Recommendations for Integrating

Green Infrastructure into the Maricopa County Multi-jurisdictional Hazard Mitigation Plan

March 23, 2020 *FINAL*

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EPA United States Environmental Protection Agency

FEMA

Flood Control District of Maricopa County

City of Phoenix

Tempe ARIZONA

ASU Sustainable Cities Network
Arizona State University

ASU Center for Emergency Management and Homeland Security
Arizona State University

Executive Summary

Local Hazard Mitigation Plans (HMPs) offer a unique opportunity to consider green stormwater infrastructure and Low Impact Development (GI/LID) strategies as a solution to mitigate arid climate hazards, such as drought, flooding and extreme heat, while providing additional co-benefits that align with broader community goals. As frequency and severity of many of these risks are increasing, many local jurisdictions are adopting a proactive and integrated approach to hazard mitigation planning that evaluates strategies that reduce risk while investing in co-benefits that increase environmental sustainability, economic value and local quality of life. The Federal Emergency Management Agency (FEMA) recently updated HMP Guidance to include provisions that allow for and incentivize integrated and GI/LID approaches to hazard mitigation, including funding opportunities for GI/LID mitigation actions included in HMPs.

The U.S. Environmental Protection Agency (EPA) Office of Wetlands, Oceans and Watersheds (OWOW), the Office of Community Revitalization, the Urban Waters Program, EPA Region 9, and the FEMA sponsored technical assistance to support the cities of Phoenix and Tempe and Maricopa County, Arizona, integrating GI/LID suitable to an arid and semi-arid climate into their 2020 HMPs and flood control documents.

The technical assistance centered around a 1.5-day technical assistance workshop held on December 10-11, 2019, to facilitate stakeholder discussion resulting in recommendations on how GI/LID suitable to an arid and semi-arid climate can be integrated into the planning process for the Maricopa County Multi-Jurisdictional Hazard Mitigation Plan (MHMP). This final report summarizes research findings and workshop outcomes, including benefits of GI/LID technologies, strategies for building the regional capacity, recommendations for participating in the MHMP process, and sample mitigation actions for potential inclusion in the 2020 MHMP.

GI/LID technologies preserve and incorporate natural features into the larger land use and site design to achieve multiple stormwater and other co-benefits. Natural features include existing native landscape or constructed systems using grading, a range of soil mediums and plants. For the arid and semi-arid climate risks identified in the 2015 Maricopa County MHMP, GI/LID technologies are most suitable to address:

- **Drought** through localized stormwater water storage/use and lower potable water demand.
- **Extreme heat** through reduced urban heat island effect by reducing impervious surface, increasing moisture storage in the soils and providing shading through trees and understory vegetation.
- **Flooding** by reducing peak flows and volumes through diversion, infiltration, storage distributed throughout the watershed (localized solutions at multiple scales and quantities).

GI/LID technologies can also provide additional co-benefits including improved water and air quality, lower carbon emissions, improved property values, enhanced pedestrian safety and amenities, and long-term cost savings.

Preparing to Engage in the Maricopa MHMP Process

As Maricopa County begins to initiate the MHMP update process, local governments, agencies and regional partners can begin preparing to engage productively and consider how to integrate GI/LID in the process, including:

- Disseminate this report, and companion presentation, to other cities, towns, and tribal communities in the region.
- Coordinate with Arizona State University (ASU) to introduce the GI/LID to Emergency Management Services staff with this report's companion presentation.
- Identify representatives with GI/LID expertise to participate in the MHMP planning process.
- Form internal staff teams to build capacity and evaluate GI/LID strategies to consider.
- Educate leadership, elected officials and constituents on the benefits of GI/LID and its integration with the MHMP.
- Identify near-term updates to local and county plans relevant to GI/LID.
- Review local zoning to identify potential conservation areas that could serve as hazard mitigation.
- Identify barriers to and incentives for integrating GI/LID into development.
- Coordinate with city street, transportation and public works department managers to identify options for integrating GI/LID into street and drainage projects.

Potential GI/LID Mitigation Actions

During the MHMP update process, each jurisdiction will have the opportunity to identify which risk mitigation actions they will adopt to be included in the 2020 MHMP. As part of this process, each jurisdiction can determine where GI/LID could play a role in mitigating risk for extreme heat, drought and flooding. This technical assistance process identified the following potential GI/LID mitigation actions that jurisdictions may wish to consider.

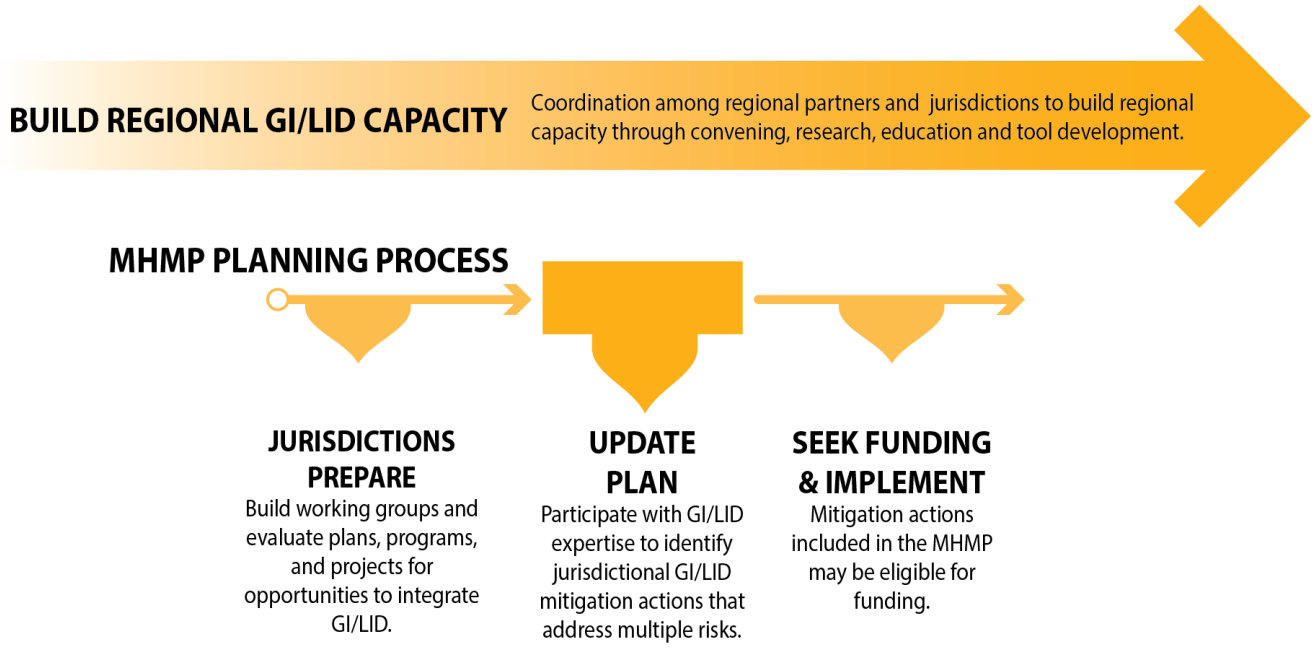
- PLANNING. Consider including GI/LID principles and technologies into relevant plans, manuals, rules, regulations, ordinances and programs, including conservation areas in the general plan and flood and stormwater management plans.
- CAPITAL PROJECTS. Consider including GI/LID projects that address multiple risks in the Capital Improvement Program (conservation area acquisition, street and drainage projects, civic buildings) and pursue a range of funding sources to accelerate their implementation.
- DEVELOPMENT. Assess development regulations and standards to remove barriers and add incentives to integrate GI/LID into new parking lots, landscapes and street improvements for development.
- EDUCATION. Develop guidance, demonstrations and training materials to educate property owners, staff, elected officials and the development community on benefits of GI/LID to address multiple risks.

Building Regional Capacity

During the workshop, participants expressed a need to build regional capacity to integrate GI/LID into local planning, projects and programs. As shown in the diagram below, this capacity building could begin now leading up to the MHMP process and continue in parallel and beyond. Regional guidance, tools, case studies and education could help support local phasing and integration of GI/LID technologies. Participants recommended increasing coordination through a designated regional entity that can build regional capacity through cross-jurisdictional convenings, research, education, and developing tools, guidance and case studies, including:

- Confirm regional partner roles in building regional capacity to implement GI/LID strategies.
- Develop a regional database and tools to help prioritize, promote and fund GI/LID implementation across the region.
- Develop tools to incentivize developers to implement GI/LID strategies.
- Build regional capacity through cross-sector trainings and education.

