Integrating Green Infrastructure Tools into Hazard Mitigation Plans

Sustainable Communities
Building Blocks

Background

U.S EPA and FEMA sponsored technical assistance for Maricopa County jurisdictions to:

- identify green infrastructure/low impact development (GI/LID) options,
- to incorporate into the 2020 Maricopa County Multijurisdictional Hazard Mitigation Plan (MHMP).

EPA United States Environmental Protection Agency

FEMA

City of Phoenix

Tempe ARIZONA

Flood Control District of Maricopa County

ASU Sustainable Cities Network
Arizona State University

ASU Center for Emergency Management and Homeland Security
Arizona State University

Regional Workshop

The technical assistance centered around a workshop held on December 10-11, 2019 with nearly 60 participants from local jurisdictions, federal agencies and regional partners.

This presentation summarizes the outcomes of the technical assistance.

Presentation Overview

- Hazard Mitigation Plans
- Green Infrastructure Benefits
- Hazard Mitigation Plan Process
- GI/LID Mitigation Actions
- Building Regional Capacity

HMP Overview

What is a Hazard Mitigation Plan?

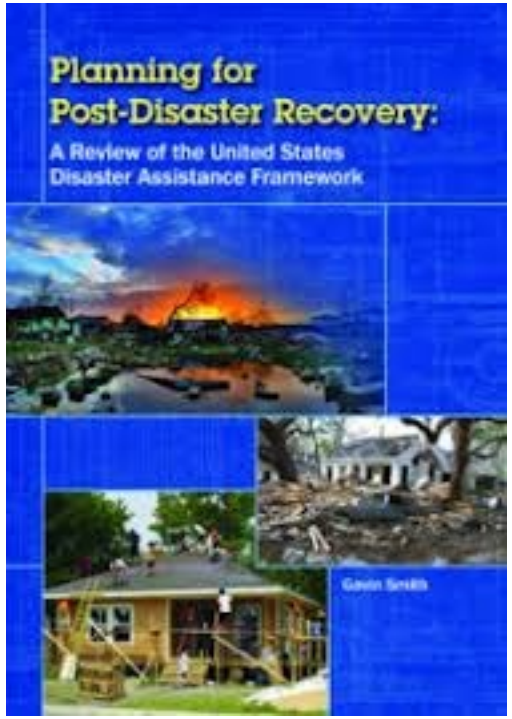
- Disaster Mitigation Act of 2000 - Requires state, local, and tribal governments to have a FEMA approved hazard mitigation plan (HMP) in order to establishes eligibility for FEMA's Hazard Mitigation Assistance (HMA) funding programs.
- Focus on mitigating natural hazard that impact the community.
- Projects must align with the plan's priorities and mitigate the vulnerabilities and impacts identified.
- Plans must be updated every 5 years and can be amended throughout the 5-year plan lifecycle.

What's included in an HMP?

- Identify Hazards
- Assess Risks and Vulnerabilities
- Outline Mitigation Capabilities
- Strategies to Reduce Risk

Integration of Hazard Mitigation into Local Planning Mechanisms

- Capital Improvement Plans
- Zoning Ordinances
- Subdivision Ordinances
- Building Codes
- Stormwater Management
- Post-Disaster Recovery Ordinances/Plans



Why Consider GI/LID in HMPs Now?

FEMA recently incorporated into HMP Guidance

More focus on integrated planning including natural resources.

Future conditions considerations including impervious area expansion.

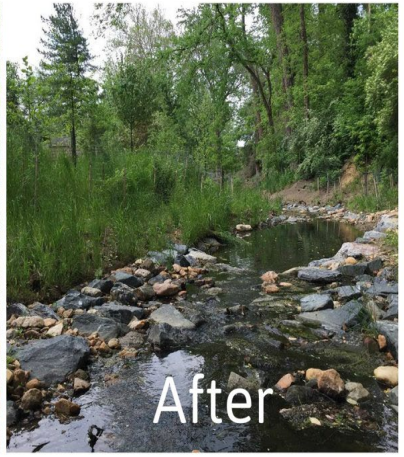
Incentives to exceed the minimum plan content requirements - “Enhanced Plans” are eligible for more post-disaster funding.

FEMA focus on resilience creates openness for local initiatives integrated into planning.

