions, and also provided them with a way to make anonymous comments. The worksheets were collected at the end of the session, and a summary of the *comments, concerns, and benefits* expressed are listed below.

Rain barrels or cisterns

- Comments on how the capacity of cisterns makes them a better choice than rain barrels, and that they already work well here
- Concerns over the cost of municipal water in the Albuquerque area, and that it is too cheap for water harvesting to make economic sense
- Benefits from increased public awareness (from visible rain barrels/cisterns) and the storage of water for later use

Green parking

- Comments on how some local green parking is already in use here, that it does work, and that it can be easily achieved even with retrofits
- Concerns about groundwater pollution from parking lot runoff, maintenance of structures, proper design and capacity
- Benefits from creating desirable or pleasing parking lots, capturing pollutants and supplemental irrigation with runoff

Green detention facilities

- Comments about how these are already in use here, and provide a great way to harvest runoff
- Concerns about proper planning and design, unintentional marshes, and that they are generally not located as close to the "source" as they could be
- Benefits from multi-use facilities, especially for recreation or wildlife

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[17] Participants were only allowed 4 votes to limit the recommended techniques to a small array, allowing for a preference to emerge.

Green streets

- Comments about how it would be effective, but that retrofits are difficult and it would require dramatic changes to the Development Process Manual (DPM)
- Concerns about pollution from roadways, whether or not the Office of the State Engineer would support green streets, liability issues, right of way increases, and that we don't get enough rain to even sustain xeric plantings
- Benefits from reducing the amount of roadway pollutants that enter our river

Swales and other earthen structures

- Comments about how these are being successfully used here already and are low cost to implement, but that they must be properly designed to reduce sediment transport
- Concerns over appropriateness of our soils and infiltration capacity, that we don't get enough rainfall to sustain vegetation, and continual maintenance is required
- Benefits from capturing the first flush and reduction in hydrograph peak

Infiltration or flow-through planter boxes

- Comments about how these would be easy retrofits and that xeric plants could be used
- Concerns over infiltration capacity, maintenance, requirement of supplemental irrigation, proximity to buildings and foundations
- Benefits from effect on hydrograph and stormwater quality, and the creation of green spaces that would be less reliant on irrigation water

Increased Urban Tree Cover

- Comments about selection of appropriate tree species, that we have multiple climate regions in our area making some trees successful in the valley and not the foothills or mountain areas

- Concerns over water use for supplemental irrigation between rain events and how this may goes against conservation measures, and that trees are difficult to establish and maintain, and they have a “trivial” impact on stormwater
- Benefits include erosion control, stormwater runoff reduction, promoting “greenness” without turf grass, and a reduced urban heat island effect

Rain Gardens (bioretention)

- Comments about the need for proper design, plant selection, and public education
- Concerns that supplemental irrigation and maintenance would be required, and that this technique may not work with our monsoonal rains
- Benefits in that it offers a simple design solution to keep runoff on site, and has positive effects on hydrograph and water quality

Porous pavements

- Comments about the wide variety of porous pavements and that each type needs to be examined individually (this category was to broad), and that some work well here for certain applications and there are some successful local examples
- Concerns over silt clogging the structures, maintenance, the slope of our landscape, soil infiltration capacity, the freezing of water in pavement, groundwater contamination, and the strength and durability of pavements
- Benefits to the hydrograph by reducing runoff

Green or “living” roofs

- Comments include the need for green roof research in semi-arid climates, that they would not work here, that they would work here with proper design, plants, and substrate, and that a green roof does not have to be lush and green
- Concerns over the costs to retrofit buildings, the high heat of rooftops, the use of potable water to irrigate roofs, that they can’t sustain on rainfall alone, and the actual impact they provide to storm hydrology
- Benefits from runoff volume reduction and aesthetics of green space

Concluding Discussion

The focus group concluded with a brief discussion to sum up the themes that emerged from the day, as well as from the last activity. Some of the concluding remarks by participants were:

- Those techniques that rated higher overall were simple, low cost and well known
- Those that rated lower were newer techniques that were not well known
- That a level playing field is needed across the greater metro area, in that everyone should adopt similar/complimentary standards and design criteria
- These techniques are about sustainability and not just flood control and property protection, which has been the conventional stormwater focus
- That we need to transition to a more ecological approach for managing our urban environment, or a systems thinking approach taking into view the larger picture
- That a fundamental issue to address is the lack of emotional or recreational connection people have to our river, meaning that no ones cares about water quality

Post-Focus Group Survey

Focus group participants were asked to take an online survey in the few weeks following the focus group, which consisted of 5 questions. Of those who completed the survey (11 of the 17 participants), the results are as follows:

1. *Did you find it useful to participate in activities and discussions related to LID/GI with other professionals in a focus group setting?*
    - 81.9% found the focus group to be *very useful*, while 18.2% found it *somewhat useful*.
2. *What did you find most useful about the focus group? (You may choose more than one).*
    - 63.6% found activities 1 and 2 most useful, 27.3% found discussion 1 most useful, and 45.5% found discussion 2 most useful[18]

[18] To clarify, activity 1 and discussion 1 focused on climate, discussion 2 focused on barriers, and activity 2 focused on the preferred techniques overall.

- Comments included the following: Water rights experts from the OSE should be in on the discussion, that there was more of a consensus on opportunities and barriers than expected, and that the focus group brought together agencies that do not normally interact although they serve a common purpose.

3. *Do you feel that additional GI/LID meetings/discussions are needed for our region/state?*
    - 100% felt that we need to create more conversation and explore this topic further
    - Comments included the following: The need for trainings or seminars on LID/GI offered locally, that this topic needs an advocate agency to keep things going, and that the focus group was a good start to identifying agencies that provide different services but also have common goals of reducing water use and improving water quality.
4. *What agencies or individuals were not represented at the focus group that should have been included? Who else would you include in future meetings on this topic?*
    - Comments included: New Mexico Environment Department, EPA, AMAFCA[19], OSE/ISC, City of Rio Rancho[20], drainage engineers, Mesa Del Sol, permaculture design specialists, planning and zoning officials, contractors and project managers, those with hands on experience installing these techniques.
5. *Do you have any feedback, criticism or other comments, either about the focus group or this research in general?*
    - This research is needed as most information is geared towards wetter climates
    - Many of the key players of the industry were there
    - We may need to consider alternatives outside the usual LID toolbox due to our semi-arid environment
    - It was interesting hearing what other participants thought of the techniques

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[19] AMAFCA was invited and confirmed attendance, but could not make the focus group that day.
[20] Rio Rancho was invited but did not participate.

Chapter 5: Analysis and Discussion

Based on the focus group findings, we can do LID/GI in our climate, and many of the techniques would (or already) work well here. The findings also indicate, however, that not all techniques are thought to be well suited for our climate and that a variety of barriers stand in the way of LID/GI implementation. In addition to a discussion of the focus group findings, this chapter also includes a discussion on the general interest in LID/GI that was found, as well as a critique of the focus group design.

Feasibility for our Climate and Preferred Techniques

The results from the focus group clearly indicate a preference for certain LID/GI techniques over others, as well as insights into the reasoning behind those preferences.

> Those techniques that rated higher overall were generally perceived as simple, well known, lower cost, and/or supported water conservation efforts.

- Rain barrels/cisterns, green parking, green streets, and green detention facilities were among the top rated/recommended techniques in both focus group activities, showing a general consensus of support for implementing these techniques.
- Living roofs, porous pavements, and rain gardens, however, received some of the lowest ratings/recommendations in both activities, indicating to a lack of support for the techniques and/or a lack of knowledge or uncertainty about their effectiveness, durability, or implementation.
- Swales, urban tree cover, and infiltration/flow through planter boxes were rated/recommended mid- to low depending on the activity.

Based on these results, and insights received by participants it appears that those techniques that rated higher overall were generally perceived as simple, well known, lower cost, and/or supported water conservation efforts. Those techniques that rated lower were perceived to be newer, not well known, or designed to function with dense green vegetation that required consistent rainfall or irrigation.

Below each of the 10 techniques are discussed individually. Although you can compare one technique to another with the ratings or votes received, more importantly are the reasons why some techniques were preferred over others, as it helps to identify specific barriers and uncertainties.