This report and the companion presentation are intended as guidance that jurisdictions within Maricopa County as well as other arid communities can use to determine how to engage in the MHMP process. The report and companion presentation also provide guidance on what mitigation actions could be considered for governing bodies to adopt, along with the appropriate outreach and education among the range of local stakeholders.



1. Introduction

Local Hazard Mitigation Plans (HMPs) offer a unique opportunity to consider green stormwater infrastructure (GI)/Low Impact Development (LID) strategies as a solution to mitigate arid climate hazards, such as drought, flooding and extreme heat, while providing additional co-benefits to improve water quality, recreation, mobility, habitat, air quality and increased property values that align with broader community goals. The U.S. Environmental Protection Agency (EPA) Office of Wetlands, Oceans and Watersheds (OWOW), the Office of Community Revitalization, the Urban Waters Program, EPA Region 9, and the Federal Emergency Management Agency (FEMA) Region 9 sponsored technical assistance to support the cities of Phoenix and Tempe and Maricopa County, Arizona, in integrating GI/LID suitable to an arid and semi-arid climate into their 2020 HMPs and flood control documents. Consulting firm, Skeo Solutions, was selected by EPA to facilitate this technical assistance. Goals for this technical assistance include the following:

1. Expand the range of tools used to mitigate flood risk to include natural and nature-based solutions (i.e., GI/LID).
2. Identify opportunities to incorporate GI/LID into hazard mitigation and stormwater management planning.
3. Support co-planning and management of flooding, nonpoint source water quality, and protection of areas important to the hydrologic connectivity of the local watersheds.
4. Enhance opportunities for FEMA funds to be directed to GI/LID projects.
5. Achieve co-benefits of GI/LID, including improved water quality, water conservation and drought mitigation, climate mitigation, urban heat island reduction, air quality, and quality of life.

The technical assistance centered around a 1.5-day technical assistance workshop held on December 10-11, 2019, convening nearly sixty representatives from agencies and Maricopa County jurisdictions to develop recommendations on how GI/LID suitable to an arid and semi-arid climate can be integrated into the planning process for the Maricopa County Multi-Jurisdictional Hazard Mitigation Plan (MHMP) and related initiatives and documents. In preparation for the workshop, Skeo reviewed a prioritized set of local city and county studies and other documents on GI/LID in semi-arid landscapes and developed a Summary Report of Research Findings (See Appendix A).

This final report and the companion presentation summarize research findings and workshop outcomes, including benefits of GI/LID technologies for arid and semi-arid climate, strategies for building the regional capacity, recommendations for participating in the MHMP process, and sample mitigation actions for potential inclusion in the 2020 MHMP. This report and companion presentation are intended as guidance that each jurisdiction can use to determine how to engage in the MHMP process and what mitigation actions would be appropriate for their governing bodies to adopt, along with the appropriate outreach and education among the range of local stakeholders. This report and companion presentation may also be a resource for other communities in arid climates as they update their HMPs.

2. Hazard Mitigation Planning Context

The Disaster Mitigation Act of 2000 requires state, local, and tribal governments to have a FEMA-approved HMP to establish eligibility for FEMA's Hazard Mitigation Assistance (HMA) funding programs. The purpose of an HMP is to identify a set of strategies to mitigate the natural hazards that impact the community. Each plan must identify hazard vulnerabilities and impacts, and then outline actions to mitigate the vulnerabilities and impacts identified. HMPs must be updated every 5 years and can be amended throughout the 5-year plan lifecycle. Hazard mitigation actions should be integrated into local jurisdictional mechanisms and can include plans/policies, capital projects, development requirements and programs.

The frequency and severity of many risks, including extreme heat, flood, drought, is increasing with urbanization and changes in climate. As such, many local jurisdictions are adopting a proactive and integrated approach to anticipating and mitigating these risks. Failing to anticipate and mitigate potential risks early can increase the cost and liability to address the hazard risk later, especially after a hazard event has occurred. In addition, hazard preparedness is beginning to factor into local economic stability in terms of bond rating and desirability for businesses and residents to locate in the region. A proactive, integrated approach to hazard mitigation planning evaluates strategies that reduce risk while investing in co-benefits that increase environmental sustainability, economic value and local quality of life.

FEMA recently updated HMP Guidance to include provisions that allow for and incentivize integrated and GI/LID approaches to hazard mitigation, including:

- More focus on integrated planning including natural resources.
- Future conditions considerations including impervious area expansion.
- Incentives to exceed the minimum plan content requirements - "Enhanced Plans" are eligible for more post-disaster funding.
- FEMA focus on resilience creates openness for local initiatives integrated into planning.

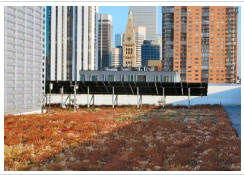
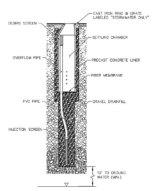
In addition to FEMA, other state and federal agencies are more often prioritizing grant and loan funding for projects with co-benefits, such as GI/LID, that provide multiple community benefits.

3. GI/LID Technologies and Benefits

GI/LID technologies preserve and incorporate natural features into the larger land use and site design to achieve multiple stormwater and other co-benefits. Natural features include existing native landscape, or constructed systems using grading, a range of soil media, and plant materials. Table 1 provides a brief overview of common GI/LID technologies.[1] The effectiveness and benefits of GI/LID features can be increased by designing GI/LID features in a treatment train (a series of consecutive features within the water flow). In addition, performance can be increased by including accessory elements such as curb cuts, rock check dams, sediment traps and dome overflow structures. Vegetation (trees and understory plants) add many co-benefits: reducing water flow, treating pollutants and cooling temperatures.

[1] The GI and LID technologies included in this section were primarily obtained from "Low Impact Development and Green Infrastructure Guidance Manual" and "Greater Phoenix Metro Green Infrastructure Handbook: Low-Impact Development Details for Alternative Stormwater Management." Image sources in order include "Low Impact Development and Green Infrastructure Guidance Manual," "Greater Phoenix Metro Green Infrastructure Handbook: Low-Impact Development Details for Alternative Stormwater Management" and "Arid Green Infrastructure for Water Control and Conservation. State of The Science and Research Need for Arid/Semi-Arid Regions."

Table 1: Overview of GI Technologies

Technology	Description
	**Conservation area** Conservation areas protect undeveloped drainage areas to tap into their natural infiltration and storage capacity. Conserved areas can potentially offer more co-benefits than constructed GI/LID features and are most readily implemented in larger sites such as lower density residential developments and open space.
	**Vegetated bioswale** Vegetated swales are long, shallow channels covered by vegetation and pervious rock or gravel. They provide an alternative to storm drain systems and are best implemented together with other GI/LID technologies, such as sediment traps, infiltration trenches, rock check dams, and curb cuts.
	**Bioretention/stormwater harvesting** Bioretention or stormwater harvesting basins are shallow depressions, sometimes constructed with engineered soils/biosoil media, that collect runoff and use it to support planted vegetation, often adjacent to impervious areas such as parking lots.
	**Rainwater harvesting** Rainwater harvesting uses containers such as cisterns to collect rain for non-potable use at residential and commercial properties.
	**Curb extension** Curb extensions are landscaped areas built out from a low-speed vehicle travel or parking lane.
	**Permeable pavement and pavers** Permeable pavement is pavement with small voids to allow water to infiltrate or drain into a reservoir below. It is appropriate for parking lots with vehicle travel speeds of less than 30 miles per hour.
	**Roof storage** Green roofs use vegetation and soils on relatively flat building rooftops to retain stormwater. They require irrigation in arid and semi-arid climates.
	**Infiltration trench** Infiltration trenches are narrow gravel-filled channels that retain stormwater or transfer it to another location. They are appropriate for commercial, industrial or high-density residential sites. Vegetation cannot be grown on the trenches, but can be placed adjacent and utilize stormwater as it soaks in.
	**Dry well** Dry wells are gravel-filled excavations that are only a few feet in diameter and are applicable for multi-family residential and commercial sites.

Considerations for a Semi-Arid Climate

GID/LID features are most successful in arid and semi-arid climates when local climate and geology, including rainfall, temperature and soils, are factored into the design. In Maricopa County, the climate is considered semi-arid with long periods of dry, hot conditions punctuated by high-intensity, short-duration storms during monsoon season (generally July through September). In the winter, fronts often bring lower-intensity storms to the area. Based on rainfall data from over 300 rain gauges in Maricopa County, the city of Scottsdale determined that 90% to 95% of all storms were less than 1.5 inches which is well suited to effective stormwater management through GI/LID applications.[2] Pima County's 2015 Low Impact Development and Green Infrastructure Guidance Manual suggests that GI/LID features should accommodate between 0.5 and 1.5 inches of rainfall. Maricopa County recommends the 0.5-inch event as the minimum sizing requirement for GI/LID features. This depth of rainfall represents the first flush rainfall, which typically accumulates the highest levels of pollutants.

