Case Study: Low Impact Development In Mesa, Arizona

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Abstract

Conventional stormwater management has several drawbacks including high costs, water pollution, and aesthetic problems that low impact development (LID) attempts to address. The City of Mesa, Arizona has embraced LID despite the absence of an extensive track record in desert climates. Through personal interviews with key people and a review of current literature, this study highlights the City's experience with LID, focusing on the benefits, barriers, lessons, future outlook, and a LID toolkit that Mesa hopes will advance the prospects of LID locally and eventually throughout arid regions.

Keywords

Low impact development, LID, green infrastructure, GI, Mesa, toolkit

Introduction

"Arizona could be out of water in six years" (Schultz, 2014). "Stormwater runoff the leading cause of water pollution in the United States" (Maricopa.gov, 2014). "Phoenix faces $38 million deficit, layoffs likely" (Kline, 2014). Headlines like these are some of the reasons arid cities in Arizona and elsewhere are turning to low impact development (LID) as a potential solution to the challenging problems associated with rainfall management in a desert environment.

Conventional stormwater management, or *grey infrastructure*, consists of pipes, gutters, tunnels, culverts, basins, pumps, and other systems to capture and convey runoff from urban areas to natural drainages such as washes and rivers. This often involves impressive engineering that is well understood and generally operates reliably. But there is also a growing awareness concerning the drawbacks of modern water management. Cities are looking to mitigate waste, pollution, and other unintended consequences while seizing opportunities to creatively reuse urban space and improve communities.

Mesa, Arizona is a forerunner in this endeavor. Covering 132 square miles east of Phoenix and home to almost half a million people, Mesa is the third-largest city in the state and the 38th largest in the nation (City of Mesa, 2014). A growing contingent in city government is advocating LID as a common sense approach that can be economically, socially, and environmentally beneficial. Those in charge of municipal infrastructure, however, have contractual mandates and adopting novel methods is often perceived as being personally and institutionally risky. Developers are frequently unfamiliar with LID techniques and usually require incentives to deviate from standard practice. Public engagement in water management is also an imposing hurdle.

Enter THE LID TOOLKIT. In recognition of the barriers to LID acceptance and implementation, the City of Mesa has embarked on a mission to create a user-friendly resource illustrating the best practices, benefits, adaptability, and diversity of LID. Formed through personal interviews with key City of Mesa personnel and an analysis of existing literature, this case study is a snapshot of that effort and narrative – the what, why, when, where, who, and how - desert cities are waking up to the great potential of innovative stormwater management.

What is LID?

In essence, LID is a time machine. Before the exponential growth in pavement, concrete, and other impervious surfaces, rainfall infiltrated the ground where it fell and excess water drained into natural channels. LID attempts to return to this state of affairs as much as possible (*Figure 1*). According to the Environmental Protection Agency (EPA), LID is a land development approach that works with nature to manage stormwater in accordance with simple principles (2013).

Low Impact Development Principles

- ✓ Keep water close to the source
- ✓ Preserve landscape features
- ✓ Minimize imperviousness
- ✓ Create functional, appealing site drainage
- ✓ Treat stormwater as a resource rather than waste
- ✓ Reduce impact of built areas
- ✓ Promote natural movement of water
- ✓ Protect ecologic and hydrologic functionality
- ✓ Encourage sustainable stormwater practices

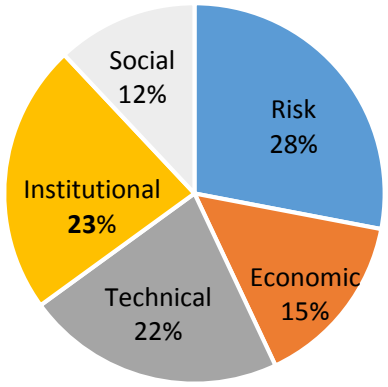
Figure 1 – Return to a more natural state: Potential rehabilitation of the Los Angeles River

Bachrach, E. (2013). "7 Dramatic Before/Afters From the Huge LA River Rehab Plan". Retrieved from http://la.curbed.com/archives/2013/09/7_dramatic_before_and_afters_from_huge_la_river_makeover_plan.php

Barriers

Resistance to LID takes many forms (*Figure 2*). Barriers can be economic, technical, institutional, and social in nature or be related to other common concerns such as perceptions of risk (Olorunkiya, Fassman & Wilkinson, 2012). One problem is that only a small percentage of assessments include the economic benefits of LID technologies (MacMullen & Reich, 2007). While LID is flexible, implementations are highly contextual and technically specific resources are not always available or useful. Ecological goals and social acceptance do not necessarily coincide and sometimes there are tradeoffs. Dense vegetation that may benefit stormwater management and mitigate the urban heat island effect, for example, can compromise people's perception of safety (Yang, Li & Li, 2013).

