US EPA CAMPUS RAINWORKS

INTEGRATING GREEN INFRASTRUCTURE IN CAMPUS PLANNING

INTRODUCTION TO GREEN INFRASTRUCTURE

WHAT IS GREEN INFRASTRUCTURE?

"Green infrastructure" refers to a variety of practices that restore or mimic natural hydrological processes in the absence of development.

While "gray" stormwater infrastructure—systems of gutters, pipes, and tunnels—is largely designed to convey stormwater away from the built environment, green infrastructure uses soils, vegetation, and other media to manage rainwater where it falls through capture, infiltration, and evapotranspiration.

Adapted from U.S. EPA, "What is Green Infrastructure?" epa.gov/green-infrastructure/what-green-infrastructure.

Image: Bioswale garden and filter strip at Cornell University Botanic Gardens (Source: ONE)

WHAT ARE THE BENEFITS OF GREEN INFRASTRUCTURE?

Green infrastructure reduces and treats stormwater at its source while delivering other environmental, social, and economic benefits today and in a changing climate, including:

- Reducing runoff, flooding, and damage to buildings as well as improving human safety
- Improving water and air quality
- Supporting the efficient use of water resources
- Providing shade and mitigating heat island as well as extreme heat
- Reducing building energy demands
- Creating and connecting habitats for pollinators and other wildlife
- Providing aesthetic, placemaking, and recreational value

Image: Stormwater wetlands at Kent State University (Source: Dave Costello, Associate Professor of Biological Sciences, Kent State University)

EPA CAMPUS RAINWORKS CHALLENGE

EPA CAMPUS RAINWORKS CHALLENGE

The **Challenge** is a green infrastructure design competition for American colleges and universities that seeks to engage with the next generation of environmental professionals, foster a dialogue about the need for innovative stormwater management techniques, and showcase the environmental, economic, and social benefits of green infrastructure practices.

Student teams are supported by faculty advisors and endorsed by campus facilities staff.

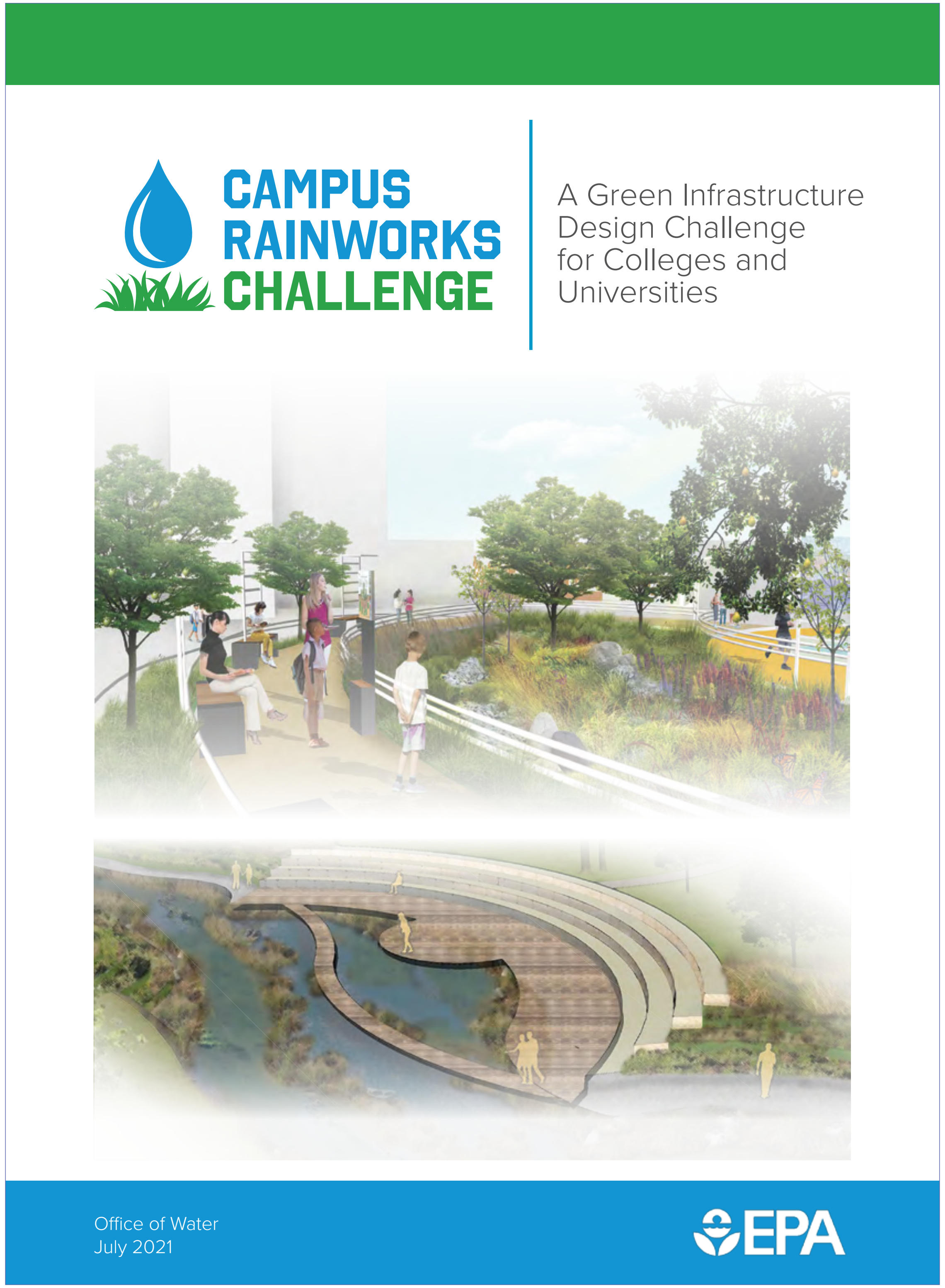


Image: EPA Campus RainWorks Challenge campaign brief

EPA CAMPUS RAINWORKS TECHNICAL ASSISTANCE

The **Technical Assistance** projects, in collaboration with Morgan State University and the University of Texas at Arlington, built on the Challenge with a one-day charrette at each university. The charrettes brought together campus stakeholders to discuss green infrastructure and stormwater planning on campus as well as to advance several objectives:

- Explore current needs and opportunities to advance green infrastructure implementation,
- Foster communication between key stakeholders that are involved in research or work related to stormwater management, and
- Highlight the environmental, economic, and social benefits related to green infrastructure for the campus, community, and watershed.