Soils in Maricopa County tend to exhibit higher permeability and alkalinity but have lower organic matter content. Some soils in Maricopa County may also contain clay or caliche layers that must be removed or punctured to support infiltration and plant growth. Native plant species are well-adapted to the unique conditions of a semi-arid environment and included in several regional GI/LID guidance documents (Pima County and City of Tucson Low Impact Development and Green Infrastructure Guidance Manual, Greater Phoenix Metro Green Infrastructure Handbook: Low-Impact Development Details for Alternative Stormwater Management, Phoenix Active Management Area's Drought Tolerant Plant List.

Risk Mitigation through GI/LID

For an arid and semi-arid climate, the risks identified in the 2015 Maricopa County MHMP, GI/LID technologies are most suitable to address drought, extreme heat, and flood,[3,4] as described in more detail below.

Drought mitigation through greater water storage and lower potable water demand

Many GI/LID features contribute to drought mitigation by increasing infiltration so that a greater volume of rainfall can be recharged at or near its source, helping infiltrate rainfall where it falls, reducing the need for supplemental irrigation. GI/LID features also provide water-efficient landscaping with proper placement of native and low water use plants. For example, a 2017 modeling study estimated that xeriscaping in Phoenix, Arizona, would result in water savings equivalent to 19.8% of the projected annual water consumption in 2050.[5] In addition, many GI features harvest rainfall for use as outdoor irrigation, reducing the demands for potable water. According to the Arizona Department of Water Resources, "the largest use of potable water in Arizona is for landscaping and as much as 70% of residential water use is outdoors."[6] A four-year study of a single-family

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[2] City of Scottsdale and Arizona State University. Greater Phoenix Metro Green Infrastructure Handbook: Low-Impact Development Details for Alternative Stormwater Management. Prepared by Dibble Engineering and Logan Simpson. January 2019.

[3] Managing stormwater at or near its source in the upper portions of a watershed can also help mitigate other flood-related hazards like levee failure and dam inundation, if overall volume and peak are reduced. Also, fissure and subsidence issues can have a significant impact to flood control facilities reducing flood risk effectiveness. Addressing over pumping of groundwater and mitigating water demand for outdoor uses via GI/LID water conservation and recharge strategies can help mitigate this risk.

[4] The benefits of GI and LID included in this section were primarily obtained from "Low Impact Development and Green Infrastructure Guidance Manual," "A review of green infrastructure performance in arid environments," and "Arid Green Infrastructure for Water Control and Conservation: State of the Science and Research Needs for Arid/Semi-Arid Regions" with supplementary information cited in subsequent footnotes.

[5] Yang, J., and Wang, Z. H. (2017). Planning for a sustainable desert city: The potential water buffering capacity of urban green infrastructure. *Landscape and Urban Planning*, 167, 339-347.

[6] Arizona Department of Water Resources Conservation Program. Retrieved November 21, 2019, from https://new.azwater.gov/conservation/landscaping.

household in Tucson, Arizona, found that rainwater water harvesting reduced the household's municipal water use by 66%.[7]

Extreme heat mitigation through reduced urban heat island effect

GI/LID features can mitigate extreme surface temperatures through shade and evapotranspiration from vegetation. Studies have shown vegetation (including trees, shrubs, grasses and groundcovers) can lower local temperatures in open terrain by 9° Fahrenheit (F) and in suburbs without trees by 4 to 6°F.[8] GI/LID features such as green roofs also provide similar cooling effects at the scale of an individual building. Green roofs reflect more solar radiation than conventional roof surfaces, leading to less solar radiation absorbed by buildings and lower roof temperatures. For instance, a study of green roofs on University of Central Florida buildings found that the average maximum temperature for green roofs was 86°F, while the average maximum temperature for conventional roofs was 134°F.[9] Similarly, a 2017 modeling study found ground air temperatures in Phoenix, Arizona, would decrease by up to 35.6°F if green roofs were present throughout the city.[4] When incorporated into large open green space, GI/LID can help cool extensive urban areas. Studies have found that temperatures in urban parks can be 2.7 to 7.2°F lower than their surroundings.[8] This cooling effect can extend well past park boundaries. In some cases, lower temperatures have been observed at distances of over half a mile from parks.

Flood mitigation through diversion, infiltration, storage

The benefits of GI/LID features for stormwater management are well-documented in the literature. GI/LID can mitigate floods by using vegetation, soils and other engineered materials to increase the infiltration, evapotranspiration, interception, and management of rainfall. Vegetation intercepts rainfall through their leaves and branches, reducing the volume of water that reaches the ground. Engineered soils and established landscape areas absorb rainfall that reaches the ground and flows into the designed water-harvesting elements. As the water moves through GI/LID features, it is slowed by check dams, plant materials, and other components. Through these mechanisms, GI/LID features reduce the overall volume and rate of runoff downstream.

Several field studies and models demonstrate these stormwater benefits in arid environments. Following large storms with over 2 inches of rainfall, a 2010 study found that permeable pavement in restrictive soils reduced discharge volumes by approximately 46%.[10] Likewise, a 2015 study found that GI in Tucson, Arizona, reduced peak flows after intense rainfall events by 10% to 24%.[11] Similarly, a 2016 study demonstrated that bioretention systems, bioswales, cisterns and permeable pavement in three areas in Tempe, Arizona, reduced peak flows between 58% to 86%.[12] A 2012 modeling study in Phoenix, Arizona, estimated that bioswales and bioretention basins can capture up to 98.4% of rainfall from 95th percentile (one inch) storms.[13]

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[7] Jiang, Y., Yuan, Y., and Piza, H. (2015). A review of applicability and effectiveness of low impact development/green infrastructure practices in arid/semi-arid United States. *Environments*, 2(2), 221-249.

[8] The Trust for Public Land. "The benefits of green infrastructure for heat mitigation and emissions reductions in cities." June 2016.

[9] U.S. Environmental Protection Agency. 2008. Reducing urban heat islands: Compendium of strategies. https://www.epa.gov/heat-islands/heat-island-compendium.

[10] Fassman, E. A., and Blackbourn, S. (2010). Urban runoff mitigation by a permeable pavement system over impermeable soils. Journal of Hydrologic Engineering, 15(6), 475-485.

[11] City of Tucson and Pima County Regional Flood Control District. Solving Flooding Challenges with Green Stormwater Infrastructure in the Airport Wash Area. Prepared by Watershed Management Group. May 2015.

[12] Tempe Area Drainage Master Study, LID Application Review and FLO-2D Modeling, Revised April 2016.

[13] Meerow S., Natarajan M., and Krantz D. "A review of green infrastructure performance in arid environments." Unpublished manuscript. October 14, 2019.

GI/LID technologies can also provide the following additional co-benefits as outlined in Table 2.

- Improved water quality
- Improved air quality
- Lower carbon emissions
- Enhanced community values
- Improved property values
- Long-term cost savings
- Enhanced pedestrian safety and amenities, including canopy shade, pedestrian-scale cooling

Table 2: Co-Benefits of GI/LID Technologies

Co-Benefit	Supporting Research
Improved water quality	76-99% reduction in total suspended solids from bioswales[14]
Improved air quality	40% reduction in nitrogen dioxide concentrations and 60% reduction in particulate matter from grass, ivy and other plants[15]
Lower carbon emissions	Over 58,700 tons of carbon stored by urban trees in Phoenix, Arizona[16]
Enhanced pedestrian safety and amenities	Lower vehicle travel speeds, greater physical activity through walking or biking[17]
Enhanced community values	Stronger sense of place, safety and trust[18]
Improved property values	Up to 30% increase in property value near parks[19]
Long-term cost savings	60% reduction in annual building energy consumption for cooling[20]

[14] Sansalone, J., Raje, S., Kertesz, R., Maccarone, K., Seltzer, K., Siminari, M., Simms, P. and Wood, B. (2013). Retrofitting impervious urban infrastructure with green technology for rainfall-runoff restoration, indirect reuse and pollution load reduction. Environmental pollution, 183, 204-212.)
[15] Jiang, Y., Yuan, Y., and Piza, H. (2015). A review of applicability and effectiveness of low impact development/green infrastructure practices in arid/semi-arid United States. Environments, 2(2), 221-249.
[16] Polonsky H., Cohen-Cline H., and Wolf K. Green Infrastructure and Health Guide. Willamette Partnership and Oregon Public Health Institute. Prepared by the Oregon Health and Outdoors Initiative. January 2018
[17] Polonsky H., Cohen-Cline H., and Wolf K. Green Infrastructure and Health Guide. Willamette Partnership and Oregon Public Health Institute. Prepared by the Oregon Health and Outdoors Initiative. January 2018.
[18] Pima County and City of Tucson. Low Impact Development and Green Infrastructure Guidance Manual. March 2015.
[19] The Trust for Public Land. Prepared by the by the Urban Climate Lab at the Georgia Institute of Technology. (2016).
[20] The Benefits of Green Infrastructure For Heat Mitigation And Emissions Reductions In Cities.