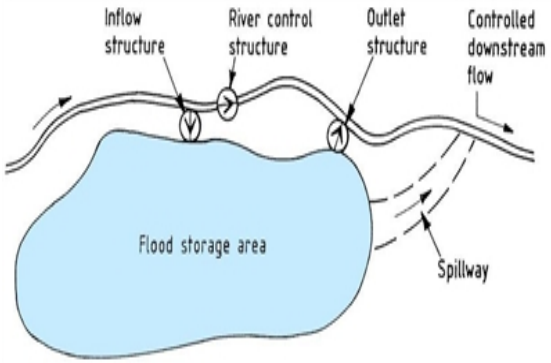
New Resiliency Project Types

Green infrastructure

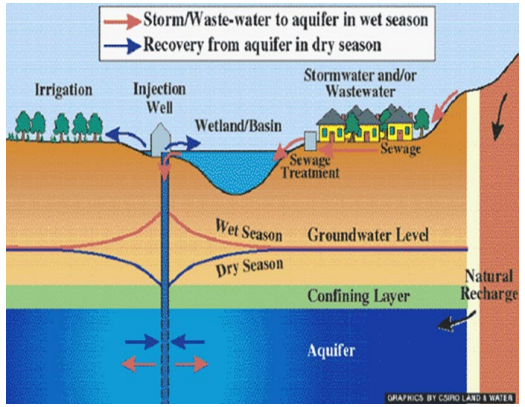
Floodplain and stream restoration



Flood diversion and storage



Aquifer storage and recovery



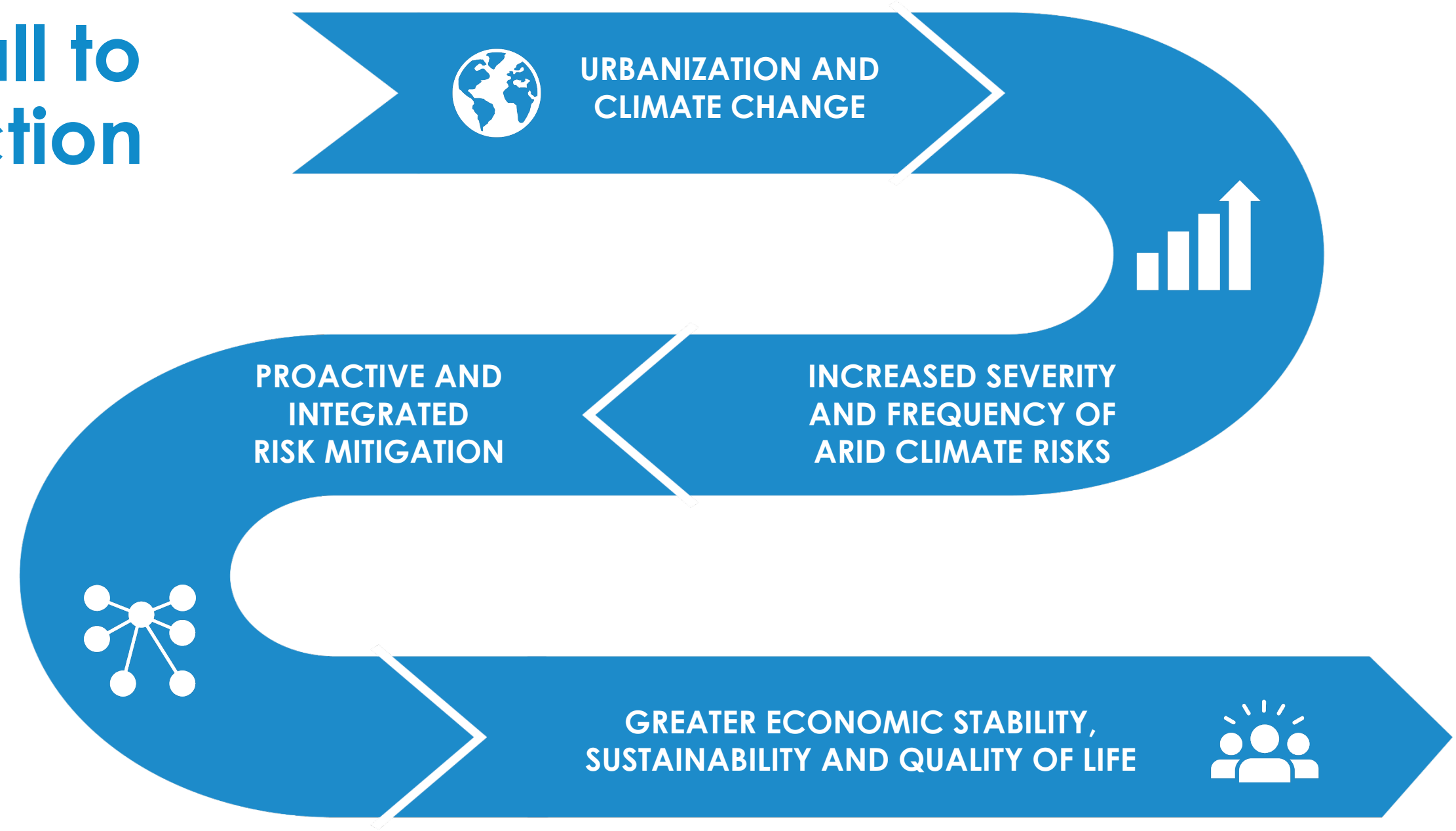
Arid Climate Risks Most Suitable for GI Mitigation Strategies