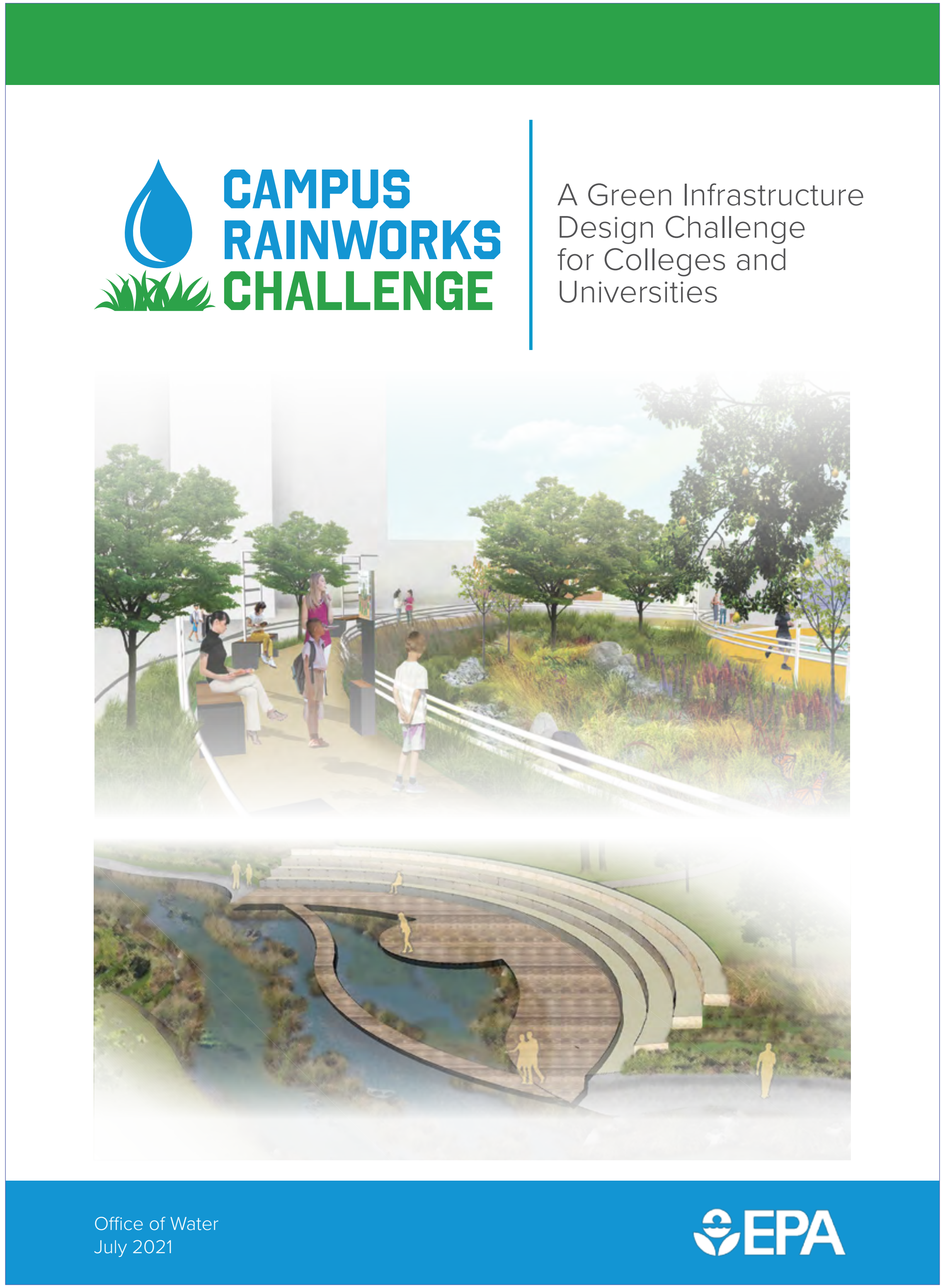

CAMPUS RAINWORKS CHALLENGE
A Green Infrastructure Design Challenge for Colleges and Universities
Office of Water
July 2021
EPA

Image: EPA Campus RainWorks Challenge campaign brief

CAMPUS RAINWORKS CHARRETTE OVERVIEW

Charrette Agenda

10:00	Welcome
10:15	Introduce charrette agenda and goals
10:30	Present campus initiatives and context
10:50	Present current student research
11:15	Campus tour
12:30	Breakout: challenges and opportunities (discussion over lunch)
1:15	Report back – all groups
1:35	Present green infrastructure strategies
1:50	Breakout: strategies and implementation
2:35	Report back – all groups
3:00	Takeaways and closing remarks



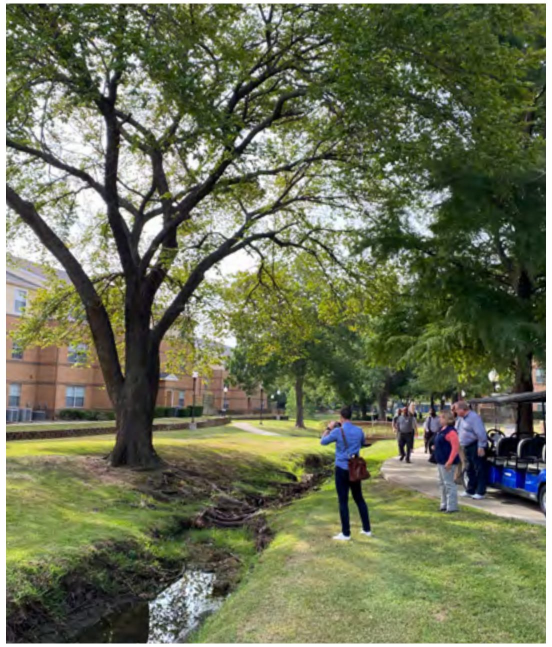


Images: RainWorks charrettes at Morgan State and UT Arlington (Source: ONE, UTA)

CAMPUS RAINWORKS CHARRETTE CAMPUS TOURS

Morgan State University

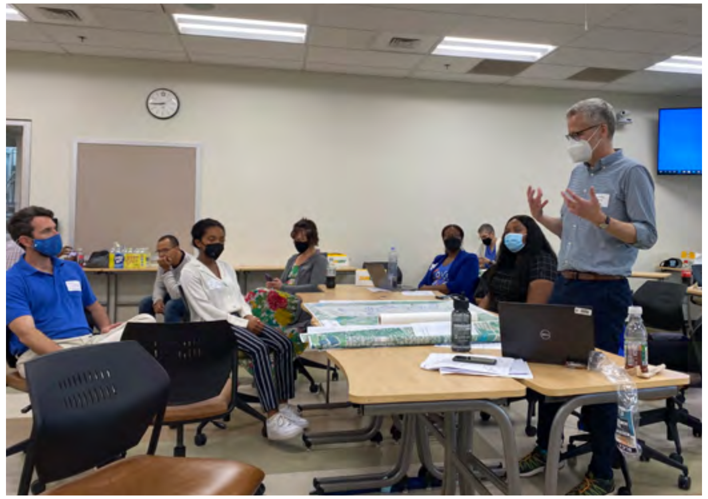
University of Texas at Arlington



Images: RainWorks charrettes at Morgan State and UT Arlington (Source: ONE, UTA)

CAMPUS RAINWORKS CHARRETTE BREAKOUT SESSIONS

Morgan State University


Breakout discussion structure
1. Neighborhoods
2. Upper watersheds
3. Middle watersheds
4. Lower watersheds and riparian corridors