Priority GI/LID Technologies

Table 3 on the next page outlines the relative benefits of GI/LID technologies for hazard mitigation in an arid and semi-arid climate as well as other co-benefits. Workshop participants identified the GI/LID technologies listed below as the most beneficial GI/LID strategies to mitigate risks from flooding, extreme heat and drought.

Extreme heat	Drought	Flooding
✓ Conservation areas ✓ Vegetated bioswales	✓ Conservation areas ✓ Bioswales, bioretention and stormwater harvesting basins ✓ Cistern/stormwater harvesting	✓ Conservation areas (and constructed wetlands) ✓ Bioretention and stormwater harvesting basins (detention)

During the workshop, City of Tempe led a tour of a local desert GI/LID installation that provides multiple benefits including enhanced pedestrian safety and amenities, including canopy shade and pedestrian-scale cooling.

Table 3: Relative Benefits of GI/LID Technologies

Technology	Relative Cost	Mitigates the Following HMP Risks				Quality of Life Benefits
		Flooding	Drought	Extreme Heat	Water Quality	
Conservation area*	$	●	◒	●	●	Wildlife habitat, planting feature, aesthetics, air quality
Vegetated* bioswale	$$	●	◒	●	●	Habitat, planting feature, aesthetics, trash capture, traffic calming, air quality
Bioretention/ stormwater harvesting *	$$	●	●	●	●	Wildlife habitat, planting feature, aesthetics, air quality
Rainwater harvesting	$	◒	◒	◒	◒	
Curb extension*	$$	◒	◒	◒	◒	Habitat, planting feature, traffic calming, aesthetics, trash capture
Permeable pavement	$$-$$$	●	◒	◒	●	Traffic calming (includes permeable asphalt, porous concrete, permeable pavers, stabilized granite surfaces)
Roof storage*	$$$	◒	○	●	◒	Wildlife habitat, planting feature, aesthetics
Infiltration trench	$	●	◒	○	●	
Dry well	$	●	◒	○	●	

Key: Benefits ● = high; ◒ = medium; ○ = low

Relative Costs (Capital and O&M) $$$ = high; $$ = medium; $ = low

* Elements that include vegetation as an essential function component addressing the hazard risks.

☐ Priorities identified by workshop participants as the most effective in mitigating the selected risks.

4. Engaging in the MHMP Process

Preparing to Engage in the Maricopa MHMP Process

As Maricopa County begins to initiate the MHMP update process, local governments within Maricopa County can begin preparing to engage productively and consider how to integrate GI/LID in the process. This section provides a menu of ideas jurisdictions can consider as they evaluate their current application of GI/LID and identify appropriate goals and next steps. These ideas and recommendations are the result of the input from the planning team and workshop attendees. Some of these recommendations could result in the need for public engagement and outreach by the jurisdiction(s) during goal development and implementation. For example, jurisdictions may consider the following activities in preparation for and during the MHMP process:

- Disseminate this report to other cities in the region to build common understanding and momentum and coordinate across cities through the MHMP process to align the integration of GI/LID across jurisdictional mitigation actions.
- Coordinate with ASU to introduce the GI/LID to Emergency Management Services staff throughout the county and metropolitan region.
- Identify jurisdictional representatives with GI/LID expertise to participate in the Maricopa County multijurisdictional HMP planning process.
- Form internal staff teams to build capacity and evaluate GI/LID strategies to consider in the mitigation action selection process.
- Educate leadership, elected officials and constituents on the benefits of GI/LID.
- Identify near-term updates to local and county plans relevant to GI/LID (e.g., drought management plan, flood management plan, stormwater management plan, capital improvement plan, general plan) and opportunities for plan integration and incorporating GI/LID systematically. See Table 4 for a list of plans generated by workshop participants that could integrate GI/LID during plan integration and updates.
- Review local zoning to identify potential conservation areas that could serve as hazard mitigation. Areas may include headwater protection, constructed wetlands, forest management, natural washes and riparian buffers, based on multiple benefits and ability to mitigate risks of drought, flooding and extreme heat. For example, see Pima County Regional Flood Control District for Riparian Acquisition and Mitigation efforts and wash setback ordinances to preserve the natural function of washes and water courses to manage flood, drought, erosion, heat and habitat loss.
- Identify barriers[21] to and incentives for integrating GI/LID into development. Consider adopting GI/LID technical guidance for development such as outlined in the Greater Phoenix Metro Green Infrastructure Handbook, along with information on native, drought-tolerant vegetation options for arid areas that can be used in GI/LID vegetated features.
- Coordinate with city street, transportation and public works department managers to identify options for

[21] For example, see Green Infrastructure Barriers and Opportunities in Phoenix, Arizona: An Evaluation of Local Codes and Ordinances (EPA, 2013).

integrating GI/LID into street and drainage projects. As a resource, see technical specifications in the Greater Phoenix Green Infrastructure Handbook[1] and relevant Complete Streets policy and guidance[1] for street improvement projects.

Considerations During the Maricopa MHMP Process

This section identifies opportunities for Maricopa County's multijurisdictional HMP planning team to consider throughout the MHMP update process. These considerations are organized by the 2015 MHMP plan sections for reference. Appendix A outlines these recommendations in a table format that cross-references relevant text from each section of the 2015 MHMP.

During the planning process (documented in Section 3 of the 2015 MHMP):

- Include representatives with GI/LID expertise in the Maricopa County multi-jurisdictional HMP planning team. (pg. 8, Section 3.3)
- Reference this report, appendices and key documents from the bibliography (such as the Greater Phoenix Metro Green Infrastructure Handbook), in the list of Reference Documents and Technical Resources. (pg. 19, Section 3.5)
- As part of the plan integration process, reference past plan updates relevant to GI/LID included in the bibliography of this report. Also include future plan updates relevant to GI/LID into the five-year plan integration strategy, such as the drought management plan, flood management plan, stormwater management plan, capital improvement plan and general plan. See Table 4 for a full list of potential plans to consider during plan integration. (pg. 21, Section 3.6)

During the Community Description phase (documented in Section 4 of the 2015 MHMP):

- Consider expanding community descriptions (for example, see community description for Phoenix) to include a more holistic understanding of the policy initiatives (such as sustainable development) that support a more integrated and GI/LID approach to hazard mitigation. (pp. 57-137, Section 4.3)

During the Risk Assessment Phase (documented in Section 5 of the 2015 MHMP):

- Include GI/LID expertise on the multi-jurisdictional planning team to inform Hazard Identification and Screening. (pg. 141, Section 5.1)
- Include the most recent data and research from ASU on drought and extreme heat vulnerability and hot spots in the Vulnerability Analysis Methodology. Also include local climate studies in Climate Change section that discuss the impact of urbanization on vulnerability to flooding and extreme heat. (pg. 144, Section 5.2)
- Under Hazard Risk Profiles for drought, include the use of rainwater as a water source to meet non-potable regional supply demands. (pg. 167) Also include the impacts of impervious surfaces and urbanization on local area pluvial flooding. (pg. 191) (Section 5.3)

As part of the Mitigation Strategy (documented in Section 6 of the 2015 MHMP):

- Include reference to an integrated or GI/LID approach in the HMP goals and objectives for the Countywide HMP. This reference better positions the county and other local jurisdictions for applicable FEMA funding to implement GI/LID-based risk mitigation strategies. For example:

  Include conservation areas, bioretention and other site appropriate GI/LID in mitigation planning, actions and education to address multiple risks (drought, extreme heat, and flooding) while providing additional quality of life and other co-benefits. GI/LID strategies provide co-benefits that address more than one risk.