Rain barrels and cisterns

Compared to the other 9 techniques, rain barrels and cisterns offer the added advantage of storing water for later use, thereby reducing the demand on potable water supplies. The water conservation component, as well as the fact that these are commonly used in the Albuquerque area, is why most participants preferred these techniques. There was no question that they work in our climate; however, some participants felt that cisterns provided real storage capacity, while rain barrels provide much less benefit. Participants also stated that both are not cost effective due to the current pricing of municipal water.[21] If water was priced higher, or restrictions were placed on using potable water for outdoor landscaping, the use of cisterns and rain barrels would be more widespread in our region.

Figure 13: Cistern at SSCAFCA offices, Rio Rancho, NM.

Green parking

Green parking was also a preferred technique, and many participants cited a few local examples with low water use vegetation. Given that much of the Albuquerque area is already urbanized, many felt that green parking could offer an easy retrofit with simple curb cuts[22], while other techniques, such as

Figure 14: Example of green parking with curb cuts, Pavilions Shopping Center, Albuquerque, NM.

[21] The Albuquerque Bernalillo County Water Utility Authority's current commodity charge for 1 unit of water (748 gallons) is $1.41 for residential customers. Source: http://www.abcwua.org/content/view/401/1/

[22] Green parking (and green streets) can also include the use of porous paving, however porous pavement will be discussed in its own section.

green roofs, were not thought to be easy retrofit options. Also, during the summer months in our arid climate, parking lots are generally unpleasant due to the urban heat island effect. Green parking offers not only stormwater benefits, but can soften and cool parking lots creating a more desirable, pedestrian friendly landscape.

Although this was a preferred technique with multiple benefits, a major concern of green parking (and green streets) was the potential for groundwater contamination. Weiss *et al.* (2008) reviewed studies examining the fate of nutrients, heavy metals, pathogens and other stormwater pollutants when infiltrated. They found that although some studies were promising, the potential for contamination relies on many factors and further research is needed. Given the heavy use of groundwater in the Albuquerque area, research may be warranted.

Green detention facilities

Green detention facilities were among the top preferred techniques, as they already work here and provide for multiple uses, such as recreation or wildlife habitat. Green detention facilities are not commonly thought of as "on site" stormwater management techniques, however, they were still included in this study. Due to high intensity rainstorms in the Albuquerque area, more conventional BMPs may still be required for secondary control and treatment if/when the capacity of primary LID/GI is reached. When secondary control measures are needed it makes sense to make them green where multiple benefits can be attained. Green detention facilities could also be located closer to the source, further minimizing the need for large, regional detention facilities downstream.

Figure 15: Green detention facility that doubles as open space. Mariposa Development, Rio Rancho, NM.

It is important to also note that in some case studies from wet climates, LID/GI eliminated the need for conventional stormwater management controls, such as detention basins. A major question for our region, and a concern from some participants, was whether or not this could be achieved here.

Green streets

Figure 16: Green street with cube cuts and native vegetation. University Blvd at Mesa Del Sol, Albuquerque.

The author was surprised by the support and preference participants had for green streets. Through initial interviews with local stormwater managers, many expressed concerns over the legality of harvesting street water due to New Mexico's state water laws limiting water harvestin, especially as most streets are public right of ways specifically designed to channel water. Although focus group participants did express concerns over the state water laws, this did not seem to affect the overall preference participants had for green streets.

As with any of the techniques that involved vegetation, there was concern from some participants over the amount of supplemental irrigation that would be required to maintain green street vegetation between rainfall events. It is important to point out however that vegetated street medians in our region are currently irrigated, and that allowing stormwater to flow into the medians will only reduce current irrigation requirements (especially when native xeric plants are used). The green street example in Figure 16 is on a "purple pipe" irrigation system of non-potable water, which can further water conservation measures.

Increased Urban Tree Cover

Urban tree cover rated as most likely performing well for our climate and it received a fair amount of votes as a recommended technique. For some participants there was an uncertainty about water use and concern over the supplemental irrigation trees require between rain events. Others highlighted the many benefits trees provide, including the promotion of green space without turf grass. Given the multiple climate regions in the Albuquerque area, some were concerned over placement of various tree species, and that a species that works best in the valley (high water table) would be inappropriate in the far NE Heights (low water table).

Figure 17: Tree lined street. Source: Brad Lancaster, www.harvestingrainwater.com

A few participants thought increased tree cover would have a trivial impact on stormwater, however a recent report shows that there are in fact many benefits. American Forests (2009) was commissioned by the City of Albuquerque to conduct an analysis of their urban forest, which used a combination of satellite imagery, GIS and the CITYgreen program. The study found that if the city increased tree cover to 8%, from the current 6%, a decrease of 25.3 acre feet of stormwater runoff could occur annually. Although this is just one study, and it would reduce just a small fraction of total runoff, it helps to quantify the benefits of trees in our urban watershed.

Trees brought out the different opinions between participants who work with trees and living structures and those who work with more engineered structures, highlighting the importance of communication and knowledge exchange between the various fields. Also, green parking and green streets often utilize tree canopies in their design, and those were some of the top rated techniques among the majority of participants.

Swales

While swales rated well for our climate, and some participants stated they were already successful techniques here, they were not highly preferred in the end when compared to the above techniques. This may be due to the term "swale" being too broad of a category, as some participants may think of a lush grassy swale, and not a swale design that is more appropriate for our climate (see Figure 18). While swales were thought to be simple low cost solutions, there was also concern over irrigation and maintenance requirements. This also could have affected its overall preference by participants.

Figure 18: Juan Tabo demonstration site, where swales were installed with native vegetation to control runoff along Interstate 40 in Albuquerque. Source: www.ciudadswcd.org

As is the case with many of the techniques, the literature tends to show grassy or densely vegetated structures, however, Figure 18 shows two examples of local swales where mulch, rock, and native vegetation are used to direct, slow and filter stormwater. This just exemplifies the need for climate specific examples and terminology. In *Rainwater Harvesting for Drylands and Beyond*, Brad Lancaster (2008) refers to swales as “diversion swales”, highlighting their important role in being able to direct runoff to vegetated basins where it can be utilized. The terminology chosen for this study, however, was based on the language that is used at the national level, or the technical BMP names that stormwater managers are familiar with.

Swales are generally utilized in green parking and green street designs, as these linear channels integrate well into street and parking lot designs. Participants however preferred green parking and green streets over swales, possibly indicating a communication issue on the part of the author, or just a preference for those approaches that incorporate many GI techniques.

Figure 19: An infiltration planter. Downspout drains to vegetation area at Pavilions Shopping Plaza, Albuquerque, NM.

Infiltration or flow-through planter boxes

Infiltration or flow through planter boxes rated most likely to perform well in our climate among participants; however they were not highly recommended having received only 1 vote. While some felt these could be an easy retrofit in a dense urban setting, others had concerns over infiltration capacity, maintenance and their effect on building foundations. As with most techniques that had vegetation, there was again the concern over supplemental irrigation.

The lack of recommendations for various planter boxes is most likely the result of these techniques not being well known by participants. As participants were only given 4 votes to allocate among 10 techniques, those techniques that were not well known received little support.

Rain Gardens (bioretention)

Rain gardens did not rate well for our climate, and they received no votes or recommendations from participants in the 2nd focus group activity. The main reason for this may be participant's perceptions of rain gardens as dense vegetated structures requiring extensive irrigation. Maintenance of rain gardens was another major concern, as rain gardens are generally located on private property, requiring public education for proper design and maintenance. Like planter boxes, rain gardens may not be as well know by participants.

Figure 20: Rain gardens at the Milagro Co-housing development outside of Tuscon, AZ. Top photos is before native vegetation was planted. Photo source: Brad Lancaster, www.harvestingrainwater.com

Rain gardens may have received no votes due to the terminology used, as rain gardens are also sometimes referred to as bioretention areas. In Rainwater Harvesting for Drylands and Beyond, Brad Lancaster (2008) states that "rain gardens" are for wet climates, and "landscaped infiltration basins" refer to the same structures in dry climates. Although the choice of terms may have altered the results, it again points out the need for climate specific terminology, design criteria, and more. On the other hand, the term rain garden could be used here, with the understanding that semi-arid rain gardens look quite different from their wet climate counterparts. Despite rain gardens not being recommended by the group, some participants still felt that they were a simple, low cost solution for on site stormwater management.