University of Texas at Arlington

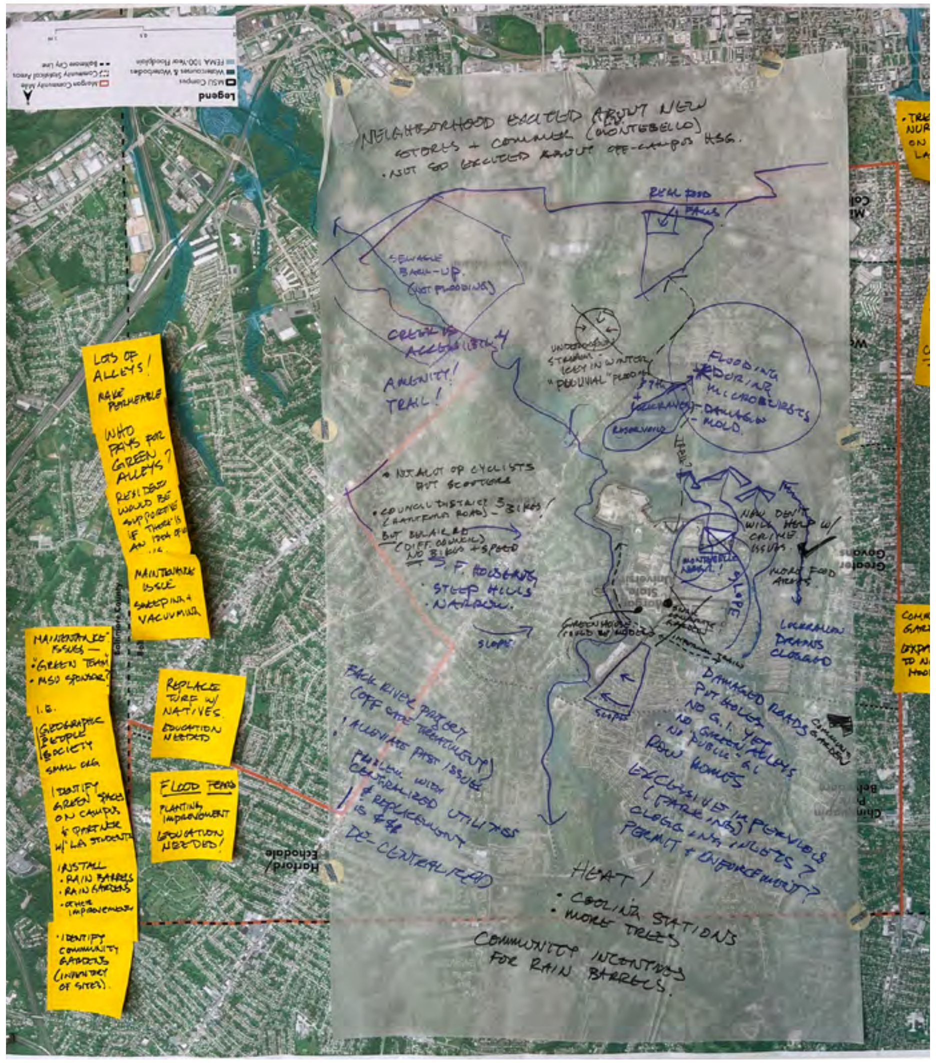


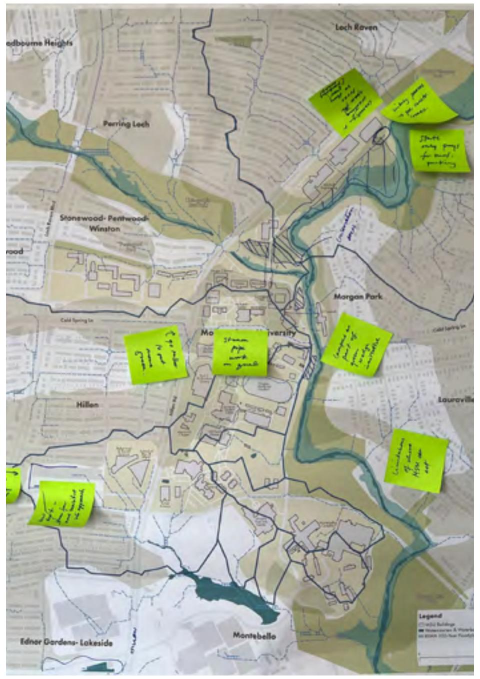
Images: RainWorks charrettes at Morgan State and UT Arlington (Source: ONE, UTA)

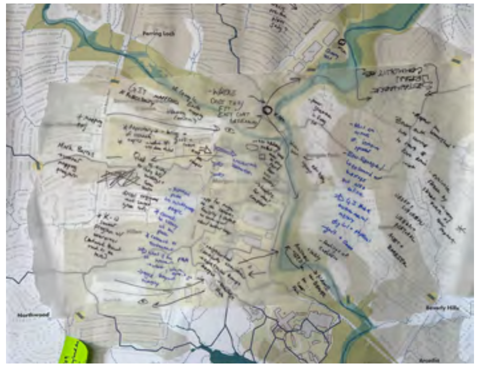
Breakout discussion structure
1. Healthy water, healthy creek
2. Climate resiliency on campus
3. Connecting communities
4. Trails for people and nature

CAMPUS RAINWORKS CHARRETTE OUTCOMES

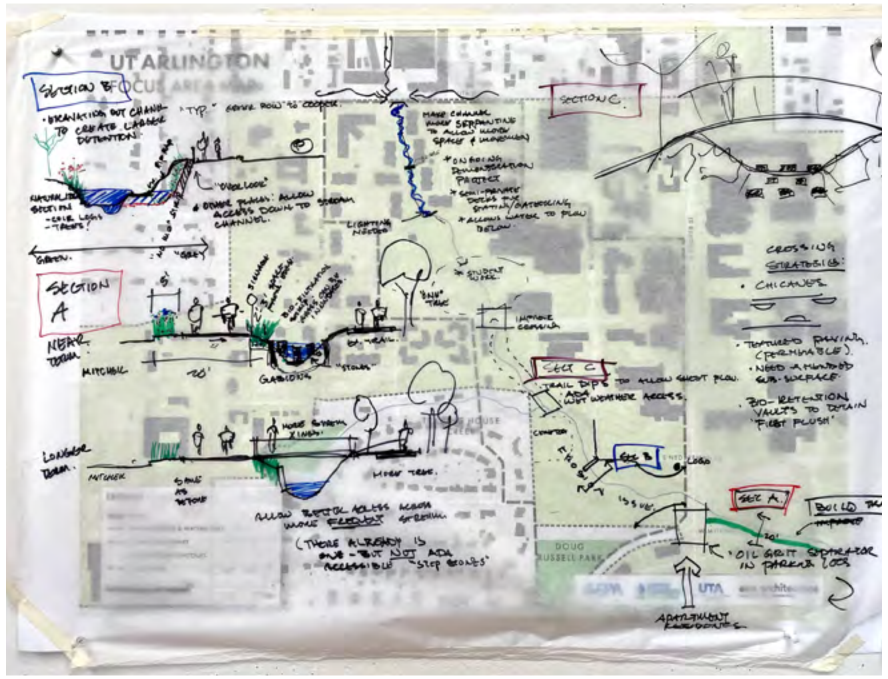
Morgan State University

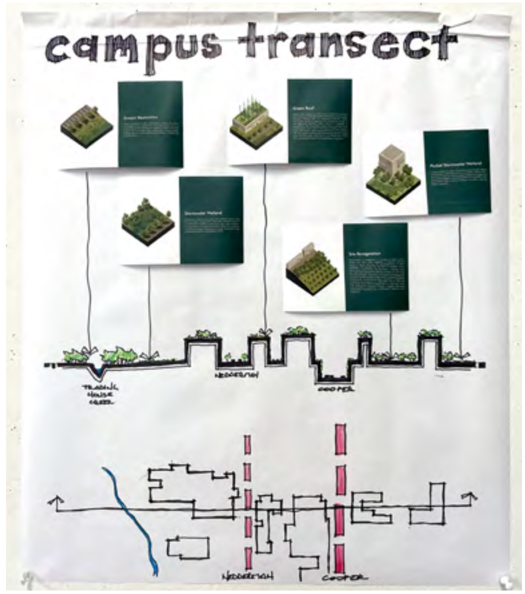


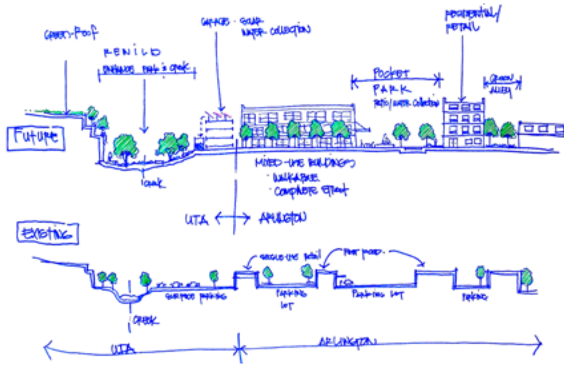


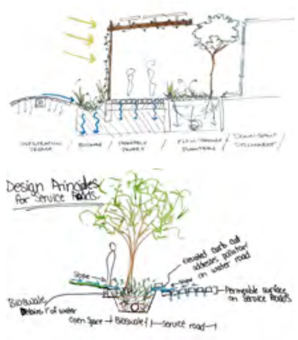


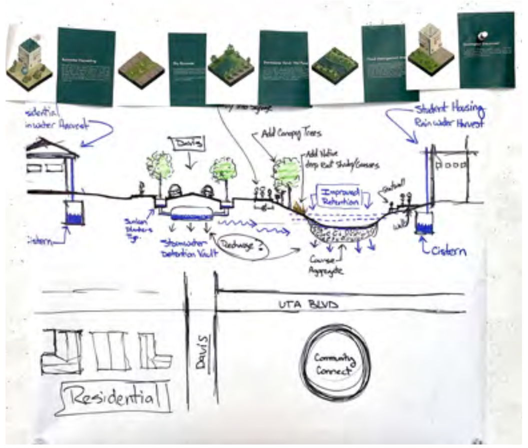
University of Texas at Arlington











Images: Morgan State and UT Arlington charrette products (Sources: ONE, Morgan, UTA)

CAMPUS RAINWORKS CHARRETTE LESSONS LEARNED

Green infrastructure applicability to other campus initiatives

- Green infrastructure in curriculum and research
- Campus plans, such as:
  - Campus master plans
  - Sustainability and resiliency plans
  - Transportation and open space plans
- Capital projects and project cycles
- Open space projects, increasing tree canopy and permeability
- Support for campus and municipal or regional partnerships
- Operations and maintenance, spurring a paradigm shift

Image: Aerial view of the UTA campus and Trading House Creek (Source: Taner Ozdil – UTA)

CAMPUS RAINWORKS CHARRETTE LESSONS LEARNED

The importance of collaboration

Successful green infrastructure implementation requires collaboration between campus staff, faculty, students, and community members.