DROUGHT MITIGATION through water storage and lower potable water demand

EXTREME HEAT MITIGATION through reduced urban heat island effect

FLOOD MITIGATION through diversion, infiltration and storage

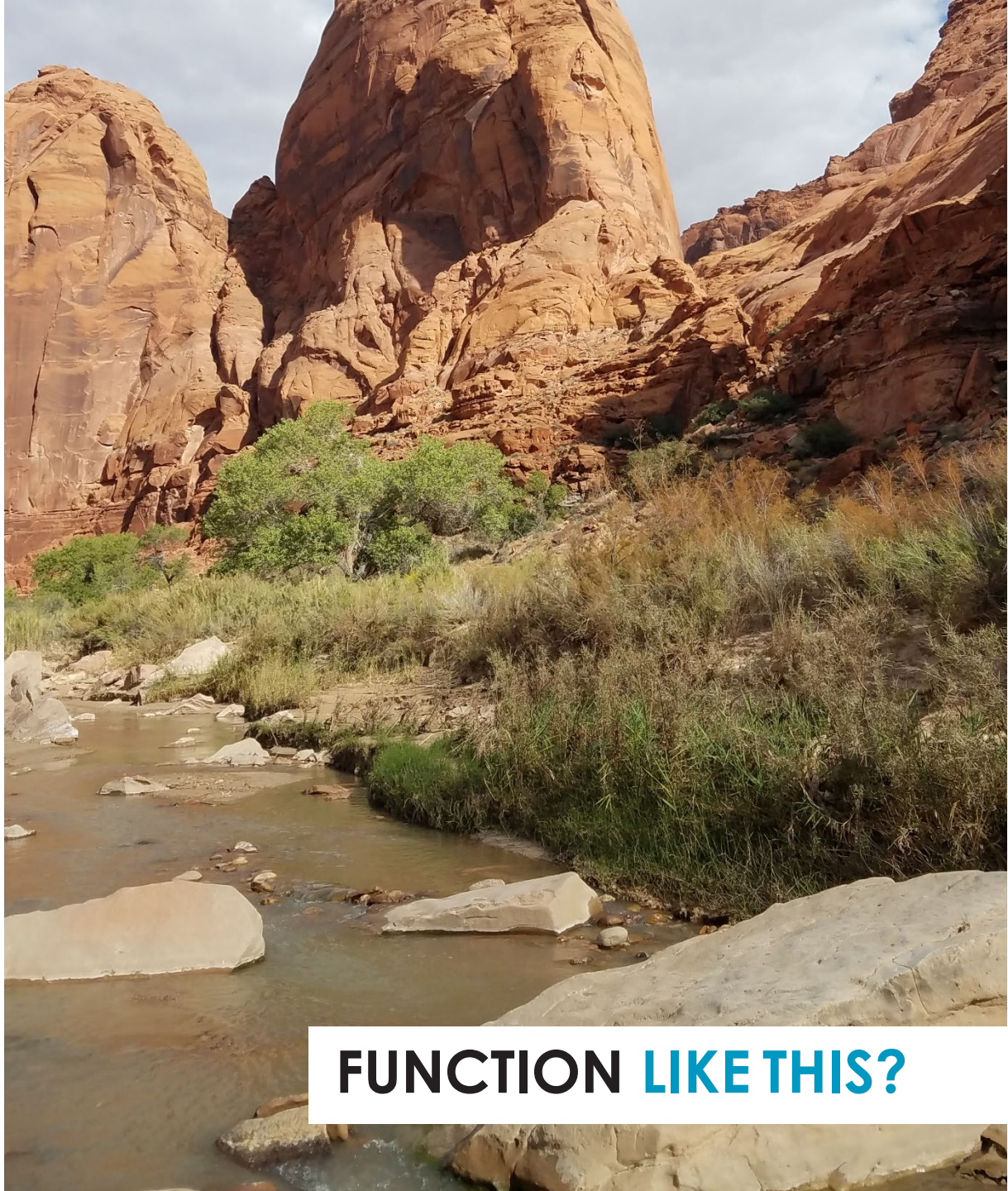
Call to Action



Green Infrastructure

Image Credits: Left: GI for Desert Communities, Watershed Management Group. Right: Pima County and City of Tucson. Low Impact Development and Green Infrastructure Guidance Manual.


HOW DO WE MAKE THIS...


FUNCTION LIKE THIS?

GREEN INFRASTRUCTURE

- An integrated approach to water management
- Design emphasizes functions of soils, plants and grading
- Preserve, enhance, or recreate natural systems





GREY INFRASTRUCTURE

Serves only one function at high cost

GREEN INFRASTRUCTURE

Provides multiple benefits simultaneously

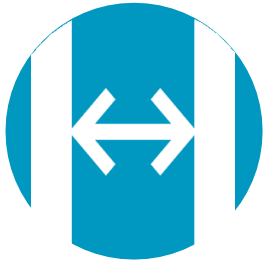
Image Credits: Left: GI for Desert Communities, Watershed Management Group. Right: Paso Robles 21st Century Street, SVR Design

GI STORMWATER FUNCTIONS

CAPTURE
stormwater for specific use

DETAIN
stormwater and slowly release it at a controlled rate

INFILTRATE
stormwater into the ground



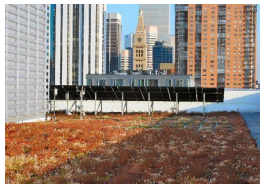
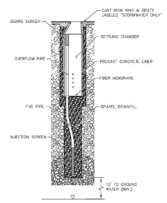
DISCONNECT
impervious areas to divert stormwater

SLOW
the movement of stormwater

GI/LID 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 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.

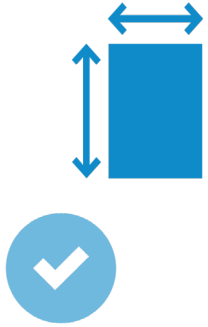
GI/LID Technologies

Technology	Description
	**Curb extension** Curb extensions are landscaped areas built out from a low-speed vehicle travel or parking lane.
	**Permeable pavement** 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.
	**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 Arid Climate

Local rainfall, temperatures and soils may affect design specifications such as:

Plants Tolerance for semi-arid environments and periodic inundation



Sizing Maricopa County recommends the 0.5-inch rainfall event as the minimum sizing requirement

Increasing GI/LID Performance

- Include accessory features (rock check dams)
- Sequence features in a treatment train
- Benefits are cumulative as more GI/LID features are installed at a larger scale

Vegetation (trees and understory plants) adds many co-benefits:

reducing water flow,

treating pollutants,

cooling temperatures.