- As part of Jurisdictional Mitigation Capabilities Assessment (Section 6.2.1), each jurisdiction has an opportunity to assess the regulatory, fiscal and technical capacity to implement GI/LID as risk mitigation and identify associated gaps and resource needs. For example:

  - Legal and Regulatory Capability: Under Regulatory Tools for Hazard Mitigation, this report's bibliography can serve as a reference for evaluation. In particular, the Green Infrastructure Barriers and Opportunities in Phoenix, Arizona: An Evaluation of Local Codes and Ordinances (EPA, 2013) provides a useful framework for evaluating barriers and gaps to implementing GI/LID. In addition, Table 4 provides a list of plans, capital projects, regulations and programs that could potentially be adapted to implement GI/LID as a risk mitigation strategy.
  - Fiscal Capability: Each jurisdiction can identify resources needed to implement the GI/LID risk mitigation actions (and funding sources as appropriate, including rates, bonds, grants, technical assistance).
  - Staff Capability: Jurisdictions may also identify the need for GI/LID technical expertise. (pp. 229-230) Workshop participants identified the need for a funded position that could provide technical GI/LID expertise to jurisdictions throughout the county.

- As part of the National Flood Insurance Program (NFIP) jurisdictional questionnaire, each jurisdiction has an opportunity to identify specific jurisdictional needs to implement GI/LID mitigation actions. These could include strategies listed in the next section of this report. (pg. 292, Section 6.2.4)
- As appropriate, the multijurisdictional team could include the GI/LID strategies documented in this report as potential new mitigation actions each jurisdiction could consider. (pg. 358, Section 6.3.2)

As part of the Tools and Definitions (documented in Section 8 of the 2015 MHMP):

- Include definitions for extreme heat and urban heat island effects. (pp. 446-447) Also include the impacts of impervious surfaces and urbanization on local area pluvial flooding. (pg. 448, Section 8.2)

Table 4: Opportunities to Integrate GI/LID into Local Jurisdictional Operations

This table outlines avenues to integrate GI/LID into local planning, capital projects, development and education programs. Jurisdictions may reference this list as they consider plan updates to identify opportunities to integrate GI/LID. Bold items are those the workshop participants identified as having the greatest GI/LID near-term potential.

Planning	Capital Projects	Development Requirements	Stewardship and Education
☐ **General plan (designate open space areas)** ☐ **Flood management plan** ☐ **Capital improvement plans** ☐ **Stormwater management plan** ☐ **Drought management plan** ☐ Area drainage studies and plans ☐ FEMA Continuity Evaluation Tool plan ☐ Water infrastructure plan ☐ Watershed management plan ☐ Integrated water resource plan ☐ Parks and trails plan ☐ Tree canopy plan ☐ Habitat plan ☐ Climate action plan ☐ Sustainability plan ☐ Specific area plans (downtown plans) ☐ Affordable housing development plan ☐ Green Streets or Complete Streets plans ☐ Transportation plans	☐ **Flood control** ☐ **Storm drainage** ☐ **Street improvements** ☐ **Civic projects such as schools, libraries, community centers and municipal buildings** ☐ Transportation or transit capital improvement projects ☐ Parks, trails or conservation projects ☐ Groundwater storage projects ☐ Cross-jurisdictional state or regional projects ☐ Neighborhood improvement or redevelopment projects ☐ Water and wastewater projects	☐ **Parking lot standards and guidance** ☐ **Landscape standards** ☐ **Street improvement standards and guidance** ☐ Building design – allow for or require rainwater harvest and gray water use in building design ☐ Building and public works standards – adopt regional standards through a multi-jurisdictional planning agency such as the Maricopa Association of Governments (MAG) ☐ Stormwater utility fees – allow credits that reduce fees for properties that incorporate GI/LID ☐ Tree canopy cover – adopt requirements for percent canopy cover ☐ Developer incentives – provide expedited permit review or fee reductions for developments that incorporate GI/LID ☐ Zoning ordinances – provide sustainability bonus points for GI/LID ☐ Rebate and audit programs – provide rebates for properties that participate in a GI/LID audit	☐ **Water conservation** ☐ **Landscape guidance** ☐ **Extreme heat** ☐ **Integrated GI guidance highlighting multiple benefits** ☐ **Standard training events for landscape contractors and developers on operation and maintenance** ☐ Flooding hazards ☐ Air quality ☐ Urban forestry and conservation ☐ Rooftop solar and stormwater storage ☐ Training events for community groups

5. Potential GI/LID Mitigation Actions

During the MHMP update process, each jurisdiction will have the opportunity to identify which risk mitigation actions they will adopt for the next five-year period, which will be documented in the individual jurisdictional Mitigation Action tables of the 2020 MHMP (currently sections 6-8-1 to 6-8-28 of the 2015 MHMP). As part of this process, each jurisdiction can determine where GI/LID could play a role in mitigating risk for extreme heat, drought and flooding. GI/LID technologies could potentially be integrated with many of the mitigation actions already included in the 2015 Maricopa County MHMP. For example, Table 5 outlines mitigation actions from the 2015 MHMP that could be adapted to include GI/LID technologies.

Table 5: Example Mitigation Strategies from the 2015 MHMP That Could Integrate GI/LID

The table below includes some of the mitigation actions by jurisdiction from the 2015 MHMP. The *italicized blue font* illustrates how GI/LID could be integrated into existing mitigation actions.

Jurisdiction	Planning	Capital Projects	Development Requirements	Stewardship and Education
City of Phoenix (Table 6-8-18, 2015 MHMP)	Updates to the Drought Response Plan. Policies in the General Plan that designate areas for open space *with an emphasis on protecting natural drainage areas*.	Drainage facilities, *with an emphasis on GI/LID strategies that address multiple risks* to mitigate flooding hazard.	Floodplain revisions to existing building codes *including incentives for GI/LID approaches to roofs, parking and landscape areas*[22].	Water use awareness outreach program.
City of Tempe (Table 6-8-24, 2015 MHMP)	Update the 2002 Water Resources Plan, the 1999 Tempe Integrated Water System Master Plan, and the 2002 Drought Management Strategy Plan *to include GI/LID projects that mitigate drought*.	Projects, *including priorities for GI/LID approaches*, to increase groundwater storage and recovery and mitigate flooding.	Building permit review for compliance with floodplain regulations *including incentives for GI/LID approaches to roofs, parking and landscape areas*.[21]	Education on the hazards of extreme heat, *including guidance on GI/LID features to mitigate extreme heat*. Workshops and conferences on hazard mitigation.
Unincorporated Maricopa County (Table 6-8-26, 2015 MHMP)	Area Drainage Master Studies/Plans. Updates to the 2009 Comprehensive Floodplain Management Plan *including priorities for GI/LID projects that provide multiple co-benefits*.	Projects to mitigate flooding hazards through the Flood Control Capital Improvement Program.	Building permit review for compliance with floodplain regulations. Revisions to existing building codes *including incentives for GI/LID approaches to roofs, parking and landscape areas*.	Public education program about flooding hazards and water conservation.

[22] Potential to adopt the Greater Phoenix LID Handbook Specs & Details for use in public and private development including private development incentives.

This section outlines a menu of potential GI/LID-based mitigation actions that jurisdictions (including the county, cities, agencies and tribal communities participating in the MHMP process) can consider as they plan for which mitigation actions they will include in the 2020 MHMP. Jurisdictions can refer to this reference list as they assess their goals, needs, and capabilities. Due to different priorities and capacities, jurisdictions may vary widely on the degree they can integrate GI/LID into their section of the 2020 MHMP. This list includes general mitigation actions that will need to be tailored and made more specific to reflect the jurisdiction's goals. The text boxes on this page and the next outline examples of specific mitigation action text from other jurisdictions including Pima County and other jurisdictions in FEMA Region 9. In addition, the implementation of some of these actions may result in the need for public engagement/outreach by the local jurisdiction to their community, including public at large, developers, non-profit organizations, educational institutions, etc. prior to implementation.

Planning

Consider including GI/LID principles and technologies into relevant plans, manuals, rules, regulations, ordinances and programs. For example:

- Incorporate conservation areas in the general plans including headwater protection, constructed wetlands, unique native landscapes or habitat, natural washes and riparian buffers.
- Incorporate (and prioritize where appropriate) vegetated bioswales, bioretention systems and other site appropriate GI/LID in local jurisdiction and agency flood and stormwater management plans.
- Include land acquisition for conservation areas and GI/LID in the capital improvement/management plans.
- Integrate GI/LID goals and strategies into other relevant plan updates over the next five-year period.