Image: Campus stakeholders tour green infrastructure during the charrette at Morgan State University (Source: ONE)

CONSIDERATIONS & BENEFITS FOR GREEN INFRASTRUCTURE ON CAMPUS

PLANNING CONSIDERATIONS FOR CAMPUS GREEN INFRASTRUCTURE

College and university campuses are unique as environments and communities where people live, work, study, and gather.

Green infrastructure and stormwater planning for campuses begins with an awareness of:

- Campus scale and underlying natural systems
- Centralized management and organization
- Range of users and needs
- Potential for impact
- Relationship of campus to watershed


Image: Aerial view of Morgan State University (Source: Google Earth)

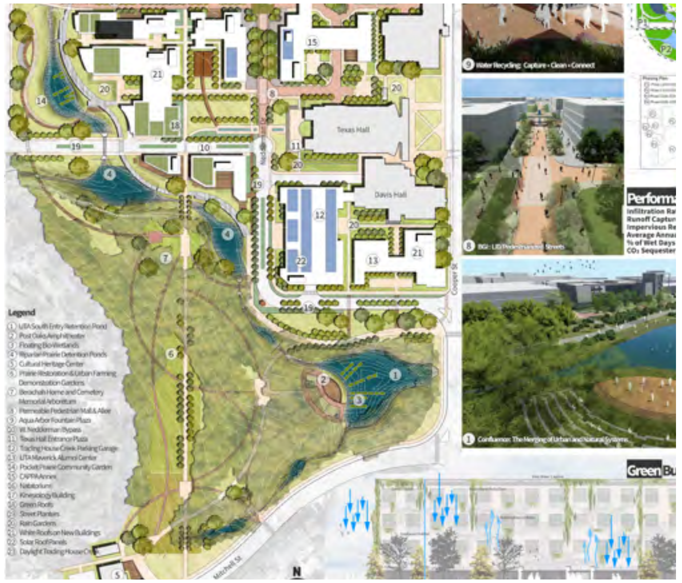
CAMPUS GREEN INFRASTRUCTURE BENEFITS AND IMPACT

Green infrastructure can provide benefits both to campuses and their surrounding areas.

Image: Rain garden at University of Chicago Laboratory Schools Gordon Parks Arts Hall (Landscape design: Mikyoung Kim Design, Photography: David Burk)

CAMPUS GREEN INFRASTRUCTURE BENEFITS AND IMPACT

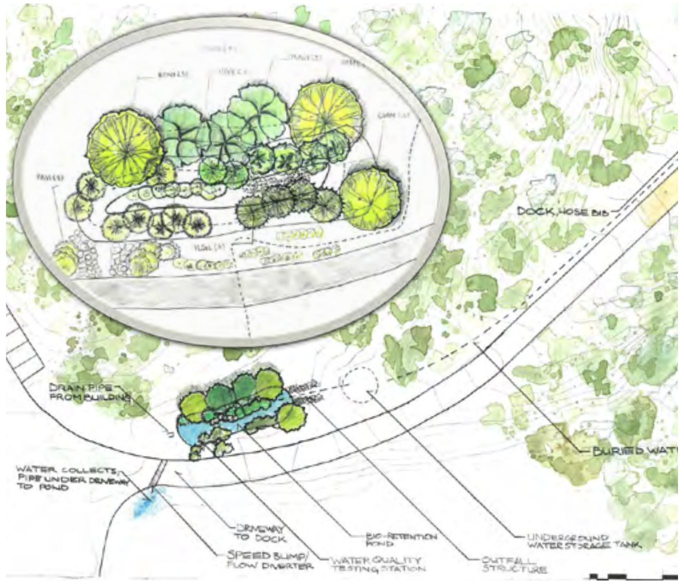
Improve open space performance



Limit damage & protect people

Meet regulatory requirements

Improve user experience



Advance research & collaboration

Improve connectivity & resilience

Lead by example

Spur regional change

Images: Campus RainWorks design submissions – UTA, 2017-2018; UTA, 2019-2020; Morgan, 2020; UTA, 2020-2021; Morgan, 2020-2021; UTA, 2020-2021; Morgan, 2020; UTA, 2020-2021

TOOLS & PROCESSES FOR INTEGRATING GREEN INFRASTRUCTURE

GREEN INFRASTRUCTURE TOOLS AND PROCESSES

- Asset management and mapping
- Strategic green infrastructure framework
- Green infrastructure prioritization framework
- Modeling tools to support planning and design decisions
- Engagement and capacity building

See next slides for detail

Image: Green roof at Calvin and Tina Tyler Hall at Morgan State University (Source: ONE)

TOOLS AND PROCESSES

Asset management

Mapping campus green infrastructure in relation to natural systems is a first step toward implementing a systematic approach on campus.

Asset mapping in relation to natural systems could include:

- Elevation and slope to assess feasibility
- Surface drainage flow paths
- Location of campus in general watershed
- Watershed reaching campus from off-site

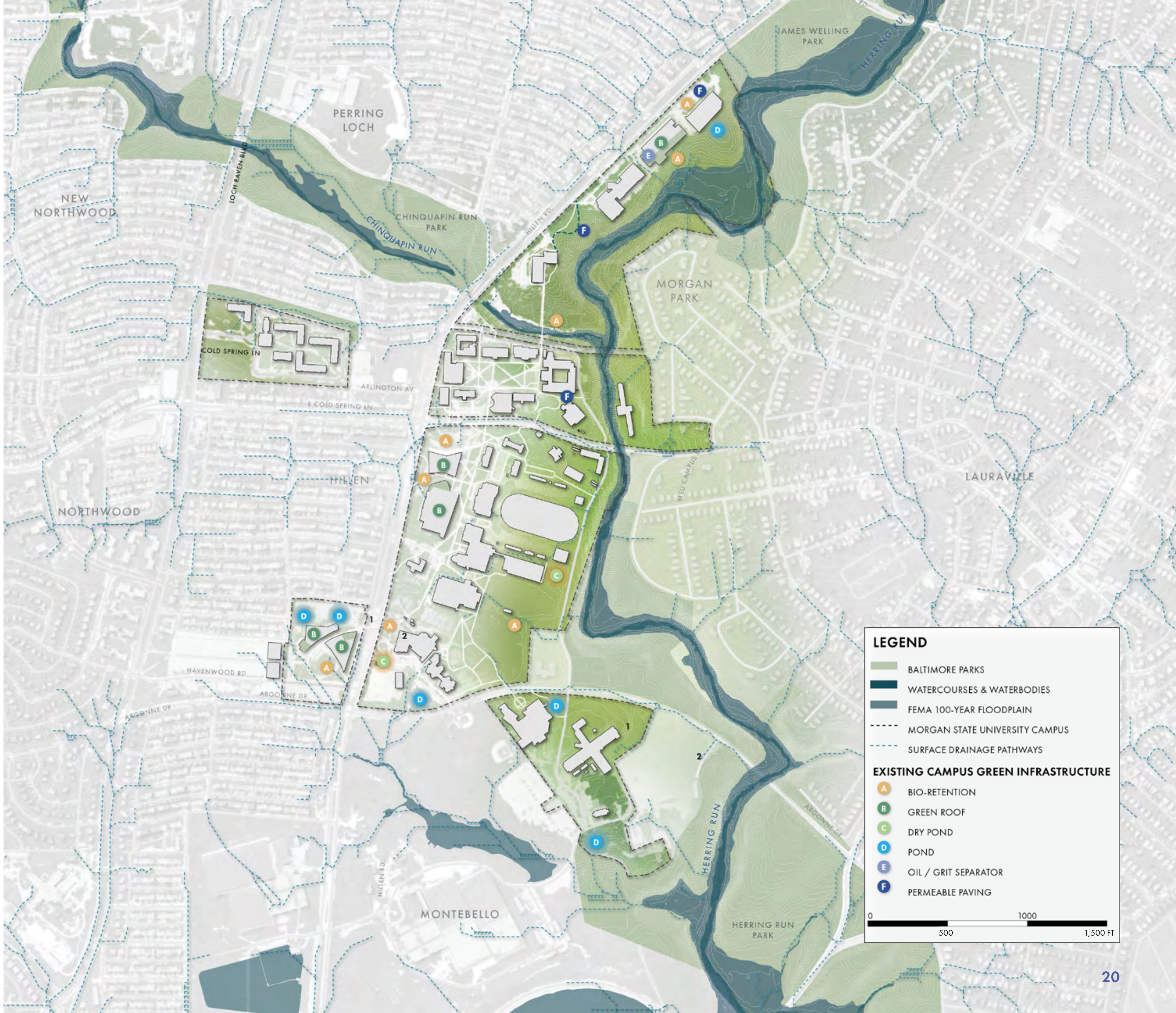


Image: Asset mapping – green infrastructure, Morgan State University (Source: ONE)

TOOLS AND PROCESSES
Strategic frameworks

A strategic framework, including but not limited to these components, can provide a conceptual and spatial basis for planning and establish the direction for considering the integration of green infrastructure on campus.