Figure 2 - Categorical Barriers to LID adoption



Adapted from Olorunkiya et al. (2012).

We found that Mesa is forward thinking, but faces the same set of challenges. The social standing of manicured landscapes makes it difficult to implement more naturalized vegetation that might perform better. Professionals are concerned about adopting new technologies if they perceive them to be risky. More economic data is desired and track records for particular technical implementations such as permeable pavement are considered to be lacking. Codes, policies, and regulations often still favor conventional infrastructure or can hinder LID deployment. Arizona's strong property rights, for example, can be a potent obstacle to change and keeping the public consistently engaged remains a difficult task.

Breaking down Barriers: Lessons From Mesa

"LID can be cheaper and less risky to reverse."

The concept of risk is important for cities to address. Mesa acknowledges that LID is often low-tech in nature and can be more easily altered or removed.

Pilot projects are critical and Mesa is proceeding however it is able. Collaboration amongst arid regions is vital.

"Arid climates still need significant research."

"The ROI argument is a pretty easy sell at Mesa."

Conventional infrastructure is expensive. Mesa is successfully socializing the economic aspects of LID but still needs more financial ammunition.

The Toolkit

One of the ways Mesa hopes to further break down barriers is through the LID Toolkit document currently being developed by Logan Simpson Design, Inc. This document showcases features and techniques that adhere to LID principles and are appropriate for the region. Curb cuts, vegetated swales, bio-retention basins, permeable paving, constructed wetlands, infiltration drainfields, green roofs, and cisterns are all part of the Swiss army knife that Mesa may use to promote LID going forward.

Figure 3 - LID toolkit example: curb cut for water harvesting

From Logan Simpson Design (2014).

Other toolkits have been created and the term is actually quite popular for LID. The concept of the toolkit or toolbox, however, is highly variable. Some examples are simply webpages with collected resources and links while others are incredibly detailed and lengthy documents (Appendix A). From what we have been able to preview, Mesa's incarnation will be one of the most useful: well-organized, straight forward, and audience appropriate. The PDF format has the potential to expand into an active online resource that grows as the needs for LID change while preserving the ability to provide a concise hard copy for dissemination (*Figure 3)*.

Why is LID important?

Entire books have been devoted to how the Phoenix region is one of the most unsustainable places on Earth (Ross, 2011). Agree or disagree, central Arizona does have several serious challenges that LID can help address such as urban heat island effects (Guido, 2008), water supply uncertainty, and extensive, unsightly urban sprawl. According to the National Resources Defense Council (NRDC), there are seven characteristics of LID that make it a viable suite of solutions to these types of urban sustainability problems: LID is effective, economical, flexible, valuable, multifunctional, systems-oriented, and sensible (Holz, 2001).

Conventional controls cause stormwater to pick up pollutants including fertilizers, pesticides, oil, chemicals, pet waste, garbage, and pathogens which eventually empty into waterways, riparian areas, and creek beds. So-called nonpoint source pollution (NPS) is indeed one of the worst culprits for water pollution. However, LID addresses much more than just pollution and water quality. LID best management practices (BMPs) can lower water bills, improve groundwater recharge rates (Newcomer, Gurdak, Sklar & Nanus, 2014) and possibly mitigate the effects of climate change (Pyke et al., 2011).

Win-win situations: Lessons from Mesa

Advocates in Mesa point to LID's multifunctional approach.

"With improved communication, LID will be more effective in the long term."

"LID will convert stormwater to a resource that supports the creation of a high-quality, sustainably built environment"

Imagine a virtuous cycle where stormwater feeds native trees that provide shade which helps people brave high temperatures and walk and exercise more while beautifying their neighborhoods, which then encourages more people to support and implement LID. This is the sort of multiplier effect that Mesa aspires to for LID.