GI Benefits

Risk Mitigation through GI/LID

Drought Mitigation

66%

lower household water use through rainwater harvesting

Extreme Heat Mitigation

4-6 ℉

lower temperatures in suburbs from trees, shrubs and grasses

Flood Mitigation

98%

of rainfall from one-inch storm captured by bioswales in Phoenix, Arizona

GI Features Contribute Co-benefits

- Improved **water quality**
- Improved **air quality**
- Lower **carbon emissions**
- Enhanced **pedestrian safety**
- Enhanced **community wellness**
- Improved **property values**
- Long-term **cost savings**

Co-Benefits by the Numbers

98.4%

Rainfall capture of the 1 in storm with bioswales and bioretention basins.

9°

Reduction in temperatures from vegetation

58,700

tons of carbon stored by urban trees in Phoenix

Social Benefits of Green Space

Improved attention and mood

Reduced stress through time spent outdoors

Increased physical activity through biking and walking

Increased social interaction among neighbors

Strengthen sense of place, safety and trust

Economic Benefits of GI

INCREASED PROPERTY VALUES

INCREASES OF UP TO 30% IN PROPERTY VALUE NEAR PARKS

GREATER NET BENEFITS THAN CONVENTIONAL INFRASTRUCTURE

RELATIVE BENEFITS OF GI/LID

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	$	◒	◒	◒	◒	

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

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

* Elements that include vegetation as an essential risk mitigation function.

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

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

RELATIVE BENEFITS OF GI/LID

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		Flooding	Drought	Extreme Heat	Water Quality	
Roof storage*	$$$	◒	○	●	◒	Wildlife habitat, planting feature, aesthetics
Infiltration trench	$	●	◒	○	●	
Dry well	$	●	◒	○	●	

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* Elements that include vegetation as an essential risk mitigation function.

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GI/LID PRIORITIES TO ADDRESS RISK

Workshop participants identified the GI/LID strategies as most effective in mitigating extreme heat, drought and flooding:

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)

MHMP Planning Process

MHMP PLANNING PROCESS

JURISDICTIONS PREPARE

Build working groups and evaluate plans, programs, and projects for opportunities to integrate GI/LID.

UPDATE PLAN

Participate with GI/LID expertise to identify jurisdictional GI/LID mitigation actions that address multiple risks.

SEEK FUNDING & IMPLEMENT

Mitigation actions included in the MHMP may be eligible for funding.

Jurisdictions Prepare

Local governments may consider the following activities to prepare to integrate GI/LID in the MHMP process:

- Identify staff with GI/LID expertise and form working groups.
- Educate leadership, elected officials and the public.
- Identify near-term updates to relevant plans.
- Review zoning to identify potential conservation areas.
- Identify barriers to and incentives for GI/LID.

Considerations During the MHMP Process

Planning Process:

- Include past and plan updates in plan integration strategy.
- Reference existing GI/LID guidance.
- Include staff with GI/LID expertise in MHMP planning team.

Community Description phase:

- Include overarching policies compatible with GI/LID approach.

Risk Assessment Phase:

- Include most recent local climate and hazard vulnerability data.

Mitigation Strategy:

- Reference GI/LID approach in HMP goals.
- Identify GI/LID mitigation actions to adopt

Jurisdictional Mitigation Capabilities:

- Identify resources needed for GI/LID based on Legal and Regulatory Capability, Fiscal Capability and Staff Capability:

Tools and Definitions:

- Define extreme heat and urban heat island effects.

Potential GI/LID Mitigation Actions

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

City of Phoenix, City of Tempe and Unincorporated Maricopa County can incorporate GI/LID into their 2015 HMP mitigation actions, using the suggested language (in *blue*):

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.	Water use awareness outreach program.

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Jurisdiction	Planning	Capital Projects	Development Requirements	Stewardship and Education
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.	Education on the hazards of extreme heat, *including guidance on GI/LID features to mitigate extreme heat*. Workshops and conferences on hazard mitigation.

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

City of Phoenix, City of Tempe and Unincorporated Maricopa County can incorporate GI/LID into their 2015 HMP mitigation actions, using the suggested language (in *blue*):

Jurisdiction	Planning	Capital Projects	Development Requirements	Stewardship and Education
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.

Example Mitigation Strategies

PLANNING

CAPITAL PROJECTS

DEVELOPMENT

EDUCATION

Planning

Potential mitigation actions include:

INCORPORATE GI/LID in General, Flood, Stormwater Management Plans.

INCLUDE LAND ACQUISITION FOR GI/LID in the Capital Improvement or Management Plan.

INTEGRATE GI/LID GOALS AND STRATEGIES into relevant plan updates.

Example

"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."

- City of Oakland HMP

Capital Projects

Potential mitigation actions include:

PRIORITIZE GI/LID in flood control projects and street or storm drainage improvements.

INCORPORATE GI/LID in civic and school projects.

ADOPT AN EVALUATION METHOD to incentivize GI/LID in capital projects.