- Guiding principles
- Vision and planning framework
- Cloudburst visioning
- Multi-benefit orientation

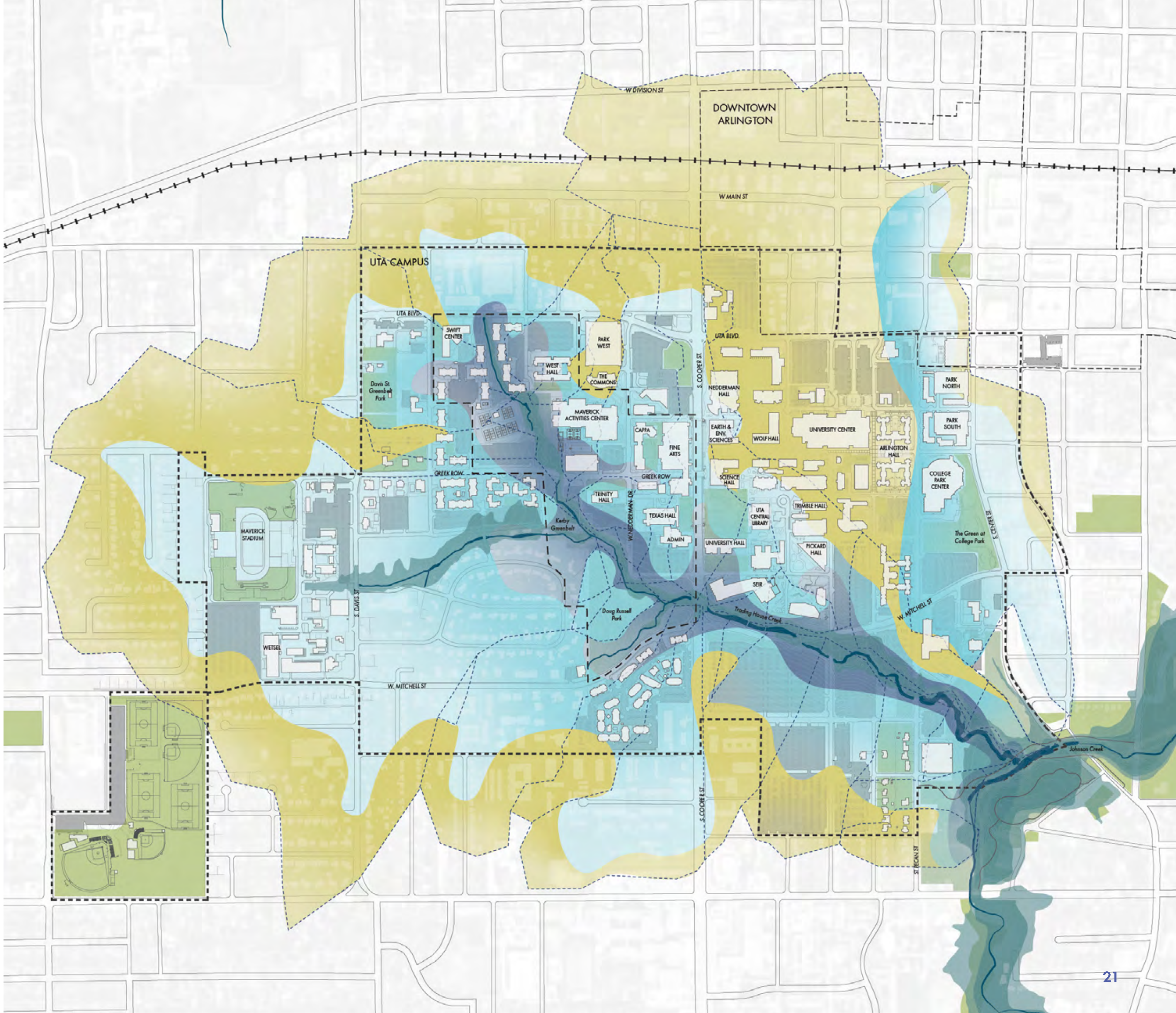


Image: map of campus watersheds, UT Arlington (Source: ONE)

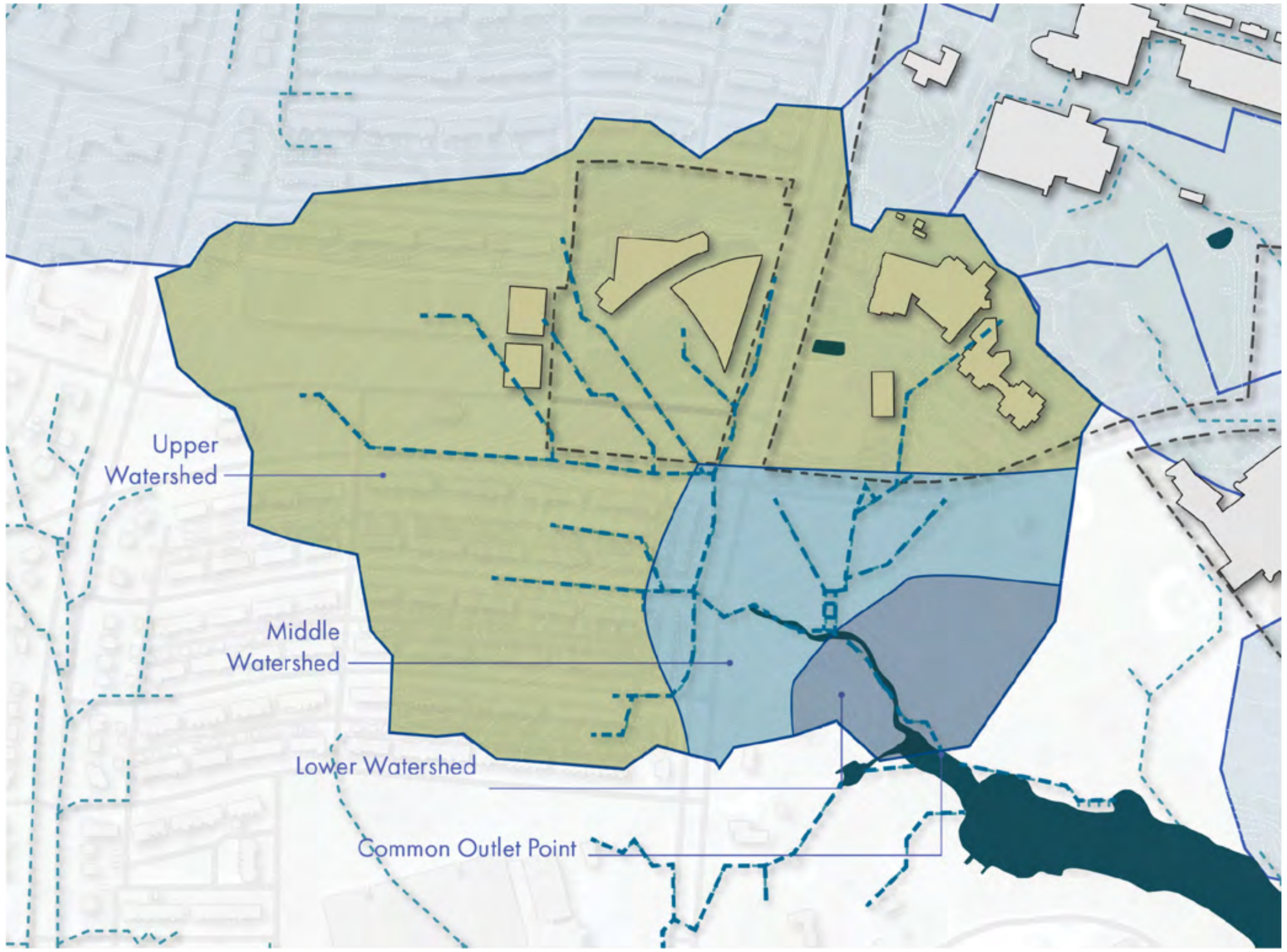
Prioritization Framework

Refer to Appendix for citations and reference documents.