Porous pavements

Porous pavements were rated as possibly performing well in our climate, however, porous pavement received only 1 recommendation vote, indicating less preference for this technique.

Figure 21: Porous pavement. Mesa del Sol, Albuquerque, NM.

Although many felt that porous pavements offered stormwater benefits, there were many concerns that may lead to less preference for this technique. Maintenance was a major concern as silt is common in the region and there was concern over the pavement becoming clogged and non-functional. Concerns were also expressed over the long term durability, freezing temperature, and the infiltration capacity of our soils. There was also concern over the cost of porous pavements compared to traditional pavements. Some of these opinions on porous pavement may have been based on opinion rather than fact, as there are limited examples of porous pavements in the area and research has not been conducted on which techniques are most suitable for the region and their comparative costs.

As stated by participants, this technique category was too broad, as a variety of different porous pavement types exist (e.g. porous concrete, porous pavers, grass pave and gravel pave systems). Some participants expressed that certain types of porous pavement work well here[23], while others do not. Based on this information it would be valuable to evaluate the different varieties and their performance in the Albuquerque area.

Green or "living" roofs

From initial interviews, many expressed that green roofs *just won't work here*. More than any other technique, green roofs were singled out as not being feasible. The focus group findings indicate that this opinion holds true, as green roofs were one of the least preferred techniques. Like rain gardens, green roofs were not recommended by any participants in the 2nd focus group activity, and they received the least favorable climate rating compared to the other techniques.

Figure 22: A "living roof" at the School of Architecture and Planning, University of New Mexico. The term "living roof" is used instead to more accurately reflect the native plant pallet used. This roof was designed to be irrigated with either potable or harvested water, and is currently being monitored to quantify benefits and hydrologic activity.

The main concern over green roofs was the amount of irrigation required to sustain them. Green, or "living" roofs can be designed with drought tolerant/native species (see Figure 22), but they still require supplemental irrigation to become established, as well as during times of drought. Green roofs may provide stormwater benefits in our climate, but participants seemed to be most concerned over the amount of water they would require to support vegetation. Given our limited water supply and increasing population, runoff from roofs could serve more beneficial purposes. For example, that water could be diverted into ground level green infrastructure, where vegetation can be seen and enjoyed by more people, while still achieving stormwater benefits. As our water supplies become increasingly limited in the future, it may become necessary to collect that water for non-potable indoor uses, such as flushing toilets. So the question is not necessarily over living roofs functionality in our climate, but whether or not water should be allocated to maintain them. Also, given that limited vegetation can be supporting in a desert climate,

[23] Gravelpave systems were thought to be one of the better porous pavement types in our climate, as some participants had first hand experience with them.

having vegetation in a location where it has limited enjoyment, such as on a roof, does not make sense. A vegetated LID/GI structure could instead be located on the ground level where it has higher visibility.

The lack of available information on living roofs in semi-arid climates is another main reason why this technique was the least preferred. There is still much research that needs to be done and living roofs should not be discounted altogether, and only when more research on semi-arid living roofs is done, can an informed decision be made. As with rain gardens, it may also take changing people's perception that these techniques in our climate will not look like those from wet climates, illustrating the difficulty in changing perceptions without semi-arid case studies and design standards. There was also concern over how much of the urban area is already built out, and that green roof retro-fits may be costly or impossible when compared to other LID/GI retro-fits.

Barriers to LID and GI Implementation

Some barriers expressed by participants were specific to our region and climate, while most were similar to the barriers the author found in other regions and climates. Also, some were perceived barriers based on opinion rather than facts and documented research. The good news is that many of these constraint and limitations have been overcome in other regions and municipalities, and the Albuquerque area can learn from the variety of solutions that other communities have used. These barriers still need to be examined in a local context and much work lies ahead for bringing the widespread application of LID/GI to our region. Also, many of the perceived barriers can be overcome through research and education. The financial, institutional, knowledge, and social barriers found in the focus group are discussed below, while many of the physical barriers, such as climate, were discussed in the previous section.

Institutional Barriers

As with most western states under the doctrine of prior appropriation, water rights and interstate compact obligations are always a concern, especially when new users consume water for beneficial use. The legality of harvesting stormwater was a major concern among focus group participants, as the OSE only has a vague policy on water harvesting[24] (see Figure 23), and the ownership of stormwater may not be clear. In addition to the brief policy on water harvesting, a variety of publications on their water conservation webpage[25] offer additional insights into what may be acceptable.

OSE Rainwater/Snowmelt Harvesting Policy

The New Mexico Office of the State Engineer supports the wise and efficient use of the state's water resources; and, therefore, encourages the harvesting, collection and use of rainwater from residential and commercial roof surfaces for on-site landscape irrigation and other on-site domestic uses.

The collection of water harvested in this manner should not reduce the amount of runoff that would have occurred from the site in its natural, pre-development state. Harvested rainwater may not be appropriated for any other uses. 11/24/04

Figure 23: OSE rainwater harvesting policy. Available online at: http://www.ose.state.nm.us/wucp_policy.html

For example, *Water Reuse in New Development*[26], a brochure geared towards developers, promotes and defines water harvesting as "water collected from hard surfaces such as roofs, patios, and parking lots," however there is no mention of harvesting street runoff. The brochure also has a disclaimer which states that "Developers should check with the New Mexico Office of the State Engineer for any new requirements regarding rainwater harvesting, as that agency is in the process of developing a rainwater harvesting policy." If the widespread application of LID/GI is a goal for the Albuquerque area, then it is very important to bring the OSE into the conversation early to outline any potential water rights conflicts.

Another major institutional barrier expressed by participants was the inflexibility of the current Development Process Manuals and ordinances, and many felt that current regulations and codes make LID/GI difficult (or impossible) to implement. As discussed in the introductory chapter, there are a variety of water conservation ordinances and policies in the Albuquerque area, while there is little to no mention of LID/GI, except for

[24] The author had contacted OSE personnel to find out more about their water harvesting policies in relation to LID/GI, and was repeatedly referred to the resources on their website or was told that this was a low priority issue for the OSE.
[25] http://www.ose.state.nm.us/conservation_index.html
[26] Available online at: http://www.ose.state.nm.us/water-info/conservation/pdf-manuals/WaterReuseBrochure.pdf

those techniques that overlap with some conservation measures, such as cisterns and catchment basins.

Another institutional barrier was the current price of municipal water. The opinion was expressed that it is priced too low for water harvesting techniques to be cost effective. For example, if water was priced higher to encourage conservation, many participants felt that residents would be more willing to harvest rainfall with LID/GI, as irrigating outdoor vegetation would be costly. Again, as with establishing funding sources, political will would be needed to increase rates. Also, increasing rates on its own may reduce water use, but it does not guarantee that people will continue to plant native vegetation and create desirable community spaces. Developers and landowners may instead replace vegetation with pervious surfaces or rock to eliminate outdoor water use, thereby creating hot, undesirable landscapes that only increase stormwater runoff.

This brings up the need for connections between development standards, water conservation, and LID/GI stormwater management, and the coordination and collaboration between various departments and agencies. Many participants raised concerns over the current disconnect and lack of coordination and how it can impede LID/GI implementation, specifically in offering incentives or changing ordinances and development standards. In addition, many participants expressed the need for LID/GI coordination across jurisdictions, so that similar standards are adopted within the watershed and the region as a whole.

Financial Barriers

A variety of financial barriers were expressed during the focus group, such as increased development costs, a lack of incentives to encourage implementation, and a lack of cost benefits analysis showing economic feasibility of LID/GI. In order to gain support for LID/GI and address concerns over increased costs, it is first important to understand how the costs of these techniques compare to conventional stormwater infrastructure. A report from the EPA (2007c) analyzed 17 LID case studies, which concluded that in most cases LID techniques reduce project costs and supply additional social and environmental

benefits that conventional approaches do not. Although this sounds promising, a local analysis should be preformed as costs can vary by location and design.
Many cost savings with LID/GI are realized when traditional stormwater infrastructure is reduced or eliminated, so this would have to be allowed for in order to make LID/GI cost competitive. For example, in the High Desert development of Albuquerque, conventional pipe size and infrastructure was still required despite LID/GI practices, thereby increasing overall development costs. As most developers are not willing or able to have these additional costs and still be profitable, the reduction of conventional stormwater infrastructure is necessary. Also, to further cost savings and encourage the adoption of these techniques, many communities offer economic incentives, such as tax credits or fee reductions. The EPA's (2009) Municipal Handbook on Incentive Mechanisms offers guidance on establishing a variety of incentive programs through successful case study examples. Since LID/GI techniques can reduce the amount of land available for development, some communities also offer increased density incentives allowing developers to maximize their land use.