Example

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

- City of Oakland HMP

FEMA-Funded Project Case Study:
Squaw Creek Flood Mitigation Project, City of Ames, Iowa

Includes:

- Channel excavation
- Natural channel design, streambank toe protection, and planting native vegetation

Part of City's 2020/2021 Capital Improvements Plan

27 ACRES
of riparian land and open space

$1 MILLION
in environmental benefits

75%
funded by FEMA Hazard Mitigation Assistance Grant

Development

Potential mitigation actions include:

ASSESS DEVELOPMENT REGULATIONS to remove barriers and add incentives to integrate GI/LID into new development.

Example

"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."

- Pima County HMP

FEMA-Funded Project Case Study:
Watershed Restoration and Flood Mitigation Project, Santa Clara Pueblo, New Mexico

Includes:

- Bottomless culverts
- Stream meandering
- Fish and wildlife habitat restoration

IMPROVED RIPARIAN HABITAT

REDUCED HAZARDOUS FUEL

EROSION MITIGATION

Education

Potential mitigation actions include:

DEVELOP LANDSCAPE GUIDANCE to educate property owners on GI/LID.

DEVELOP TRAINING to deliver to staff, elected officials and the development community.

CONSTRUCT GI/LID DEMONSTRATION SITES.

Example

"Conduct a public education campaign to increase awareness of natural hazards"

- Pima County HMP

Building Regional Capacity

BUILD REGIONAL GI/LID CAPACITY

Coordination among regional partners and jurisdictions to build regional capacity through convening, research, education and tool development.

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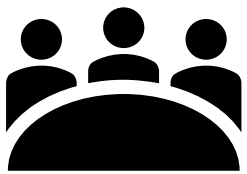


Workshop participants recommended investing in regional capacity to integrate GI/LID into local planning, projects and programs.

Capacity-Building Strategies

1.

CONFIRM REGIONAL PARTNER ROLES in building regional capacity to implement GI/LID strategies.

2.

DEVELOP A REGIONAL DATABASE AND TOOLS to help prioritize, promote and fund GI/LID implementation across the region.

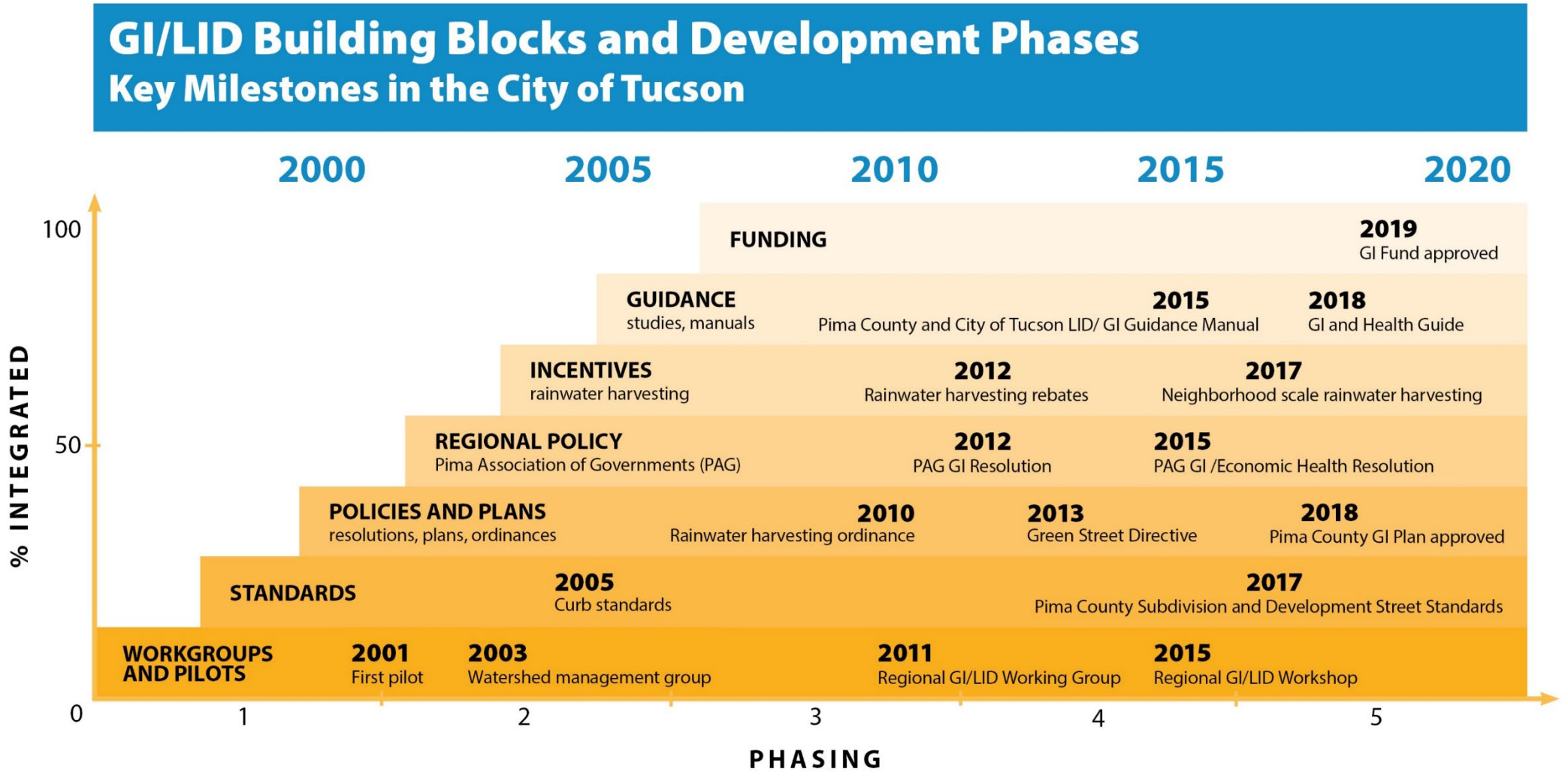
3.