	ECOLOGICAL CONSIDERATIONS		ECONOMIC CONSIDERATIONS		COMMUNITY CONSIDERATIONS					TECHNICAL CRITERIA		
DESIGN OPTIONS (MEASURES, BMPs)	**Location in Watershed**	**Ecological Co-Benefits**	**Relative Initial Cost**	**Relative Maintenance Cost**	**Integration with Surroundings**	**Environmental Stewardship**	**Aesthetic Value & Placemaking Potential**	**Permitting / Coordination Complexity**	**Benefit to MS4 Compliance**	**Maximum Drainage Area**	**Pressure Head Needed**	**Maximum Slope**
	Upper, Middle, Lower	Low, Medium, High	$ / $$ / $$$	$ / $$ / $$$	Low, Medium, High	Low, Medium, High	Low, Medium, High	Low, Medium, High	Low, Medium, High	Acres	Feet	%
Green Roofs	All	Medium	$$$	$$$	Medium	Medium	High	Medium	Medium	100% of BMP size	0.5 - 1	10
Rainwater Harvesting	All	Low	$$	$	Medium	High	Medium	Medium	Medium	N/A	N/A	2
Oil Grit Separator	All	Low	$	$$	Medium	Medium	Low	Medium	Low	5	4	6
Downspout Disconnect	All	Low	$	$$	Medium	High	Low	Low	Low	0.06	N/A	6
Site Reforestation/Revegetation	All	High	$$$	$	High	High	High	Low	High	0.25 Min	N/A	N/A
Infiltration Trench	Upper	Medium	$	$$	Low	Medium	Medium	Low	Low	5	1-3	6
Permeable Pavers/Surfaces	Upper	Medium	$$$	$$	Low	Low	High	Medium	Medium	300% of BMP size	N/A	0.5
Organic Filter	Upper	Medium	$$	$$	Low	Medium	Low	Low	Low	10	5-8	6
Surface Sand Filters	Upper	Low	$$	$$	Low	Low	Low	Low	Medium	10	2-6	6
Bioretention	Upper/Middle	High	$$$	$$	Medium	High	High	Medium	High	5	N/A	5
Flow-Through Planters/ Landscape Infiltration	Upper/Middle	Medium	$$	$	Medium	Medium	High	Low	Medium	0.06	2	6
Dry Well	Upper/Middle	Medium	$$	$$	Low	Low	Low	Medium	Low	0.06	2	6
Dry Bioswales	Middle	Medium	$$$	$$	Medium	Medium	High	Medium	Medium	5	3-5	4
Wet Bioswales	Middle	Medium	$$$	$$	Medium	Medium	High	Medium	Medium	5	1	4
Dry Detention Pond	Lower	Medium	$	$$	Low	Medium	Medium	Medium	High	10 Min.	N/A	15
Extended Dry Detention Pond	Lower	Medium	$	$$	Low	High	Medium	Medium	High	10 Min.	N/A	15
Wet Pond	Lower	High	$	$$	Medium	High	Medium	High	High	25	6-8	15
Pocket Pond	Lower	Medium	$	$$	Low	Medium	Medium	Medium	Low	10	6-8	0
Underground Filter	Lower	Low	$$	$	Low	Low	Low	Medium	Medium	5	2-5	4
Flood Management Area	Lower	Low	$	$	Low	Medium	Medium	Medium	Low	N/A	N/A	N/A
Stormwater Wetland	Lower	High	$$	$	High	High	High	High	Medium	25	3-5	8
Pocket Stormwater Wetland	Lower	Medium	$$	$	Medium	High	Medium	Medium	Low	5	2-3	0
Stream Restoration	Lower	High	$$$	$	High	High	High	High	Low	N/A	N/A	N/A

Source: One Architecture & Urbanism / Sherwood Design Engineers, 2023

Prioritization Framework – Ecological Considerations



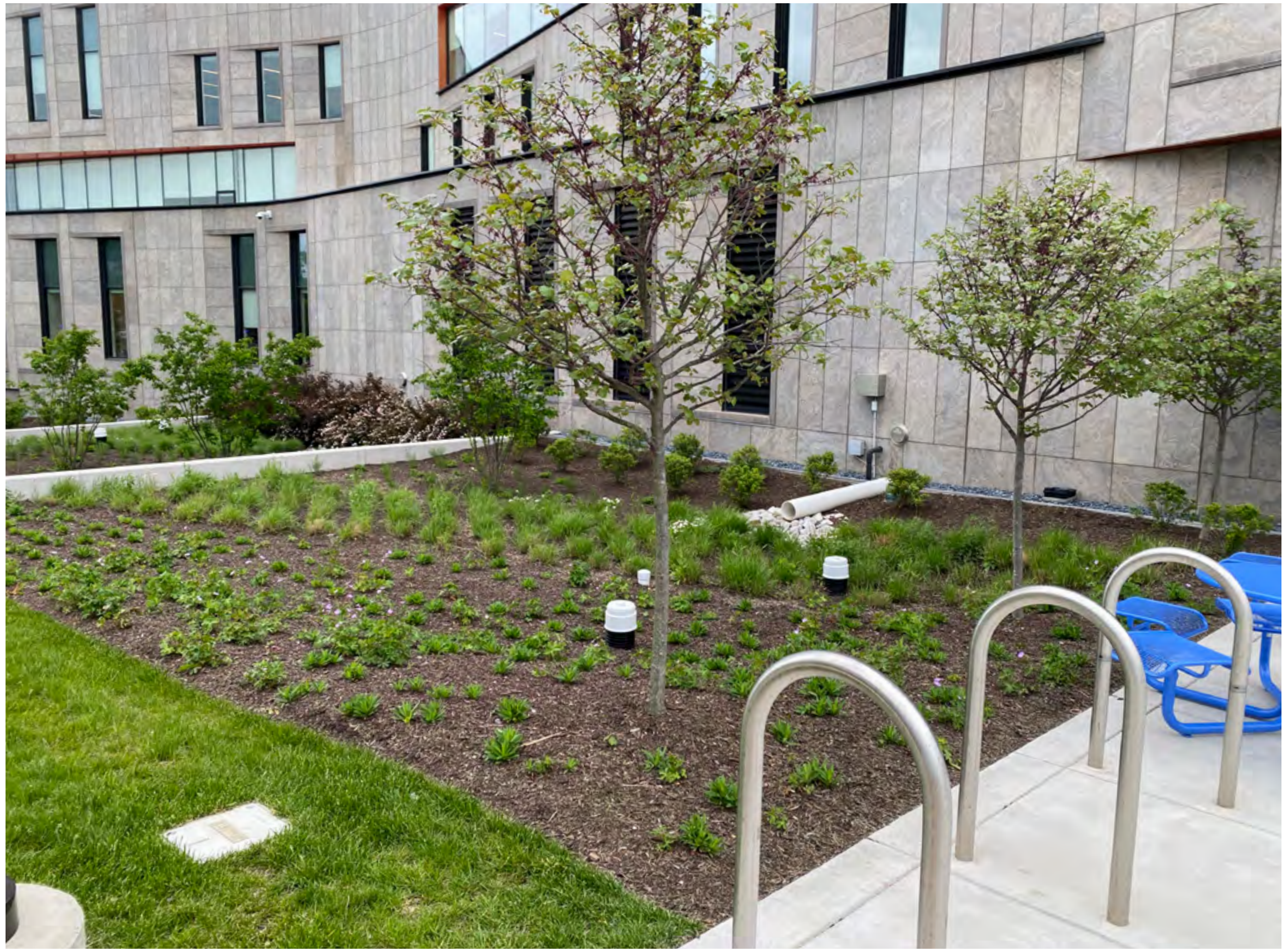
Position in Watershed

Ecological Co-benefits

Images: (left) Watershed diagram (Source: Sherwood Design Engineers / ONE); (right, clockwise) Stormwater Pocket Wetland designed by Armentrout, Matheny, Thurmond P.C. and installed at McLane Company via Athens-Clarke County; UTA CAPPA building (Source: Taner Ozdil / UTA), Kerby Street Greenbelt, UTA (Source: John Hall / UTA); bioretention feature at Morgan State (Source: ONE)