Stormwater program costs were another major barrier, as some participants already face limited budgets for their stormwater programs, and there were concerns over increased staff, maintenance, training and equipment costs with LID/GI. Fortunately there are a variety of funding mechanisms that have proved effective, such as stormwater fees, taxes, impact fees, and general fund allocations. Additionally, some communities have taken advantage of EPA Clean Water State Revolving Funds or grant funding. Examples of these funding options are detailed in the EPA's (2008b) Municipal Handbook series on Funding Options. It is important to point out that many participants stated there was a lack of local political will for LID/GI, and that officials may be reluctant to support increased fees or taxes. Funding options therefore, need to be examined in the local context and political climate, and extensive outreach and education will be required to gain support.

Social Barriers

One of the major social barriers to LID/GI implementation expressed by participants was the fundamental disconnect between urban dwellers and their environment, specifically that many do not realize they live in a watershed and have an impact on it. Participants also pointed out that although much recreation occurs in the riparian forest along the Middle Rio Grande, there is limited recreation in the river itself. This raised concern for a lack of public support to improve our waterways. Upon examination of LID/GI programs in wet climates, such as those in the Puget Sound region or Chesapeake Bay, public outreach for gaining support often focuses on the need to protect receiving waters for various recreational, economic and ecosystems purposes. This may be a difficult angle to take in the Albuquerque area, as many participants felt there was a lack of recreational or emotional connection to our river, and there is limited economic connection to protecting water quality, such as with a fishing industry.

Although this may be a major social barrier to overcome, there are angles that can be taken to gain public support that fit our local situation. First is the LID/GI connection to water conservation, which is a benefit for all climates, but should really be pushed here to gain support. Since LID and GI can help to achieve *both* stormwater and water conservation goals simultaneously, this connection really makes LID/GI marketable to a broad range of agencies and stakeholders in our semi-arid climate. Also, the need for water conservation has been on the radar in the Albuquerque area for a while, whereas LID/GI for managing stormwater has not. By creating a strong link between LID/GI and water conservation, more public support will be gained.

The second angle that could be pushed to gain support for LID/GI is the connection to drinking water, as polluted stormwater enters our river directly upstream from where water is diverted to the drinking water treatment plant. Although this is not a threat to our water supply, as the treatment plant meets all state and federal drinking water standards, people do seem to care a great deal about drinking water quality. Making this connection may be a public relations issue for the ABCWUA, but it really drives home the movement of water within the watershed, and that residents do in fact have an impact on its health.

Previously mentioned was the concern over a lack of political will to adopt new stormwater technologies and methods, especially if it involves fees or adopting policy that has yet to gain public support. There was also concern that engineers and those in the building industry are slow to adopt new strategies and technologies, and that many are skeptical of LID/GI. The reluctance to support these techniques locally may be linked to the fact that engineers and other professionals only see wet climate case studies and designs at conferences and in publications, and there is a perception that these techniques must be green and lush. Also, engineers may be reluctant to accept LID/GI techniques, as if these techniques fail to properly manage stormwater they will be liable for the consequences.

Part of the issue faced in the Albuquerque area is that LID/GI is a relatively new conversation for our region, and only through communication and education can many of these perceptions be changed.

Knowledge Barriers

Participants expressed concern that local builders, engineers, architects, planners, government officials and citizens are unaware of LID/GI, their benefits, and how to design, construct, or maintain them properly. Many barriers to LID/GI can be linked to a lack of knowledge, and it is those uncertainties that lead to a lack of support and a fear of innovation. As the focus group findings highlight in this chapter, we face a large list of unknowns, which to some may seem daunting.

Some Major Knowledge Gaps

- Sustainable funding sources and incentives
- Inventory of local examples and how well they function
- Proper designs for our climate, soil types and native vegetation
- Irrigation requirements to sustain vegetation
- Appropriate porous pavements
- Official OSE policy on water harvesting

Figure 24: Major knowledge gaps related to LID/GI.

The Albuquerque area is fortunate in that much can be learned from other communities, but those unknowns specific to our region and climate will take time and effort to solve locally. In many cases the knowledge we need is already here, and by bringing the right experts to the table this information can be communicated, documented and distributed.

General Interest in LID/GI

Initially the author thought it would be difficult to find interested participants for the focus group, but this was not the issue in the least. There was much more interest than expected so a limit of 20 participants had to be decided, although 30+ participants could have easily been found. It is important to note that many participants were found through conversations recruiting other participants, indicating that the LID/GI conversation is already taking place to some extent in our region. Also, the results from the post-focus group survey showed that 100% of respondents felt the conversation about LID/GI needed to continue for our region, indicating much support or interest in further examining and/or implementing these techniques.

Although many in the Albuquerque may be unfamiliar with LID/GI, there is still a strong interest from a variety of professionals and citizens in the area. There are local examples of LID/GI in the Albuquerque area, indicating that although "on site" management is not necessarily required or encouraged, and there is a lot of local support and momentum for water conservation.

Critique of Focus Group Design

The focus group was a successful method for gaining the desired information, but improvement could have been made in hindsight. It is important to critique its design and share the lessons of what worked well and what did not.

Some of the successes from the focus group include:

- The focus group represented the first time a diverse group of local professionals got together to discuss and share their opinions on using LID/GI in our region

- The design of the two activities allowed for the creation of a visual that clearly showed trends and preference for the different techniques, and this helped to stimulate the discussion
- It provided a venue for participants to share the barriers they face for implementing LID/GI in their profession/agency
- The author was able to collect information and provide insight that has already proved useful, specifically in helping to guide the design of an LID/GI workshop that is being planned for the Spring of 2010[27]

Some improvements that could have been made included:

- Many participants felt that a representative from the Office of the State Engineer should have been present, and that without the OSE presence some major institutional barriers and unknowns could not be fully addressed. Also, participants felt that a representative from AMAFCA should have been present. Although participants from these agencies were invited, it was a failure on the part of the research design to not ensure the representation of these agencies.
- For the purposes of time, only 10 technique categories were evaluated, and some felt that a few of the categories, such as porous pavement, were too broad. This may have lead to the results being skewed, as it was difficult to rate a broad category instead of the various techniques within that category. Also, one individual's interpretation of a technique, such as rain gardens or swales, could be very different than someone else's, especially if they use different terms to describe the same technique.
- The 2.5 hour timeframe worked well; however, many of the discussions had to be cut off to adhere to the focus group agenda. A longer focus group, or multiple focus group sessions, would have allowed for more discussion, but it may not have been as feasible for participants to attend.

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[27] In the fall of 2009, Bernalillo County and EPA Region 6 began planning a 2-day Green Infrastructure Workshop for the Albuquerque area to take place in March of 2010. The author is on the local planning committee for this event.

- Although examining barriers with focus group participants was informative, it would have been beneficial to focus also on proposed actions or strategies for overcoming those barriers.

Chapter 6: Recommendations

In light of the focus group findings, the author offers the following 6 categories of recommendations for overcoming barriers and moving forward with LID and GI for the Albuquerque area.

6 Recommendations

- Promote Collaboration and Communication
- Conduct Outreach and Education
- Identify Local Knowledge and Efforts
- Utilize Outside Knowledge
- Lead, Don't Just Follow
- Take a Multifaceted Approach

Figure 25: List of 6 recommendations.

Promote Communication and Collaboration

The LID/GI conversation must become more widespread for our region. If the various stakeholders don't start talking about LID/GI on a larger scale then it is never going to happen. Also, this conversation can't happen in a vacuum or behind closed doors; communication across various agencies, departments, organizations, and other stakeholders is critical. More communication and collaboration is needed locally among:

- All municipalities and MS4's in the Albuquerque area
- Landscape architects, architects, and other design professionals
- Engineers and flood control authorities
- The development and business community
- The ABCWUA, NMED, OSE and other agencies
- Various departments (e.g. planning and zoning, municipal development, parks and recreation, transportation)
- Citizens and neighborhood associations
- Various local experts
- And special interest groups

Communication and collaboration also needs to extend beyond the Albuquerque area to include other developed regions in New Mexico, municipalities in similar climates outside of New Mexico, and EPA Region 6 and EPA Headquarters, specifically to share concerns and barriers, seek support and guidance, and share with them successes and case studies from our region.