Long term maintenance and benefits of LID still need study in Mesa but the upfront costs can also be significantly lower.

"It is more cost effective to implement LID."

The Toolkit

The toolkit highlights the direct and indirect benefits of LID and the intelligent treatment of water through conveyance, infiltration, evapotransporation, storage, and re-use. It is a clear example of what Mesa is trying to preach: treat water as the valuable resource that it is. The marketing and communication of LID through accessible information is vital to its future expansion.

Why Now?

This case study kept circling around to an important finding: LID is currently at a critical juncture in its history. It seems poised to take off in arid places like Mesa, but in terms of the typical technology adoption curve, LID appears to be in the early adopters' stage. How will LID leap the infamous "chasm" to successfully move from early adoption into being a standard option or requirement for future projects?

The urban heat island (UHI) is a well-studied phenomenon in the Phoenix region that has significantly raised minimum temperatures (Guido, 2008). LID is well positioned to contribute to urban forest cover and motivate the removal of dark-colored heat sinks like asphalt that exacerbate UHI.

Climate change has also upped the ante. As stated in a recent report, a "witches' brew of more frequent and extreme storms, drought, and sea-level rise is beginning to stress some cities' water infrastructure", especially those "already under strain from population growth, development, underfunding, and maintenance backlogs" (Kessler, 2011). Recently, Phoenix and Mesa's infrastructure could not keep up with record rainfall (*Figure 4*) and other cities are already building expensive infrastructure to handle the uncertainties of climate change.

Figure 4 –Flooding in the Phoenix Area, September 2014

Chow,M. (2014).Retrieved from http://www.abqjournal.com/458939/news/cars-engulfed-as-rain-sets-record-for-phoenix.html

Polletta, M. (2014). Retrieved from http://www.azcentral.com/story/news/local/mesa/2014/11/19/lawsuit-filed-over-mesa-neighborhood-flooding/19295677/

Staying ahead of the curve: Lessons from Mesa

"We are now dealing with the consequences of the cookie cutter growth mindset from the 1980s and 90s."

As part of its MS4 stormwater permitting process (for cities with separate stormwater and sanitary sewers), the EPA now mandates LID evaluation and/or implementation (2014). Thus far, Mesa only has to evaluate LID but it wants to remain ahead of the curve and avoid having to abide by regulations that may be inappropriate for a desert climate. Being proactive is a primary driver at the City of Mesa.

Multiple study participants also mentioned that the building lull in Arizona caused by the recent housing collapse has created a golden opportunity for municipalities to institute LID friendly regulation and address institutional barriers. It will too late to lay the groundwork once growth begins anew.

"People won't care until the Colorado River is a political issue."

There is deep division over how to think about water in Arizona. Phoenix's robust water supplies and infrastructure stand in stark contrast to serious drought in the Colorado River Basin and doubts about how many people the area can support. LID can conserve water but also educate people about water in the desert. Educating people before water problems arise should be a high priority.

The Toolkit

The project to create the toolkit comes on the heels of these developments. If the toolkit works as intended, the timing may be perfect. People around the Phoenix metropolitan region are starting to take action and have identified concerns and barriers that, if remedied, could advance LID statewide (EPA, 2012). As a regional leader, Mesa's mission to stay ahead of the EPA and inform the community about the effectiveness of LID will depend on having useful resources at the ready.

The Where

LID has largely developed under the guises of those managing infrastructure in wet and humid climates. It is popular in the Northwest, for example, where annual rainfall can be 15 times that of Phoenix (Osborn, 2014)! Arid cities like Albuquerque and Tucson, however, are also increasingly deploying LID solutions.

Desert cities have unique challenges like water scarcity, heat island effects, and urban sprawl that LID is well-suited to address. And they are increasingly learning from each other through collaborations like The Sustainable Cities Network. Tucson has compiled a list of LID case studies with lessons learned that can be utilized by others to avoid mistakes. The lesson from one project that featured mirobasins, rock wall gabions, curb cuts, and pervious pavement: correct heights for pipes and outlet drains can be challenging so "early coordination with the Civil Engineer is suggested" (LID Working Group, 2014). The accumulation and sharing of LID knowledge over time for arid climates is crucial to help build momentum and save money.