Prioritization Framework – Economic Considerations

Relative Initial Cost



Relative Maintenance Cost

Images: (left) dry and wet detention ponds under construction in Lafayette, Louisiana (Source: ONE); (right) downspout disconnect at Calvin and Tina Tyler Hall, Morgan State University (Source: ONE)

Prioritization Framework – Community Considerations

Integration with Surroundings

Environmental Stewardship

Aesthetic Value & Placemaking Potential

Permitting / Coordination Complexity

Benefit to MS4 Compliance

Images (from left to right): Baldwin Hall, Morgan State University (Source: ONE); Blue-gray Gnatcatcher, Davidson College (Source: Eric Keith); Orange Mall Green Infrastructure, Arizona State University (Landscape design: COLWELL SHELOR, Image: Marion Brenner); stream bank restoration on the Chinquapin Run, Morgan State University (Source: ONE); Bioswale garden and filter strip at Cornell University Botanic Gardens (Source: ONE)

Modeling tools to support planning and design decisions

EPA has developed innovative models, tools, and technologies for communities to manage water runoff in urban and other environments.

The resources in this toolkit incorporate green or a combination of green and gray infrastructure practices to help communities manage their water resources in a more sustainable way, increasing resilience to future changes.

For further information on EPA tools, visit the EPA website.

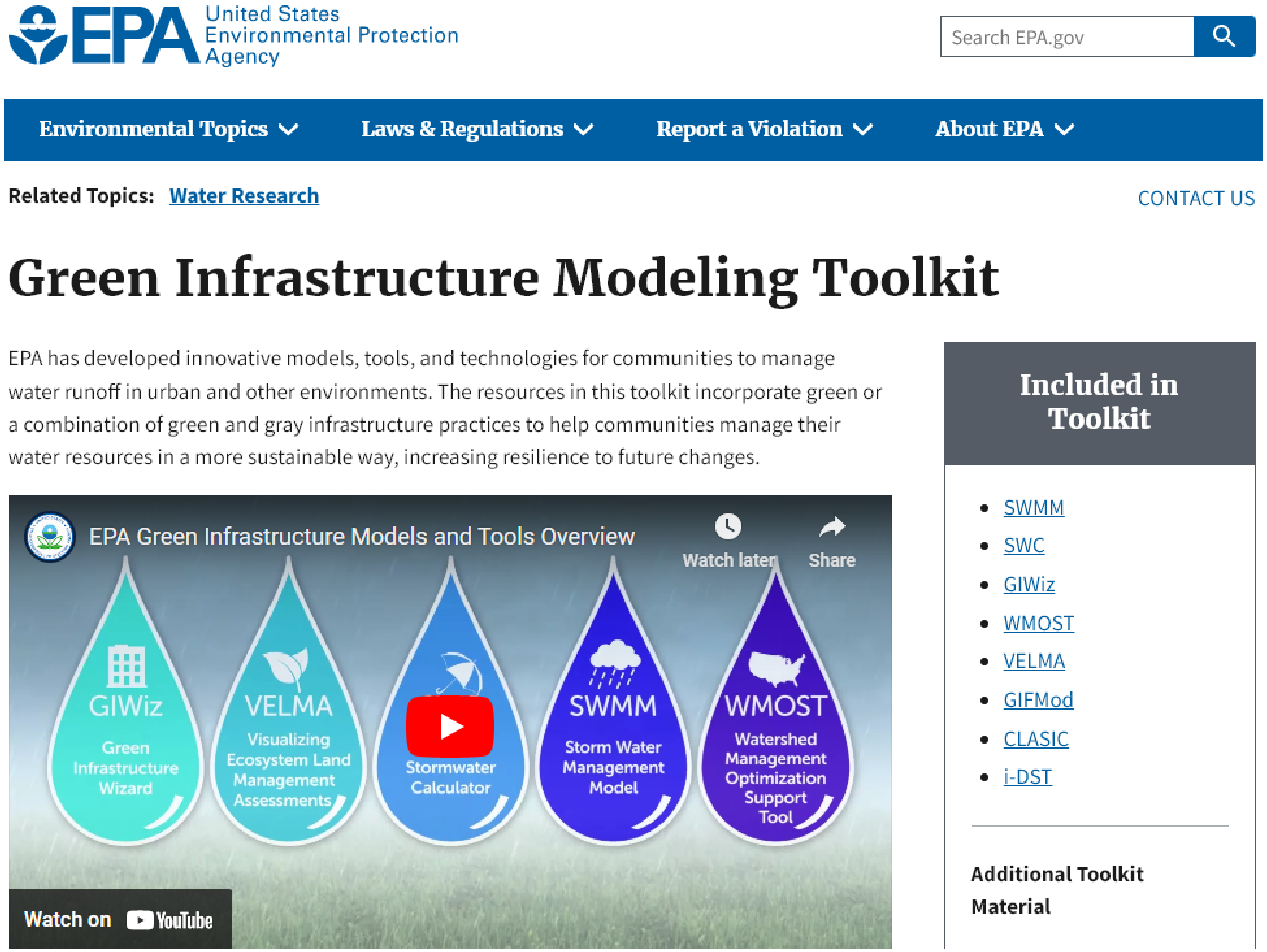


Image: EPA web page

Link: www.epa.gov/green-infrastructure/green-infrastructure-modeling-tools

Engagement and capacity building

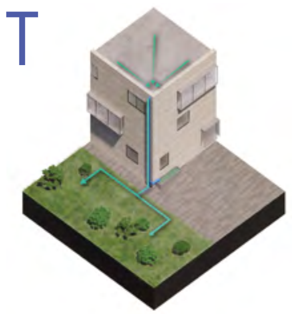
Successful implementation and stewardship of green infrastructure requires collaboration among the many stakeholders on campus. It also requires education and capacity building to make stormwater planning and green infrastructure an active part of the larger campus consciousness.

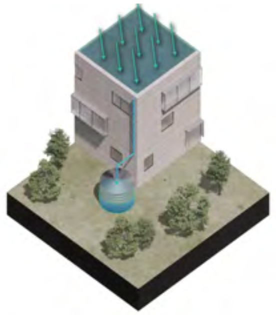
Image: Multi-stakeholder site visit during the UT Arlington design charrette (Source: ONE)

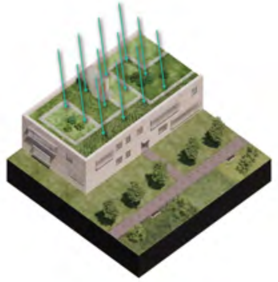
CAMPUS GREEN INFRASTRUCTURE DESIGN TOOLKIT

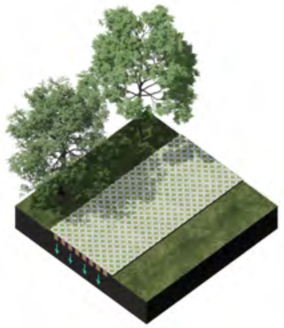
DESIGN TOOLKIT

■□□ Upper watershed strategies
□■□ Middle watershed strategies
□□■ Lower watershed strategies