Mitigation Action Examples from Pima County MHMP

- Continue to identify vulnerable populations for heat recreational activities, visitors/travelers, hospitality industry, homeless populations, and build cooling center capacity. --$100K
- Conduct a public education campaign to increase awareness of natural hazards by distributing Arizona Division of Emergency Management and Pima County mitigation flyers at community events and public gathering opportunities, as appropriate. --$500
- Remove regulatory barriers and develop programs that support sustainable designs, landscapes, green infrastructure, and development practices. Update and develop new building codes and design standards that help reduce urban heat island effect. --Staff Time
- Continue to fund and promote rebate and incentive programs: --$1.4M
- Continue to participate in, promote and sponsor the Pima County SmartScape program in partnership with the University of Arizona Cooperative Extension. --$239K
- Buffelgrass Mitigation – identify public outreach opportunities, locate county areas for mitigation of buffelgrass and administer grant funding for ongoing activities related to wildfire reduction through removal and reduction in Buffelgrass. --$3K

Capital Projects

Consider including GI/LID projects that address multiple risks in the capital improvement programs and pursue a range of funding sources to accelerate their implementation. For example:

- Prioritize vegetated bioswales, bioretention systems and other site-appropriate GI/LID in flood control projects and removal of non-native vegetation to reduce wildfire risk.
- Prioritize vegetated bioswales, bioretention systems and other site-appropriate GI/LID in street/storm drainage improvements.
- Incorporate vegetated bioswales, bioretention systems and other site-appropriate GI/LID in civic and school projects.
- Adopt an evaluation method to incentivize the use of GI/LID in capital projects.
- Pursue a range of funding to implement GI/LID projects that address multiple risks.

FEMA Funded GI/LID Mitigation

Squaw Creek Flood Mitigation Project, City of Ames, Iowa

The Squaw Creek Resilient Infrastructure Flood Mitigation Project, included in the City's 2020/2021 Capital Improvements Plan, is estimated to reduce flooding by two feet along the major flood damage center in the South Duff Avenue commercial corridor. The project includes channel excavation of Squaw Creek at South Duff Avenue to improve creek capacity and resilience in large storm events. Additionally, the project will use stabilization techniques including natural channel design, streambank toe protection, and planting native vegetation to increase protection to area development.

Hazard Mitigation Assistance Grant: *Funded 75% ($3.7 million) of the project's $4.9 million cost.*

Benefit Cost Analysis (BCA): *Included almost $1M in environmental benefits. The FEMA BCA tool calculates the environmental benefits of turning land into a riparian area at $39,535/acre which was a competitive feature of this grant application. The total project area was about 27 acres of which 90% would be converted into riparian land and the remaining 10% would become open space.*

Example of local desert GI/LID installation with plantings suitable for arid and semi-arid climates.

Development

- Assess development regulations and standards to remove barriers and add incentives to integrate GI/LID into new parking lots, landscapes and street improvements for development.

Education

- Develop and distribute landscape guidance and training materials to educate property owners on how to design and manage their landscape with GI/LID co-benefits that address multiple risks to address extreme heat, water conservation and stormwater management.
- Develop guidance and training to deliver to staff, elected officials and the development community on GI/LID, benefits, value to incorporating into MHMP.
- Construct GI/LID demonstrations to evaluate performance, provide case study examples, and provide a means to educate development professionals and the broader community.

FEMA Funded GI/LID Mitigation Project

Watershed Restoration and Flood Mitigation Project, Santa Clara Pueblo, New Mexico

Santa Clara Pueblo is a federally recognized tribe located on the Rio Grande in Northern New Mexico. Since 1998, three severe wildfires have burned over 80% of Santa Clara forested lands, and post-fire flooding devastated the Santa Clara Creek and Canyon resulting in five Presidential Disaster Declarations. Recovery efforts focused on watershed restoration and prioritized innovative restoration principles to mitigate future flood events and periods of drought, while revitalizing stream habitat for reintroduction of native Rio Grande Cutthroat Trout. Mitigation includes bottomless culverts, and utilizing on-site, natural materials to provide grade control, induced stream meandering, and fish and wildlife habitat enhancement. The project received EPA Green Infrastructure Award in 2018 at the 205h Annual Stormwater Conference.

HMA grant: *HMGP*

BCA: *Environmental benefits accounted for in the BCA include improvement of riparian habitat to support reintroduction of Rio Grande Cutthroat Trout, resiliency to variable events through flood and drought mitigation, hazardous fuel reduction, mitigation against erosion /sediment transport.*

Nearly sixty representatives from federal, state, and local government, ASU and partner organizations gathered on December 10 and 11 to develop recommendations for integrating GI/LID into local and regional hazard mitigation planning.

Mitigation Action Examples from Other MHMPs in FEMA Region 9

City of Oakland HMP

- GI planning - develop a GI Plan to identify areas of opportunity and standards for inclusion of GI in public capital projects.

San Mateo County HMP

- Support GI projects that enhance resiliency to natural disasters and incorporate green design elements into hazard mitigation projects where feasible.
- Develop and implement a GI Plan to improve stormwater quality and flood protection.

City of Alameda HMP

- Complete and implement a municipal GI Plan for the inclusion of low impact development drainage design into storm drain infrastructure on public and private lands.

Vallejo Sanitation and Flood Control District HMP

- Analyze the District's stormwater system to reduce local flooding caused by possible inadequate storm drainage using modeling, design, GI and construction.

City of San Leandro HMP

- Develop a GI Plan to identify areas of opportunity and standards for inclusion of GI in public capital projects.

City of Orange HMP

- Develop and implement long-term strategies to reduce community water use, including mandatory use of drought-tolerant plants in new or replacement landscapes, and requirements to install water fixtures in new buildings that exceed minimum code requirements.

City of Huntington Beach

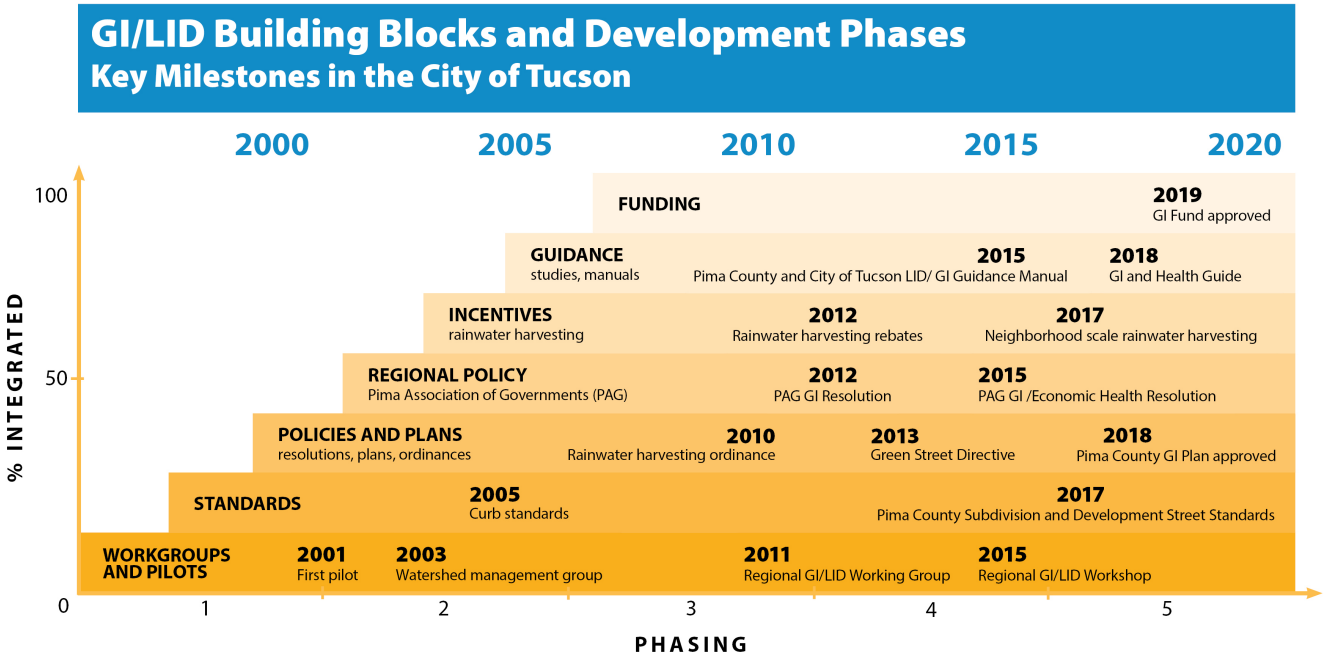
- Require all new bluff-top developments to submit drainage plans to minimize erosion, emphasizing soft infrastructure where feasible.
- Use LID strategies in new and substantially retrofitted City-maintained areas as appropriate, including landscapes, roads, parking lots, and public parks and spaces.
- Ensure that new development projects or infrastructure will not alter local hydrology and increase the flood risk for surrounding properties.
- Require development projects within the 100-year floodplain to be sited, designed, and constructed to minimize flood risk.
- Require large new developments and substantial retrofits to use LID strategies to reduce ponding risks, including permeable paving, bioswales and rain gardens.
- Encourage the use of setbacks, low-impact development and elevated structures.
- Replace landscaping at City properties with drought-tolerant plantings to the extent feasible.