DEVELOP TOOLS TO INCENTIVIZE DEVELOPERS to implement GI/LID strategies.

4.

BUILD REGIONAL CAPACITY through cross-sector trainings and education.

Building Blocks for Phasing GI/LID Over Time



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

- Form a cross-jurisdictional stormwater subcommittee.
- Adopt a joint resolution that formally articulates support for GI/LID strategies.
- Identify how best to leverage regional authorities and expertise.
- Coordinate a peer exchange.
- Engage the state to integrate GI/LID in the State HMP.
- Fund regionally accessible GI expertise.

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

- Develop a regional prioritization GIS-based tool.
- Create a regional cost-benefit tool.
- Document case studies in arid environments.
- Develop a guidance document on potential policy options.
- Provide informational resources on GI/LID funding options.

A Closer Look at Cost-Benefit Tools

Cost-benefit tools make the case that GI/LID investments provide benefits to a wide range of stakeholders.

ECONOMIC, SOCIAL AND ENVIRONMENTAL BENEFITS

CONSTRUCTION AND MAINTENANCE COSTS

Case Study: Cost Benefit Analyses (CBAs) in Phoenix, Arizona

City of Phoenix conducted several CBA studies, which evaluated:

- Water quality and flood risk
- Carbon and air pollution reductions
- Heat island mortality
- Property values

+ $6,200
Triple Bottom Line (TBL) Net present Value (NPV) from swales

+ $8,300
TBL-NPV from bioretention basins

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

- Develop GI/LID educational materials for developers.
- Identify developer incentives.
- Organize trainings for developers, builders, and neighborhood organizations.
- Pilot public-private partnerships for GI/LID implementation.

Build regional capacity through cross-sector trainings and education.

ORGANIZE TRAINING EVENTS OR A LEADERSHIP ACADEMY to educate municipal staff on GI/LID implementation.

ORGANIZE A WORKSHOP with both local and county decision-makers to explore funding options and to align efforts.

ACTIVATE PUBLIC INTEREST AND SUPPORT by holding tours, trainings and workshops, distributing GI/LID guidance for property owners.




Reference Information

GI/LID Technologies

MENU OF GI/LID TECHNOLOGIES

- Infiltration trench
- Dry well
- Vegetated or rock bioswale
- Bioretention system
- Stormwater harvesting basin
- Sediment trap
- Permeable pavement
- Green roof
- Conservation area
- Cistern
- Curb extension

INFILTRATION TRENCH

Long, narrow channels that are filled with gravel to retain stormwater or transfer it to another location

DRY WELL

Excavations that are only a few feet in diameter and are filled with gravel

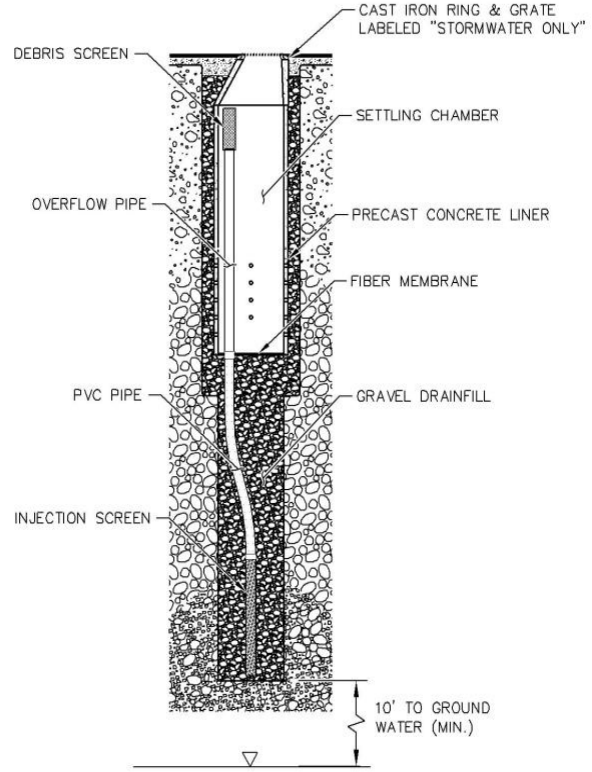


Image Credits: Left: Flood Control District of Maricopa County. Reduce Your Flood Risk: A Resource Guide. Right: Pima County and City of Tucson. Low Impact Development and Green Infrastructure Guidance Manual.