Because of the lack of long track records for LID technologies in arid environments, Mesa is pursuing pilot projects to make an impact and raise public awareness. The public right of way in front of the Mesa Urban Garden was recently retrofitted with curb cuts, stormwater harvesting, and drought tolerant vegetation through a volunteer workshop. The revitalization of the Fiesta District has also presented a chance to watch LID features in action and start to accumulate evidence and knowledge about LID infrastructure.

Figure 6 **-** Before and After: Southern Avenue (Fiesta District) in Mesa

Parker, L. (2014). Retrieved from http://www.azcentral.com/story/news/local/mesa/2014/09/23/mesas-fiesta-district-next-hotspot/16099913/

Parker, L. (2014). Retrieved from http://www.azcentral.com/story/news/local/mesa/2014/09/23/mesas-fiesta-district-next-hotspot/16099913/

The importance of place: Lessons from Mesa

The case of permeable pavement illustrates why LID is so contextual. Permeable pavement has shown to perform well in many situations (Bratteboo & Booth, 2003) but we found a common perception among professionals that the pores of permeable pavement cannot handle the dusty environment of the desert. In addition to treating stormwater and reducing flooding, the lifespan of permeable pavement can be twice as long as conventional pavement and has shown to develop less cracks and potholes (Bean, Hunt, & Bidelspach, 2007). This LID technology may prove to be extremely useful in the desert but maintenance speculation has impeded the public attitude toward its usefulness.

Maintenance, in fact, was the biggest concern of study participants due to uncertainty. The desert's recommended plants and unique climatic conditions causes examples from other parts of the country to be less convincing. But low technology techniques like bioswales and curb cuts have gained traction because of the low capital installation costs and minimal upkeep. These types of LID techniques might enjoy widespread support as part of standard code.

The Players

Part of the reason LID holds so much promise, and faces so many challenges, is because it involves a wide range of stakeholders. Urban planners, architects, engineers, transportation departments, operations and maintenance personnel, developers, private enterprise, property owners, and residents are all ultimately part of LID's success or failure. This chain of responsibility for LID inevitably creates competing interests (Trinkaus, 2009) but Mesa has started to put the pieces of the puzzle in place for future success.

Engagement: Lessons from Mesa

"*The group in Mesa is progressive: we want to be ahead of the curve.*"

Instead of letting change unfold organically, Mesa actively seeks to put the right people in the right places.

Executive level advocacy is key, but the devil is in the details. Maintenance crews will often determine if LID projects are successful over the long run or not.

"*Do we do a good job of cascading? The verdict is out on that.*"

"*Education of the public is critical. What is the value of water?*"

Mesa is a conservative place. In fact, a recent study dubbed it the most conservative large city in the United States (Tausanovitch & Warshaw, 2014). This may make wholesale change based on government initiative difficult. LID in Mesa needs a strong groundswell of support from the community.

One of the most talked about ways to accomplish this is through education, but it is sometimes difficult to determine what department should be doing what. Shoe string budgets also stymie outreach.

The Toolkit

The danger we see with many of the available LID resources thus far is their accessibility. They are either difficult to follow or try to be all things all at once. Mesa's toolkit avoids these pitfalls and seeks to get people familiar with LID without overwhelming them. Designers, developers, and the general public alike can get a solid feel for LID and its benefits and why it really makes sense in so many situations. Being realistic about the people aspect should be a great strength and ensure that the toolkit is not just another source that sits on a shelf or hides in some corner of cyberspace. The open communication and collaboration deployed in Mesa's toolkit effort can serve as a model for others on how to engage the right people.

How to Get It Done

Mesa in Action!

Water Use It Wisely Partner

Sustainable Cities Network

2012 Parks Bond Program

WIFA Grant

LID Toolkit!

Mesa's story of how it got to this point depends largely on passionate people, the exact kind we interviewed for this case study. They have pursued creative funding opportunities, such as the Water Infrastructure Finance Authority (WIFA) grant that funded the toolkit project, and built trust between departments to ensure success. The LID Toolkit itself is designed to be accessible to a wide range of people including engaged citizens, designers, and developers. The document's simplicity and clarity separate it from the majority of toolkits and resources.