Collaboration both locally and outside of our region is important as it makes the process more efficient, cost effective, and successful in the long run. For example, local municipalities can share the costs and other resources related to research, pilot studies, and the development of public outreach materials or design guidelines. Also, it makes more sense for there to be similar LID/GI standards or guidelines from one municipality to the next, as developers don't build in just one jurisdiction but across the region as a whole. Collaboration would also allow for the establishment of and LID/GI implementation committee that could create a set of actions to move forward with.

Collaboration between similar efforts also needs to occur. For example, if the ABCWUA promotes water harvesting, the[28]re should be collaboration between their conservation programs and LID/GI programs as the efforts overlap and are very complimentary. Similarly, the City of Albuquerque's urban forestry program needs to also coordinate with LID/GI efforts.

Some examples of successful collaboration include:[29]

- The Keep It Clean Partnership (the Denver/Boulder area equivalent of the Albuquerque area Stormwater Quality Team) which is currently working to promote the use of LID/GI and overcome barriers in their region. Our Stormwater Quality Team could play a similar role here in promoting LID/GI, and expand beyond its current membership to include more stakeholders.
- The Puget Sound Partnership, where local governments, citizens, businesses and researchers and working together statewide to improve the health of the Puget Sound. Some of their efforts include the creation of an action agenda, the promotion of LID/GI, public education and outreach, and more.
- The City of Portland provides an example of collaboration among various departments. For example, in 2001 the Sustainable Infrastructure Committee was formed to coordinate efforts between staff in various departments. That effort was then followed by the creation of the interdisciplinary Sustainable Stormwater Management Program within the City's Bureau of Environmental Services.

These are just some of the many examples of agency, watershed, or statewide collaboration that exist, and similar efforts for LID/GI can be undertaken here.

[28] The city began an urban forestry program in 2006 to promote and manage a healthy urban forest. http://www.cabq.gov/albuquerquegreen/green-goals/trees/urban-forestry
[29] See Appendix F for links to these program websites.

Conduct Outreach and Education

Outreach and education are important tools for overcoming barriers related to political will, public support, and gaps in knowledge. Initially, the audience of outreach and education efforts might be municipalities, MS4s, government officials, agencies, and members of the design and development community who are not yet involved with or interested in LID/GI. Once efforts are more underway, the focus of outreach and education may then shift towards citizens and landowners. Some recommendations for outreach and education include:

Host informational meetings, workshops and events

Workshops, meeting, and events, can be used to increase the initial interest in, and support for, LID/GI. The 2010 Green Infrastructure workshop that is being planned for the Albuquerque serves as a great example, and similar efforts could be geared towards residents and businesses.

Host technical workshops and trainings

LID/GI trainings could be offered on a variety of topics including proper design, construction, maintenance, incentives and funding options. These trainings could be geared towards a variety of audiences including residents, business owners, and those in the construction, design, and development fields.

Create informational resources

LID/GI information can be distributed in a variety of manners depending on the target audience. For example, brochures, billboard ads, mailings, flyers, or other materials can serve as educational or promotional tools. Technical information, design manuals, vegetation guidelines, and other resources can be created to address specific gaps in knowledge.

Create an online presence

On online presence is very important for the promotion of LID/GI in the Albuquerque area. While a variety of stakeholders may choose to provide information online, a collaborative effort could result in a main LID/GI site for the region, with a clearinghouse of information. An online presence provides not only a means for distributing publications and resources, but also for promoting events, new regulations, policies, funding sources, and more.

Promote "on the ground" education

This can include LID/GI site tours, informational signs at case study sites, or hands on workshops where people help to install or maintain structures. Just as it is important to have publications or meetings, awareness and education need to occur in the urban landscape with the actual LID/GI structures themselves.

Create a campaign that works for our region

As discussed previously in the paper, the connection LID/GI has to water conservation is a huge selling point, as this can help increase support for LID/GI locally, especially if there is limited support for increasing the quality of urban runoff. Also, the Albuquerque area already has the *Scoop the Poop* and *Keep the Rio Grand* campaigns, and they should be evaluated for their effectiveness.

Identify Local Knowledge and Efforts

The Albuquerque area does not have to start from scratch when overcoming barriers and knowledge gaps related to LID/GI, as there are a variety of local experts, examples, and complimentary efforts here in our region.

Although LID/GI techniques are not widely implemented in the Albuquerque area, there are examples of each found here- designed and constructed by local experts. These local case studies need to be documented and evaluated and these experts need to be brought into the conversation. Also, there are a variety of experts who can address climate specific barriers related to vegetation selection, proper mulching, constructed soils, irrigation requirements and more. These experts need to be involved with developing LID/GI manuals and design criteria specific to our climate.

Identifying current efforts where LID/GI already “fits in” promotes collaboration and reduces costs for all agencies involved. Some complimentary efforts in the Albuquerque area include:

- The promotion of xeriscaping, rainwater harvesting, and water conservation by the ABCWUA
- The City of Albuquerque urban forestry program
- Parks and recreation department and open space programs
- Main street or “complete street” programs
- Watershed restoration efforts, such as the WRAS which specifically defines actions for on-site stormwater management
- And of course existing stormwater quality efforts

Linking these efforts to LID/GI will only further its implementation in the region.

Utilize Outside Knowledge

The Albuquerque area can learn a great deal from existing case studies, manuals, policies and outreach efforts from other communities around the U.S. and abroad. While some information may not be suited for our climate, a lot of what we can learn is not necessarily climate specific. For example, model LID/GI ordinances, public outreach, incentive programs and funding mechanism could be used as a framework for the Albuquerque region. There are also a variety of resources from similar climates that could be utilized here. A listing of valuable LID/GI websites and resources can be found in Appendix F.

Lead, Don’t Just Follow

The Albuquerque area could wait until LID/GI become mandatory components of NPDES stormwater discharge permits, or until more information becomes available on implementing LID/GI in arid climates and then take action. Alternatively, the Albuquerque area could take the initiative now and become a leader showcasing LID and GI innovations for semi-arid climates. This region could provide case studies, research, publications, design manuals, and other resources that would not only benefit and improve the MRG watershed, but other urban watersheds in similar climates.

The 2010 Albuquerque area Green Infrastructure workshop illustrates a first step towards taking this initiative, which could ultimately lead to the widespread implementation of these techniques and approaches for the region.

Take a Multifaceted Approach

Overcoming the constraints for implementing LID/GI in the Albuquerque area will require a multifaceted approach, as there is no "one stop" solution or action to overcome barriers, and LID/GI requires the efforts of multiple groups and agencies.

Intersection of groups and agencies

As there is no single agency or group that has the resources or authority to make LID/GI happen in the Albuquerque region, an intersection of efforts from a variety of groups and agencies will be required (see Figure 26). As LID/GI goes beyond just stormwater management, a variety of groups and agencies that don't even deal with stormwater need to be involved, and those who do manage stormwater need to expand their roles to encompass LID/GI.