Rancho Santiago Community College District Natural HMP

- Incorporate drought-tolerant practices to reduce dependence on irrigation.

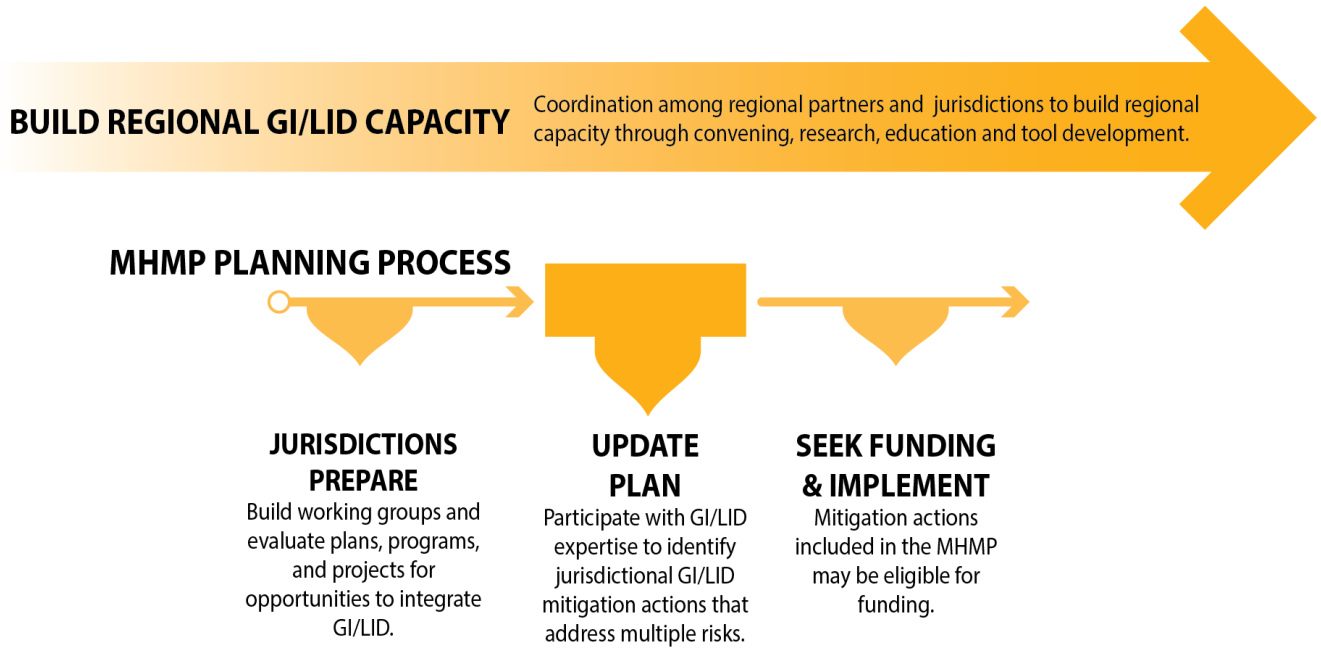
Building Blocks for Phasing GI/LID Over Time

Each jurisdiction will have its own timeline for adopting GI/LID approaches into local planning and development. For example, the City of Tucson has been phasing in GI/LID over twenty years beginning with their first pilot in 2000 and most recently adopting a GI/LID funding plan. The diagram below shows how jurisdictions can use building blocks to step up GI/LID integration (vertical axis) though phasing over time (horizontal axis). Key milestones in City of Tucson are highlighted to show the evolution from demonstration to guidance, incentives policy and funding.



6. Building Regional Capacity

During the workshop, participants expressed a need to build regional capacity to integrate GI/LID into local planning, projects and programs. As shown in the diagram below, this capacity building could begin now leading up to the MHMP process and continue in parallel and beyond. Regional guidance, tools, case studies and education could help support local phasing and integration of GI/LID technologies suitable to an arid and semi-arid climate. Participants recommended increasing coordination through a designated regional entity that can build regional capacity through convening, research, education and developing tools, guidance and case studies. Participants suggested the following regional capacity building strategies.



1. Confirm regional partner roles in building regional capacity to implement GI/LID strategies.

Action steps could include:

- Form a Stormwater Subcommittee, either within the Maricopa Association of Governments (MAG) or as part of AZ Water Association to coordinate on regional roles, initiatives and information exchange.
- Coordinate a peer exchange between MAG, Pima Association of Governments (PAG) and ASU to identify actions MAG could adopt to support GI/LID.
- Identify how best to leverage regional authorities and expertise among ASU, MAG, AZ Water Association, Flood Control District of Maricopa County (FCDMC).
- Adopt a joint resolution that formally articulates MAG's support for GI/LID strategies to advance transportation safety, water quality, air quality and economic development while reducing risks of drought, extreme heat and flooding.

- Fund regionally accessible GI expertise (for example through The Nature Conservancy or the Watershed Management Group).
- Leverage ASU expertise, research findings, data collection and analysis, and convening capacity. Coordination with existing programs such as the Sustainable Cities Network (GI Workgroup) that are already working with local communities on GI/LID policy, practices, are resource development.
- Engage the state to integrate GI/LID in the State HMP and implement demonstration pilots throughout multiple jurisdictions.

Potential Funding Resources: Arizona Department of Water Resources (ADWR), Arizona Department of Environmental Quality (ADEQ) and FCDMC.

2. Develop a regional database and tools to help prioritize, promote and fund GI/LID implementation across the region.

Action steps could include:

- Develop a regional prioritization GIS-based tool to assess existing GI/LID projects and prioritize future conservation areas and capital improvement projects based on natural resources, equity and risk severity.
- Develop/adopt a regional cost-benefit tool with success metrics to support funding and integration into local planning and projects.
- Document case studies in arid environments that assess pilot project performance and long-term function and include cost-benefit analyses comparing GI/LID strategies with conventional gray infrastructure.
- Develop a guidance document to suggest municipal planning and policy options that will facilitate GI/LID implementation. This document may involve coordination with the MAG's Water Advisory Committee, Standard Specifications & Details Committee, Active Transportation Committee, Building Codes Committee and Transportation Safety Committee.

GI/LID Cost Benefit Tools

Cost benefit tools provide a means of comparing the cost of constructing and maintaining GI/LID features to the economic value obtained from flood control and other benefits. Cost Benefit Analysis (CBA) quantifies and attributes monetary values to the Triple Bottom Line (TBL: economic, social, environmental) impacts resulting from an investment. TBL-CBA expands the traditional financial reporting framework (such as capital, and operations and maintenance costs) to also consider social and environmental performance. The City of Phoenix, Pima County and other jurisdictions have applied a cloud-based cost/benefit model (Autocase) to evaluate the net value of GI/LID features. In 2014, Pima County published the "Evaluation of GI/LID Benefits in the Pima County Environment" which summarized results from an Autocase Beta Testing project that considered additional benefits including traffic calming, reduced accidents, road surface life, and arid climate water concerns as part of the overall value.

In 2018, the City of Phoenix conducted several studies including the "Triple Bottom Line Cost Benefit Analysis of Green Infrastructure/Low Impact Development (GI/LID) in Phoenix," AZ which demonstrated that swales and bioretention basins can have a positive TBL-NPV of $6,200 and $8,300 respectively over a 50-year period, and "Study: Effectiveness of Existing Green Infrastructure in Phoenix" that evaluated specific in-the-ground features based on financial, environmental (water quality, carbon emissions, air pollution reductions, carbon reduction, air pollution from energy use reduction, carbon emissions from energy use reduction), and social benefits (heat island mortality, heat island morbidity, flood risk and property value). This business case approach provides a comprehensive assessment and makes the case that these investments provide benefits to a wide range of stakeholders.

- Provide informational resources on funding options for GI/LID, including tips on applying for FEMA pre-disaster mitigation funds (once MHMP language has been updated to incorporate GI).

Potential Resources: ASU Sustainable Cities Network (SCN), Water Management Group, Arizona Conservation Corps, Vitalyst Health, FEMA Building Resilience Infrastructure

3. Develop tools to incentivize developers to implement GI/LID strategies.

Action steps could include:

- Develop GI/LID educational materials for developers that may include a road map of steps for implementation and maintenance.
- Identify incentives for developers such as streamlined permitting, density bonus, or others, and promote incentives offered in each jurisdiction throughout the county.
- Organize seminars and trainings for developers, builders, and neighborhood organizations.
- Pilot a program that leverages public-private partnerships for GI/LID implementation.