> "*Often people are not even aware that we have implemented cost-effective LID solutions that are working.*"

Education topped the list of goals for LID for our interviewees and there are high expectations for the toolkit in this regard. But it was also expressed that the onus cannot lie entirely with city personnel; active civic participation from Mesa's communities is necessary to realize the vision of a more livable and vibrant city. Internally, a focus on communication has paid dividends and there is a real sense of teamwork and shared goals. Demographic shifts may continue to present more opportunities for younger designers, engineers, and executives to work on their own visions of a high quality urban environment.

There are continuing challenges, however. Risk, maintenance, research, resources and expanded education are concerns that surfaced during the study. To address the first, we recommend assessing real and perceived risk at the City of Mesa. Who is responsible for LID implementation and what is their personal or departmental exposure to project failure or other problems? Answering and addressing this question may expedite LID innovation adoption. Contractual risk sharing might be an effective method for Mesa to make risk more equitable and less threatening to individual decision makers.

Strong team collaboration, which Mesa is already working on, has potential to reduce perceived risk while equitable risk sharing can reduce real contractual liabilities to any particular party (Olorunkiya, Fassman & Wilkinson, 2012). The lack of extensive and long term evidence for LID outcomes in arid environments means that risk taking, pilot projects, and experimentation are required to raise the profile of LID and get it implemented on a wider scale. Otherwise, it could remain an infrequent practice with little impact on larger scales.

Maintenance and research are likewise great concerns because of the paucity of evidence. Cities are in the unfortunate crosshairs of a Catch 22: they are often in the best position to advance LID and add to the portfolio of knowledge and experience but lack the resources and institutional controls to produce documented research and data that can be disseminated for wider use. To resolve these problems, funding must be consistently available or they simply will not be addressed. LID can involve considerable capital and ongoing efficiency savings and should be a good fit for a green revolving fund. This may be difficult at the present time because the financial

savings inherent to LID are not as established as other technologies where data collection is much simpler, say for example, direct metered energy savings. Alternatively, this might involve creative use of the EPA's state revolving funds and Clean Water Act grants to establish LID in Mesa as a reputable way to reduce non-point source pollution.

If revolving funds are simply not feasible or available, then LID projects should include a budget item to contribute to both general landscape maintenance training sponsored by the city and LID research and monitoring activities. Money for onsite educational materials could also become mandatory so that all LID projects have publicly accessible plaques explaining and visually showing the improvements to the area, the benefits of LID including any taxpayer savings and how to participate or contribute.

The City of Mesa has started down a path that has the potential to save the city considerable money and resources while raising the quality of life for many of its residents. Along the way, it has the ability to be an important contributor to a growing body of arid climate LID literature. We wish them the best of luck and hope for continuing partnerships that advance ambitious solutions to urban problems.

Mesa Urban Garden

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Appendix A – Toolkit Examples

Source	Information	Included Materials
Tucson Case Studies[1]	LID practices for arid environment categorized by type of space	Detailed examples of LID pilots in Tucson including specs, cost, lessons learned and pictures
Stormwater Low-Impact Development Sites in the Albuquerque Metro Area [2]	Short document with examples	Examples of LID projects
Los Angeles LID Standards Manual[3]	Very extensive document for developers	Technical tools for LID practices
Metropolitan Area Planning Council[4]	Has detailed information but Somewhat difficult to download and use	Reports on watershed management and community workshops
Department of Ecology – State of Washington[5]	Narrow audience	Checklists, worksheets, codes, engineering specs,
San Francisco Water Power Sewer[6]	Well-organized website	Features, siting, benefits, limitations, performance
EPA Green Infrastructure Tool[7]	Online dynamic calculations for engineers	
Cahaba River Society[8]	Lists case studies from around the country	Links to practices, guides, and cost savings sources
Seattle Public Utilities[9]	Detailed information on LID/GI for rainy environments for the general public	YouTube video, features, principles
Oregon Metro Govt[10]	Nice graphics and shallow overview of LID/GI	Case studies, features, comparisons
California Stormwater Quality Association[11]	New website starting to collect documents relevant to CA water management	Compilation of case studies and economics of LID documents
US Army Corps of Engineers[12]	Collection of diverse water resource links	Laws, technologies, data sources, water issues

= arid climate specific

Notes

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