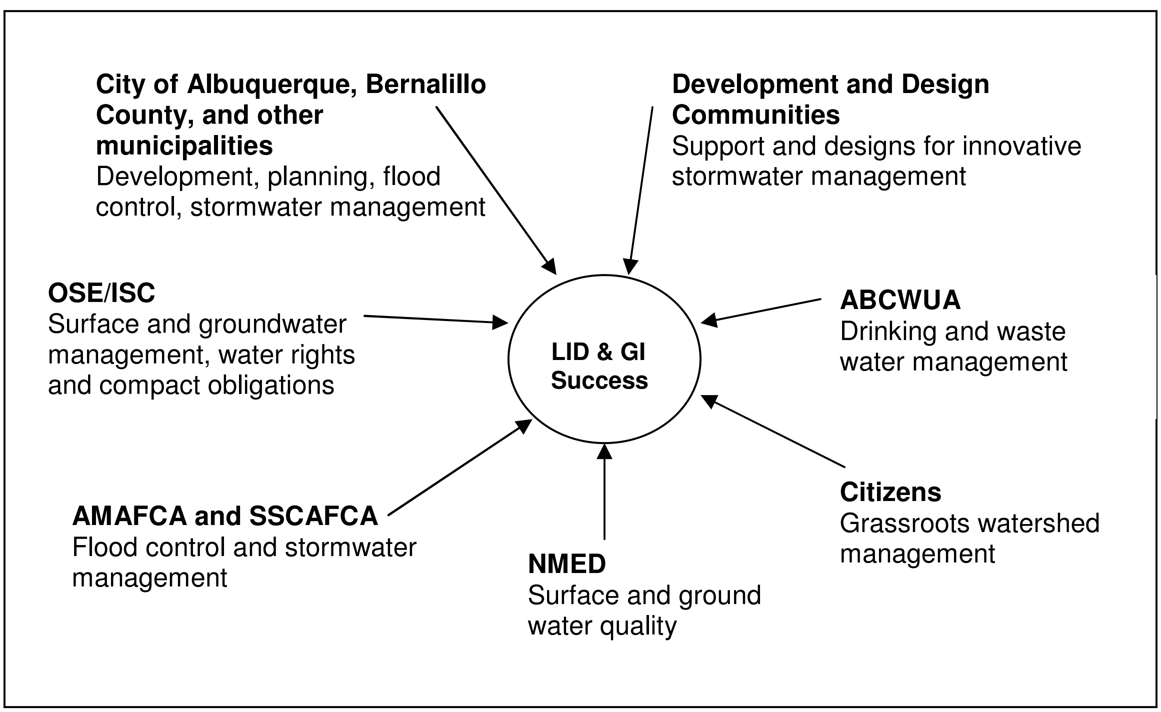

Figure 26: Groups and agencies that need to be involved in LID/GI efforts for it to be successful.

For example, if the OSE/ISC is not involved in or does not have policies supporting LID/GI, developers will most likely choose to not use these techniques due to concerns over illegal water harvesting. Without OSE/ISC support, LID/GI will not happen or be severely limited in its application. Another example is the local flood control authorities. If LID and GI are used extensively and successfully, AMAFCA and SSCAFCA would benefit by having reduced and cleaner stormwater flows to manage, so they too are a critical agency that needs to be involved with and support LID/GI through their drainage policies. Since AMAFCA and SCCAFCA are funded through property taxes, and there is no city or county stormwater utility to fund stormwater programs, they could also serve in a financial capacity related to LID/GI, especially as they are receiving the benefits mentioned above. Other examples include the various municipalities that have the authority to include LID/GI in planning and development guidelines, NMED which has the authority over surface and groundwater quality, and the ABCWUA which can offer incentives and create policies for water harvesting and conservation.

Intersection of actions and strategies

Just as multiple agencies need to be involved with LID/GI, multiple actions and strategies are needed in conjunction for successful implementation and overcoming barriers. For example, focus group participants cited the low cost of municipal water as a barrier to LID/GI, making the techniques not cost effective. While raising the cost of municipal water may reduce consumption, it does not guarantee that people will turn to LID/GI water harvesting techniques to maintain vegetated spaces. Instead, people may opt to have rock landscaping with no vegetation at all, requiring outreach and education, incentives, or other measures to encourage the use of LID/GI water harvesting techniques. Similarly, if an ordinance was created requiring that 50% of landscape irrigation come from harvested water[30], it again does not guarantee the adoption of LID/GI techniques and other measures are needed to encourage their implementation. Also, simply requiring LID/GI in new developments and redevelopment will not be

[30] Tucson, Arizona has a new ordinance requiring 50% of commercial landscape irrigation to come from harvested rainwater. This ordinance goes into effect in June of 2010. Ordinance available online at: http://www.ci.tucson.az.us/water/docs/rainwaterord.pdf

successful without proper incentives, and will just create a backlash from the development community. This is why an intersection between a variety of actions and strategies is required for LID/GI implementation, as illustrated below in Figure 27.

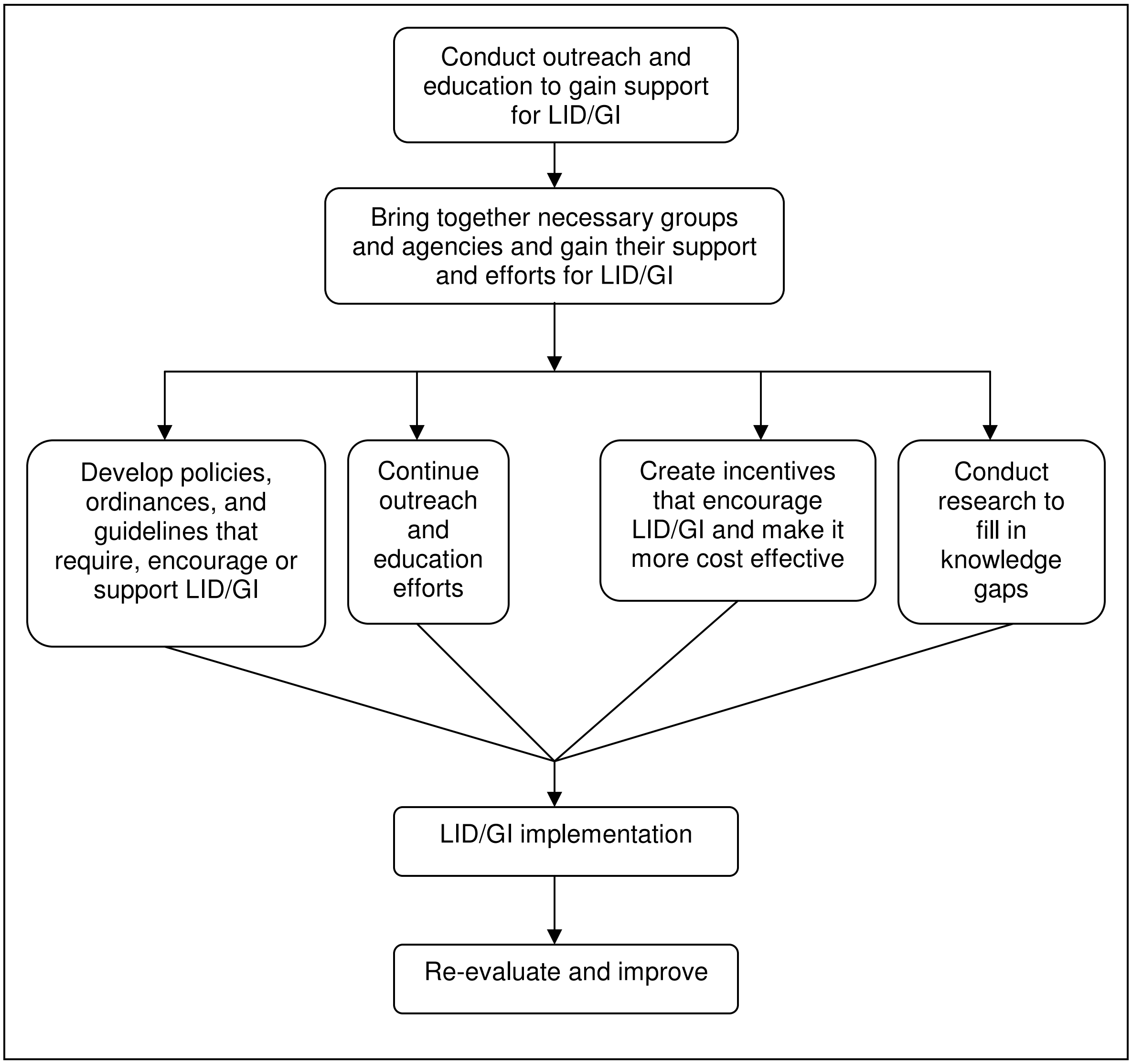

Figure 27: Actions and strategies necessary for successful LID/GI implementation.