Potential Resource Partners: ASU, SCN, and jurisdictional department leads for emergency management, planning and sustainability.

4. Build regional capacity through cross-sector trainings and education.

Action steps could include:

- Organize training events or a leadership academy to educate city or county staff on GI/LID implementation. These educational events may involve ASU, non-profits such as the WMG and TNC, providing venues for cross-sector connections.
- Organize a workshop with both local and county planners and decision-makers to align efforts. This workshop may also involve the Valley Metro Transit System, ASU, local neighborhood coalitions and homeowners' associations.
- Hold a workshop to explore the range of local, state and federal funding tools that could support GI/LID implementation.
- Activate public interest and support by holding tours, non-profit/neighborhood group trainings/workshops, distributing GI/LID guidance for property owners and creating visual aids to help the community envision the multiple benefits of a GI/LID approach.

Potential Resource Partners: ASU SCN, PAG, Salt River Project, Tucson, STORM

7. Summary of Recommendations

Local HMPs offer a unique opportunity to consider GI/LID strategies as a solution to mitigate arid climate hazards, such as drought, flooding and extreme heat, while providing additional co-benefits that align with broader community goals. As frequency and severity of many of these risks is increasing in arid climates, many local jurisdictions are adopting a proactive and integrated approach to hazard mitigation planning that evaluates strategies that reduce risk while investing in co-benefits that increase environmental sustainability, economic value and local quality of life.

GI/LID technologies preserve and incorporate natural features into the larger land use and site design to achieve multiple stormwater and other co-benefits. Natural features include existing native landscape or constructed systems using grading, a range of soil media and plant materials. GI/LID technologies are especially effective in addressing drought, extreme heat and flood in arid climates. GI/LID technologies can also provide additional co-benefits including improved water and air quality, lower carbon emissions, improved property values, enhanced pedestrian safety and amenities, and long-term cost savings.

Workshop participants developed and prioritized GI/LID recommendations to consider during in the 2020 Maricopa County Multi-jurisdictional Hazard Mitigation Update process.

Preparing to Engage in the Maricopa MHMP Process

As Maricopa County and other arid communities begin to initiate the MHMP update process, local governments, agencies and regional partners can begin preparing to engage productively and consider how to integrate GI/LID in the process, including:

- Disseminate this report and companion presentation to other cities in the region.
- Coordinate with ASU to introduce the GI/LID to Emergency Management Services staff throughout the region with this report and companion presentation, as well as other

resources. Leverage existing relationships with communities via ASU SCN to engage city sustainability staff with EMS staff.

- Identify representatives with GI/LID expertise to participate in the MHMP planning process.
- Form internal staff teams to build capacity and evaluate GI/LID strategies to consider.
- Educate leadership, elected officials and constituents on the benefits of GI/LID.
- Identify near-term updates to local and county plans relevant to GI/LID.
- Review local zoning to identify potential conservation areas that could serve as hazard mitigation.
- Identify barriers to and incentives for integrating GI/LID into development.
- Coordinate with city street, transportation and public works department managers to identify options for integrating GI/LID into street and drainage projects.

Potential GI/LID Mitigation Actions

During the MHMP update process, jurisdictions will have the opportunity to identify which risk mitigation actions they will adopt to be included in the MHMP update. As part of this process, each jurisdiction can determine where GI/LID could play a role in mitigating risk for extreme heat, drought and flooding. This technical assistance process identified the following potential GI/LID mitigation actions that jurisdictions may wish to consider:

- PLANNING. Consider including GI/LID principles and technologies into relevant plans, manuals, rules, regulations, ordinances and programs, including conservation areas in the general plan and GI/LID approaches in flood and stormwater management plans.
- CAPITAL PROJECTS. Consider including GI/LID projects that address multiple risks in the capital improvement programs (conservation area acquisition, street and drainage projects, civic buildings) and pursue a range of funding sources to accelerate their implementation.
- DEVELOPMENT. Assess development regulations and standards to remove barriers and add incentives to integrate GI/LID into new parking lots, landscapes and street improvements for development.
- EDUCATION. Develop guidance, demonstrations and training materials to educate property owners, government staff, elected officials, and the development community to promote an understanding of the risk mitigation benefits of GI/LID.

Building Regional Capacity

Finally, most arid communities can invest in building regional capacity to integrate GI/LID into local planning, projects and programs by increasing coordination through a designated regional entity that can coordinate cross-jurisdictional convening, research, education and tool development including:

- Confirm regional partner roles in building regional capacity to implement GI/LID strategies.
- Develop a regional database and tools to help prioritize, promote and fund GI/LID implementation across the region.

- Develop tools to incentivize developers to implement GI/LID strategies.
- Build regional capacity through cross-sector trainings and education.

Near-Term Steps

The local planning team for this technical assistance identified the following near-term steps to help disseminate this report and companion presentation to key stakeholders to help prepare the region to thoughtfully consider how to integrate GI/LID in the Maricopa County Multi-jurisdictional Hazard Mitigation Update:

- ASU offered to share this information with EMS leads across the region.
- City of Phoenix planning team staff offered to share this information with NPDES Phase 1 and 2 leads and AZ Water.
- Maricopa County Flood Control District offered to share this information through a GI/LID lunch and learn for flood managers.
- City of Phoenix planning team staff offered to coordinate internally to set up a meeting with the Maricopa County HMP project lead to share this information.

This report and companion presentation are intended as guidance that jurisdictions within Maricopa County as well as other arid communities can use to determine how to engage in the MHMP process and what mitigation actions they might consider adopting, along with the appropriate outreach and education among the range of local stakeholders.



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Workshop Agenda

AGENDA
Integrating GI/LID into Hazard Mitigation Plans (HMPs)

Maricopa County, Phoenix and Tempe
DAY 1 – Tuesday, December 10

Workshop Purpose: Identify options for integrating green infrastructure into Hazard Mitigation Plans

8:30-9 am	**Registration** ***(Coffee and breakfast generously provided by City of Phoenix)***
9-9:30 am	**Introduction** • Welcome (EPA, FEMA, Maricopa County, Tempe, Phoenix, ASU) • Workshop purpose and overview • Introductions
9:30-10:30 am	**Menu of GI/LID Options Relative to HMP Risks and Benefits** • Presentation: Overview of HMP risks, GI options and benefits (Skeo) • Breakout groups: Review and confirm range of GI/LID technologies
10:30-11 am	**Opportunity to Integrate GI in Heat Mitigation Planning** Melanie Gall and Sara Meerow, Arizona State University; Braden Kay, City of Tempe
11:00 am	**Break**
11:15 am	**Working session** • Breakout groups: How can GI/LID options address HMP risks? • Report out from groups
12-1 pm	**Lunch** *(Lunch generously provided by Arizona State University Sustainable Cities Network and Center for Emergency Management and Homeland Security)*
1-2 pm	**Adapting to Extreme Heat, Flooding & Drought in Urban Areas of the Desert Southwest** Presentation by Marie Light, Pima County Department of Environmental Quality (Principal Hydrologist) and Irene Ogata, City of Tucson, Tucson Water (Urban Landscape Manager) • Group questions and discussion
2-2:15 pm	**Break**
2:15-4 pm	**Integrating GI/LID into Hazard Mitigation Plans** • Presentation: Review current HMP language and avenues for integration (Skeo) • Breakout groups: Workshop how to integrate GI into HMPs • Report out from groups
4 pm	**Adjourn for day**

Smart Growth
BUILDING BLOCKS FOR SUSTAINABLE COMMUNITIES

AGENDA

Integrating GI/LID into Hazard Mitigation Plans (HMPs)

Maricopa County, Phoenix and Tempe

DAY 2 – Wednesday, December 11

8:30-9 am	**Coffee** ***(Coffee and breakfast generously provided by City of Tempe)***
9-9:30 am	**Overview of preliminary HMP recommendations** • Review outcomes from previous day • Discuss and refine recommendations
9:30-10:30 am	**Implementation Barriers, Strategies and Priorities** • Breakout groups: Identify GI barriers, strategies and priorities • Report back and prioritize key considerations
10:30-10:45 am	**Break**
10:45-11:45 am	**Funding and Resource Opportunities** • Review of potential funding options • Discussion on potential alignments between local priorities and funding • Recap of near-term funding opportunities
11:45-Noon	**Closing** • Recap recommendations • Share next steps
Noon	**Adjourn**

City of Phoenix · Flood Control District of Maricopa County · Tempe. ARIZONA · ASU Sustainable Cities Network, Arizona State University · ASU Center for Emergency Management and Homeland Security, Arizona State University · EPA United States Environmental Protection Agency · FEMA