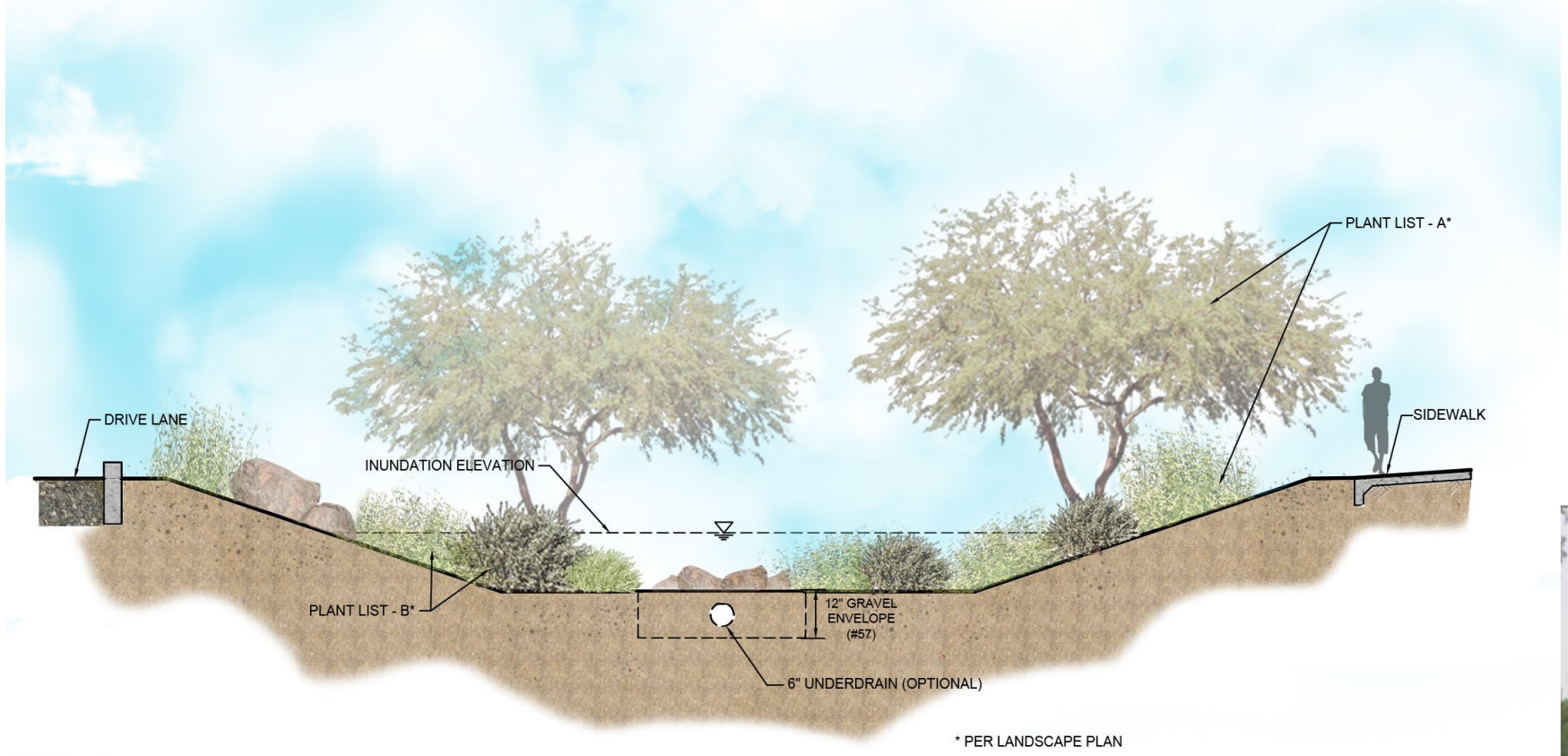
VEGETATED OR ROCK SWALE

Elongated, shallow channels covered by vegetation and pervious rock or gravel

BIORETENTION SYSTEM

Use vegetation to remove pollutants from stormwater

Image Credits: Left: Pima County and City of Tucson. LID and GI Guidance Manual. Right: Study: Effectiveness of Existing Green Infrastructure in Phoenix



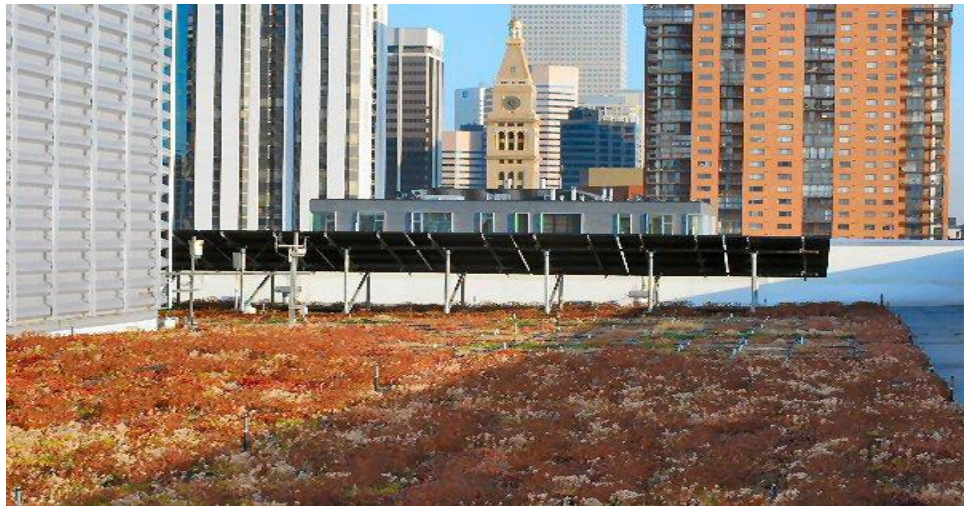
STORMWATER HARVESTING BASIN

Shallow depressions that collect runoff and use it to support planted vegetation

Image Credits: Top: City of Scottsdale and Arizona State University. Greater Phoenix Metro Green Infrastructure Hand-book: Low-Impact Development Details for Alternative Stormwater Management. Bottom: Pima County and City of Tucson. Low Impact Development and Green Infrastructure Guidance Manual