The chart above illustrates outreach and education and bringing together necessary groups and agencies as the first step towards LID/GI implementation. Then a variety of concurrent and complimentary efforts can occur. For example, if the OSE/ISC establishes a water harvesting policy in support of LID/GI, then the City of Albuquerque would be more likely to include those techniques in their ordinances and development guidelines. Those efforts alone however will not lead to successful LID/GI implementation. For example, there may be financial barriers to overcome, or incentives may need to be established to make these techniques cost effective or acceptable to the development community. There may also be a need for extensive outreach and education to the development community about proper design, installation and maintenance of the techniques, or to gain their support for LID/GI. Research may also need to be conducted to determine the best possible designs of these techniques, and design manuals may need to be developed. This illustrates again how the actions of many agencies and groups are needed for LID/GI implementation, and that bringing all of these efforts together will take collaboration and time.

Chapter 7: Conclusion

Based on the focus group findings, as well as the author's insights, the following conclusions are made in regards to the implementation of LID/GI in the Albuquerque area.

Climate Considerations

- The region's climate is an issue, but proper design is the solution
- We have the local experts and knowledge to overcome climate barriers and unknowns
- A few techniques may not be the best choice, but there are others to choose from
- Once skeptics start seeing climate appropriate examples that work, more will support LID/GI
- LID/GI needs to be linked to water conservation in our semi-arid climate

Barriers to Implementation

- Getting the conversation going is the first major step in overcoming most barriers
- We have the local knowledge and interest needed to overcome many barriers, and LID/GI knowledge and interest will continue to grow
- Municipalities across the U.S. have overcome these barriers, and so can the Albuquerque area

In conclusion, this region of New Mexico is going to continue to grow in size and population, its residents will continue to consume water and desire green spaces, and urban runoff issues will only increase without a different strategy. While LID/GI can't control population growth and development, these techniques and approaches would allow the region to develop in a more sustainable way that would both protect water quality and conserve water resources. Although many barriers are faced for implementing LID/GI in the Albuquerque area, the potential benefits gained from these techniques warrants further research and action.

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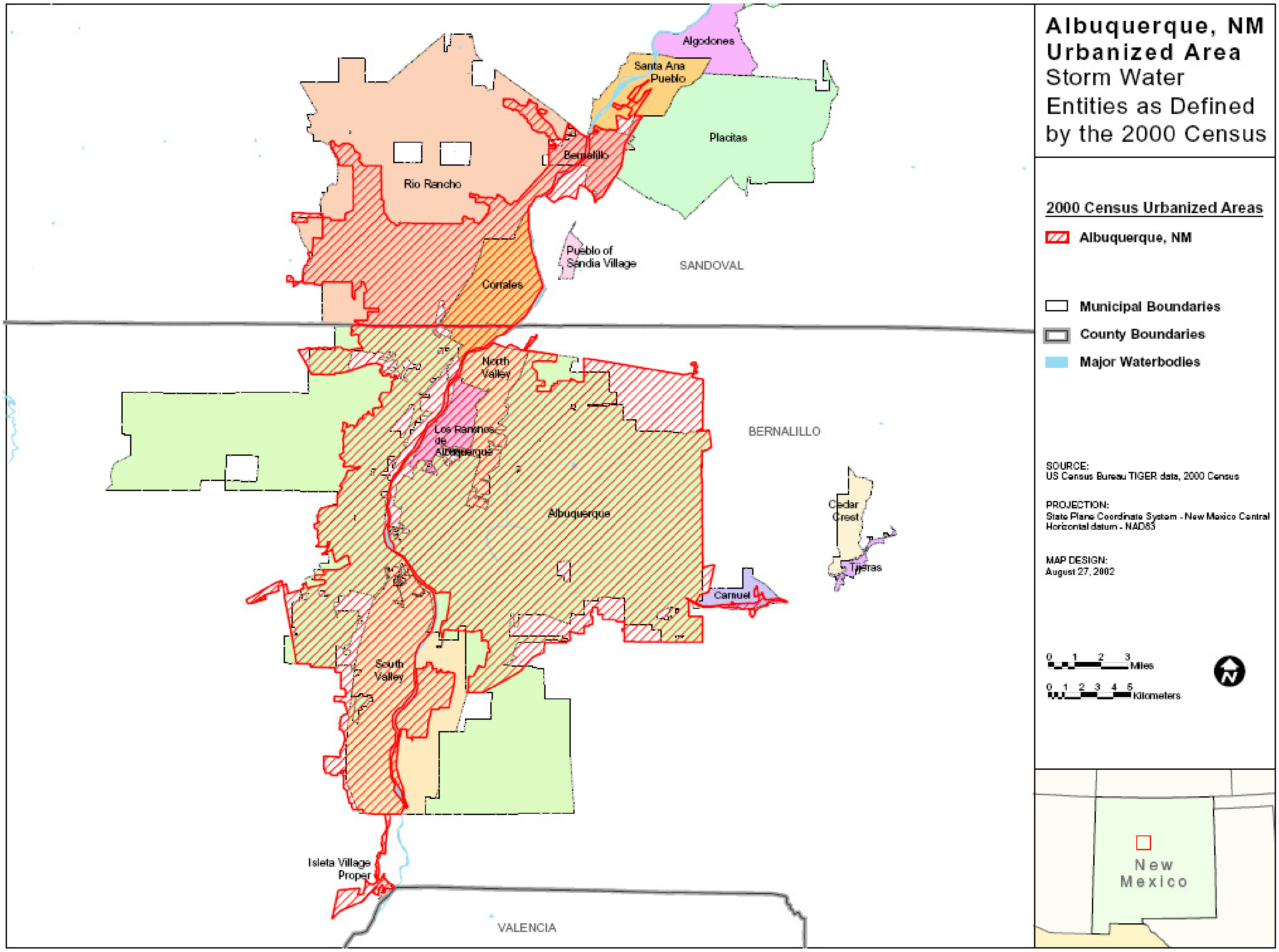
<u>Appendix</u>

A: Map of Albuquerque Urbanized Area



Source: http://cfpub1.epa.gov/npdes/stormwater/urbanmapresult.cfm?state=NM

B: Memorandum on the Use of Green Infrastructure in NPDES Permits and Enforcement

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

AUG 1 6 2007

OFFICE OF
ENFORCEMENT AND
COMPLIANCE ASSURANCE

MEMORANDUM

SUBJECT: Use of Green Infrastructure in NPDES Permits and Enforcement

TO: Water Division Directors, Regions 1 – 10
Regional Counsel/Enforcement Coordinators, Regions 1 - 10
State NPDES Directors

FROM: Linda Boornazian, Director
Water Permits Division (MC 4203M)

Mark Pollins, Director
Water Enforcement Division (MC 2243A)

Administrator Stephen Johnson entered into an agreement on April 19, 2007, with State, environmental and wastewater utility groups to formalize the use of green infrastructure[1] approaches.[2] As part of the agreement, the Agency committed to develop "memoranda … that would explain how regulatory and enforcement officials should evaluate and provide appropriate credit for the use of green infrastructure in meeting Clean Water Act requirements." One frequently encountered question is how green infrastructure practices fit into existing regulatory programs.

[1] Green Infrastructure uses natural or engineered systems – such as green roofs, rain gardens and permeable pavement – that mimic natural processes and direct stormwater to areas where it can be infiltrated, evapotranspirated or re-used. Green infrastructure can provide many environmental benefits: stormwater control, air quality improvements, urban heat island mitigation, energy demand reductions, carbon sequestration, headwaters protection, etc.

[2] Green Infrastructure Statement of Intent, http://www.epa.gov/npdes/pubs/gi_intentstatement.pdf.

In developing permit requirements[3], permitting authorities may structure their permits, as well as guidance or criteria for stormwater plans and CSO long-term control plans, to encourage permittees to utilize green infrastructure approaches, where appropriate, in lieu of or in addition to more traditional controls.

EPA will also consider the feasibility of the use of green infrastructure as a water pollution control technology in its enforcement activities, and encourages state authorities to do likewise.

We are working on more specific guidance to help facilitate implementing this message -- e.g., model permit and enforcement consent decree language, and we are compiling examples of where green infrastructure has been incorporated into permits and enforcement mechanisms in an appropriate and effective manner.

If you have examples of permits, CSO long term control plans or settlements that utilize green infrastructure, or have any questions on this matter, please contact either of us, or have your staff contact Jenny Molloy of Water Permits Division at molloy.jennifer @epa.gov, 202 564-1939 or Gary Hudiburgh of Water Enforcement Division at hudiburgh.gary@epa.gov, 202 564-0626.

cc: Steven Neugeboren, Office of General Counsel, (MC 2355A)

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[3] NPDES permits require compliance with effluent limitations developed to meet technology-based requirements, as well as more stringent water quality-based requirements; the permits also contain general and special conditions, including monitoring and reporting. The discharger makes the decision on how to achieve compliance with limitations and conditions contained in an NPDES permit, and may decide to make use of green infrastructure to comply with NPDES permit terms, limitations and conditions. These permits must meet the requirements of CWA §§ 301, 302, 306, 307, 308, and 313. EPA has issued regulations to implement the NPDES program, 40 CFR Parts 122 – 125, and guidance and policy.

C: Focus Group Participant List

Participants	Name	Affiliation	Title
1	Trevor Alsop	Southern Sandoval County Arroyo Flood Control Authority (SSCAFCA)	Drainage/ Environmental Engineer
2	Reza Afaghpour, P.E.	New Mexico Department of Transportation, Drainage Bureau	Drainage Development Engineer
3	Brad Bingham, P.E.	City of Albuquerque	City Hydrologist
4	Kris Callori	Environmental Dynamics, Inc.	Principal, Architect, LEED Accredited Professional
5	Michael Cecchini	1)Kayeman Custom Homes, and 2)Green Build Council	1)Vice President, 2)Chair
6	Douglas H. Collister	High Desert Investment Corporation	President
7	Dale R. Dekker, AIA, AICP	Dekker/Perich/Sabatini	Principal
8	Steve Glass	1)Bernalillo County Public Works Division, 2) Ciudad Soil and Water Conservation District	1)Water Resource Planner, 2)Chairman
9	Nick Kuhn	City of Albuquerque	City Forester
10	Jonathan D Niski, P.E.	Tierra West, LLC	Civil Engineer
11	Rolland Penttila	City of Albuquerque	Storm Drainage Design Manager
12	George Radnovich	1)Sites Southwest, and 2) Xeriscape Council of New Mexico	1) Senior Principal and Founder, and 2) President and Founder
13	David Stoliker	Southern Sandoval County Arroyo Flood Control Authority (SSCAFCA)	Executive Engineer
14	Bruce Thomson	University of New Mexico, Water Resources Program	Director
15	Kathy Trujillo	New Mexico Department of Transportation (NMDOT) District 3	Assistant District Engineer
16	Kathy Verhage	City of Albuquerque	Storm Water Quality Engineer
17	Katherine Yuhas	Albuquerque Bernalillo County Water Utility Authority (ABCWUA)	Water Conservation Program Manager
Facilitators	Name	Affiliation	Title
1	KT LaBadie	UNM	Graduate Student
2	Tim Karpoff	Karpoff & Associates	Consultant and Facilitator

D: Informational handout given to focus group participants

General Technique	Description	Variations/Examples	Links to more information
Urban tree cover	Tree canopies intercept precipitation, thereby slowing rainfall and reducing the amount that hits the ground	Creating tree lined streets, increasing tree cover in parking lots and in residential, commercial, and industrial areas, riparian buffers	Urban Tree Canopy, Watershed Forestry
Green or "living" roofs	Vegetated roofs designed to slow and reduce stormwater through the use of appropriate plants and specific substrates/soil	Application at the residential, commercial and industrial scale, can sometimes double as public spaces	Green Roofs for Healthy Cities EPA Report on Green Roofs for Stormwater Control Info on green roof at EPA Region 8 headquarters
Rain barrels or cisterns	The use of storage tanks to capture runoff, generally from rooftops, which can be utilized later for non-potable uses	Small or medium scale residential harvesting, larger scale for commercial or industrial buildings, above or below ground tank storage	Rain Harvesting, EPA (pdf)
Infiltration or flow-through planter boxes	A vegetated built structure generally used in urbanized settings, such as a downtown, where space is limited. Functions similarly to a rain garden or swale, but vegetation and soil are contained in a built structure/planter, often made of concrete.	Used next to buildings to filter/slow roof water from downspouts, used along pedestrian malls or plazas to filter/slow runoff, may also be used for certain street-side applications	Infiltration planter box fact sheet Flow through planter box fact sheet
Rain gardens (bioretention)	A vegetated depression that manages runoff from roofs, driveways, parking lots and other impervious/compacted surfaces, generally the water is retained/infiltrated	Rain gardens are often used at the base of roof downspouts, along roadways and parking lots	Rain Gardens and Bioretention
Swales and earthen structures	Landscape elements that are designed to slow and direct the movement of water, allowing for the capture of sediments and pollutants in mulch, rip rap and/or vegetation	Application in a variety of land uses, especially along highways, roads, parking lots and subdivisions	Vegetated Swales Fact Sheet, EPA

Harvesting parking lot runoff, "green parking"	A variety of LID/GI techniques could be used, a common one being to direct parking lot runoff into swales or rain gardens within or next to the parking area (through alternative curb designs)	Curb cuts to direct runoff into vegetated areas such as swales or rain gardens, curb-less or alternative curb designs, use of porous pavement, can also include use of tree canopies	Greening Surface Parking Lots manual, Toronto Green Parking Lot Case Study (pdf)
Porous or permeable pavements	The use of permeable materials, such as interlocking concrete pavers, porous concrete/asphalt, bricks, open cell paving blocks, crusher fines and gravel, in place of or in conjunction with impervious paving	Can be used in roads, parking lots, sidewalks, driveways, and a variety of other applications	EPA Fact Sheet on Porous Pavements Article in Stomwater (the journal) addressing commonly asked questions about porous pavement
Harvesting street or highway runoff, "green streets"	Green streets include a variety of LID/GI techniques to manage stormwater, a common technique being to direct runoff from the street into vegetated areas to reduce and filter runoff	Curb cuts along vegetated medians or roadside areas to allow water to flow into swales or rain gardens, porous pavements in roadways or along curb/parking areas	LID Center Green Streets Website EPA webpage on Green Streets Green Highways Partnership
Green detention facilities	Larger "green" detention areas that manage stormwater close to its source, often designed for multiple use	Parks, pocket wetlands, and open spaces that double as stormwater detention/management areas in addition to being areas for recreation and wildlife	Green Detention Facilities manual (Indianapolis)

E: Focus Group Worksheet

Focus Group Worksheet: *Technical Feasibility and Performance Rating of GI Techniques*

Your task: Rank the technical feasibility or performance of the various techniques for achieving stormwater goals in our climate as if no external constraints existed.

Rating Scale: 1 to 5

1: This technique or approach **would perform well** in our arid region	2: This technique or approach **would most likely perform well** in our arid region	3: This technique or approach **may perform well** here	4: This technique or approach **would most likely not perform well** in our arid region	5: This technique or approach **would not perform well** in our arid region

Technique/Approach	Rating	Reason/s why you rated the performance of the technique as such?
Increased Urban Tree Cover		
Green or "living" roofs		
Rain barrels or cisterns		
Infiltration or flow-through planter boxes		
Rain Gardens (bioretention)		
Swales and other earthen structures		
Harvesting parking lot runoff "green parking"		
Porous pavements		
Harvesting street or highway runoff, "green streets"		
Green detention facilities		

Is there something you feel is not on this list but should be? Please let me know here:

F: Online LID/GI Resources Listing

EPA's main Green Infrastructure website
http://www.epa.gov/greeninfrastructure/

EPA's LID website
http://www.epa.gov/nps/lid/

Low Impact Development Center, Inc
http://www.lowimpactdevelopment.org/

Rainwater Harvesting for Drylands and Beyond
http://www.harvestingrainwater.com/

Puget Sound Partnership
http://www.psp.wa.gov/

Portland Bureau of Environmental Services Sustainable Stormwater Management
http://www.portlandonline.com/BES/index.cfm?c=34598

Keep it Clean Partnership
http://www.keepitcleanpartnership.org/

Southeast Michigan Council of Governments Statewide LID Manual
http://www.semcog.org/LowImpactDevelopment.aspx

The Conservation Fund
http://www.greeninfrastructure.net/

Green Infrastructure Wiki
http://www.greeninfrastructurewiki.com/

Natural Resources Defense Council
http://www.nrdc.org/water/pollution/storm/stoinx.asp

Center for Watershed Protection's Stormwater Resource Center
http://www.stormwatercenter.net/