PERMEABLE PAVEMENT

Pavement with small voids to allow water to infiltrate or drain into a reservoir below



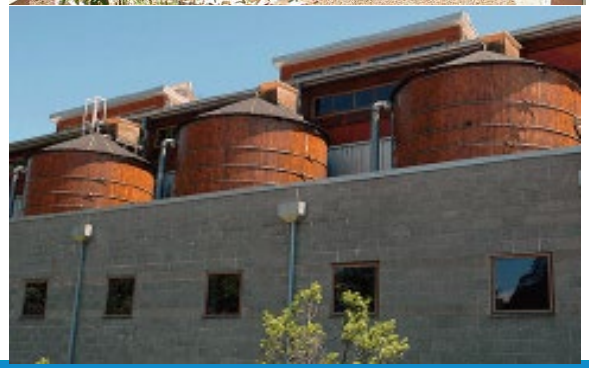
GREEN ROOF

Use vegetation and soils on building rooftops to retain stormwater

Image Credits: Top: Pima County and City of Tucson. Low Impact Development and Green Infrastructure Guidance Manual. Bottom: GI Opportunities and Barriers in the Greater Los Angeles Region, EPA.

CONSERVATION AREA

Protect undeveloped drainage areas to tap into their natural infiltration and storage capacity



CISTERN

Metal, plastic or concrete containers that collect rain for non-potable use

- Typically can hold several thousand gallons.

Image Credits: Left: City of Scottsdale and Arizona State University. Greater Phoenix Metro Green Infrastructure Hand-book: Low-Impact Development Details for Alternative Stormwater Management. Right: EPA, Managing Wet Weather with Green Infrastructure Municipal Handbook and EPA, Green Infrastructure in Arid and Semi-Arid Climates.

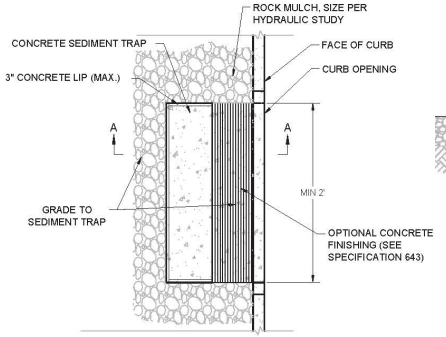
SEDIMENT TRAP

Depressions at inlets with debris pads to collect sediment from concentrated stormwater flows

Provide some pretreatment before stormwater enters a stormwater capture feature

CURB EXTENSION

Landscaped areas built out from a vehicle travel or parking lane



SEDIMENT TRAP PLAN VIEW

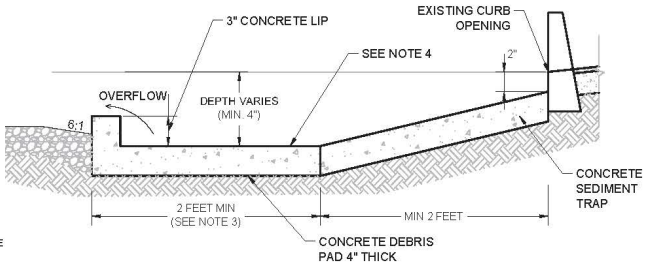


Image Credits: GI for Desert Communities, Watershed Management Group

GI CONSIDERATIONS

Image Credits: Left: GI for Desert Communities, Watershed Management Group. Right: Pima County and City of Tucson. Low Impact Development and Green Infrastructure Guidance Manual.

Considerations for Arid Climate

Local rainfall, temperatures and soils may affect design specifications such as:

Plants

Tolerance for semi-arid environments and periodic inundation

Sizing

Maricopa County recommends the 0.5-inch rainfall event as the minimum sizing requirement for GI/LID features

Maintenance Considerations

Without the appropriate maintenance, GI/LID features may not perform at optimum levels. Maintenance generally includes:

REMOVING debris, sediments and weeds

REPLACING dead plants and mulch

WATERING vegetation during establishment or drought periods

PRUNING trees and shrubs

REPAIRING any damage from erosion or human activity

Increasing GI/LID Performance

- Include accessory features (rock check dams)
- Sequence features in a treatment train
- Benefits are cumulative as more GI/LID features are installed at a larger scale

Vegetation (trees and understory plants) adds many co-benefits: reducing water flow, treating pollutants, cooling temperatures.

APPLICABILITY TO LAND USE

	Street	Open space	Parking lot	Commercial/ institutional	Residential building	Residential subdivision
Infiltration trench	x	x	x	x	x	
Curb extension	x		x	x		x
Sediment trap	x		x	x		
Bioswale	x	x	x	x	x	x
Bioretention system	x	x	x	x		
Stormwater harvesting system	x	x	x	x	x	x
Permeable pavement	x*		x	x	x	x
Green roof				x		
Conservation Area		x		x	x	x
Cisterns				x	x	x
Dry well			x	x	x	x