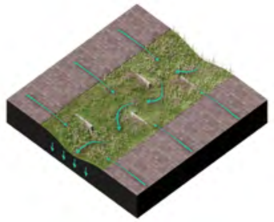

■■■ Downspout Disconnect

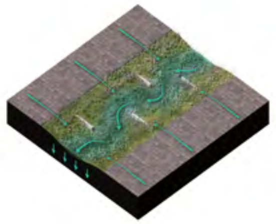

■■■ Rainwater Harvesting

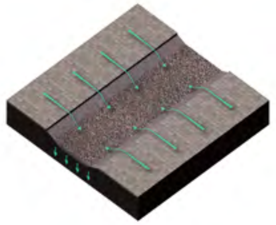

■■■ Green Roofs

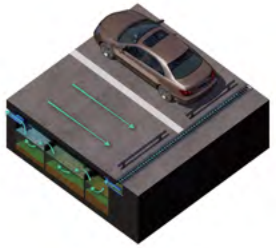

■□□ Permeable Pavers / Surfaces

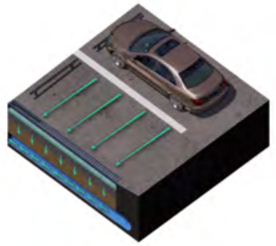

■■□ Flow-Through Planters

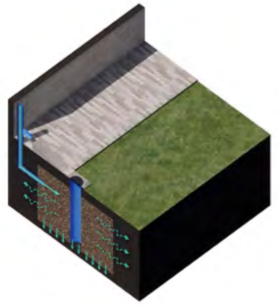

□■□ Dry Bioswales


□■□ Wet Bioswales


■□□ Infiltration Trench


■■■ Oil / Grit Separator

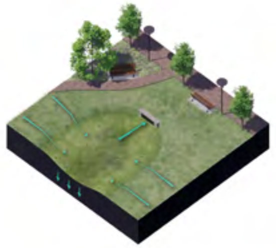

□□■ Underground Filter


■■□ Dry Well

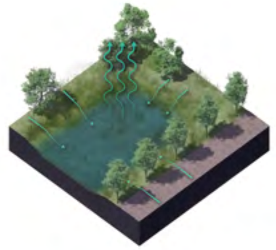

■■□ Bioretention


■□□ Organic Filter


■□□ Surface Sand Filters

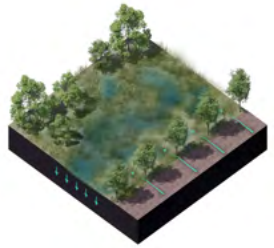

□□■ Dry Detention Pond


□□■ Extended Dry Detention Pond


□□■ Wet Pond


□□■ Pocket Pond


□□■ Pocket Stormwater Wetland


□□■ Stormwater Wetland


■■■ Site Reforestation / Revegetation


□□■ Stream Restoration


□□■ Flood Management Area

Source: One Architecture & Urbanism, 2023

UPPER WATERSHED: INFILTRATE

Refer to Appendix for image credits.

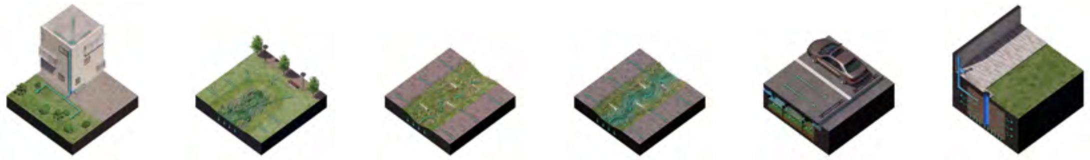
Bioretention and conveyance

Bioretention

Green roof

Downspout disconnection / rain garden

MIDDLE WATERSHED: SLOW AND STORE



Refer to Appendix for image credits.

Roadside bioswale

Channelized water flow

Bioretention

Roadside bioswale

LOWER WATERSHED: RESTORE

Refer to Appendix for image credits.

Riverbank restoration

Modular subsurface tank

Floodable open space

Water reclamation pond

CONCLUSIONS

CONCLUSIONS

- Green infrastructure can play an important role on college and university campuses, delivering benefits to the community, the environment, and campus resources.
- Campuses are unique environments given their scale, community members, and management, as well as potential for impact on the physical environment of their surrounding areas and thought leadership on stormwater management.
- Implementing green infrastructure requires a collaborative, multi-stakeholder approach. Design charrettes are one way to effectively engage campus stakeholders and build consensus around an understanding of existing conditions, campus challenges, opportunities, design strategies, and implementation pathways.
- There are a range of tools and processes that can help support green infrastructure implementation: asset management, strategic frameworks, prioritization tools, and modeling tools, and this body of practice and knowledge continues to grow.

EPA

CAMPUS RAINWORKS CHALLENGE

For more information:

www.epa.gov/green-infrastructure

Climate Resilience Consulting

one architecture
new york city amsterdam

SHERWOOD
DESIGN ENGINEERS

IMAGE CREDITS

Cover: Calvin and Tina Tyler Hall at Morgan State University (Source: ONE)

3: Bioswale garden and filter strip at Cornell University Botanic Gardens (Source: ONE)

4: Stormwater wetlands at Kent State University (Source: Dave Costello, Associate Professor of Biological Sciences, Kent State University)

6, 7: Cover of Campus RainWorks design brief (Source: US EPA)

8, 9, 10, 11: RainWorks charrettes at Morgan State and UT Arlington (Sources: ONE, Morgan, UTA)

12: Aerial view of the UTA campus and Trading House Creek (Source: Taner Ozdil, UTA)

13: Campus stakeholders tour green infrastructure during the charrette at Morgan State University (Source: ONE)

15: Aerial view of Morgan State University (Source: Google Earth)

16: Rain garden at University of Chicago Laboratory Schools Gordon Parks Arts Hall (Landscape design: Mikyoung Kim Design, Photography: David Burk)

17: Campus RainWorks design submissions – UTA, 2017-2018; UTA, 2019-2020; Morgan, 2020; UTA, 2020-2021; Morgan, 2020; UTA, 2020-2021; Morgan, 2020; UTA, 2020-2021

19: Green roof at Calvin and Tina Tyler Hall at Morgan State University (Source: ONE)

20: Asset mapping – campus green infrastructure, Morgan State University (Source: ONE)

21: Map of campus watersheds, UT Arlington (Source: ONE)

23: (left) Watershed diagram (Source: Sherwood Design Engineers / ONE); (right, clockwise) Stormwater Pocket Wetland designed by Armentrout, Matheny, Thurmond P.C. and installed at McLane Company via Athens-Clarke County; UTA CAPPA building (Source: Taner Ozdil / UTA), Kerby Street Greenbelt, UTA (Source: John Hall / UTA); bioretention feature at Morgan State (Source: ONE)

24: (left) Dry and wet detention ponds under construction in Lafayette, Louisiana (Source: ONE); (right) downspout disconnect at Calvin and Tina Tyler Hall, Morgan State University (Source: ONE)

25: (from left to right) Baldwin Hall, Morgan State University (Source: ONE); Blue-gray Gnatcatcher, Davidson College (Source: Eric Keith); Orange Mall Green Infrastructure, Arizona State University (Landscape design: COLWELL SHELOR, Image: Marion Brenner); stream bank restoration on the Chinquapin Run, Morgan State University (Source: ONE); Bioswale garden and filter strip at Cornell University Botanic Gardens (Source: ONE)

26: EPA web page

27: Multi-stakeholder site visit during the UT Arlington design charrette (Source: ONE)

29: Green Infrastructure design option visualizations (Source: ONE)

30: (clockwise) Bioretention in Redwood City, California (Source: Sherwood); rain garden at Doyle-Hollis Park, Emeryville, California (Source: Blue-Green Building); House 5 (the Flora Rose House) at Cornell University (Design & source: KieranTimberlake); downspout disconnection / bioretention at Lafayette Public Works, Louisiana (Source: ONE)

31: (clockwise) Roadside bioswale (Source: The Klausing Group); channelized water flow in Seattle, Washington (Source: Sherwood); bioretention at Woods Hall, University of Maryland (Source: UM); roadside bioswale, Tower Road - Cornell University (Source: Cornell)

32: (clockwise) Chinquapin Run restoration at Morgan State University (Source: ONE); modular subsurface tank installed in San Antonio, Texas (Source: Contech); floodable open space in Manassas Park, Virginia (Source: O'Shea Wilson Siteworks); water reclamation pond at Duke University (Design: Nelson Byrd Woltz Landscape Architects, Photo: Mark Hough)

PRIORITIZATION FRAMEWORK CITATIONS

Location in watershed
Based on the priorities listed for each portion of watershed. Upper watershed: infiltrate; convey downstream. Middle watershed: slow water flows through storage; divert flows from problem areas; convey downstream. Lower watershed: absorb and store.

Technical criteria (maximum drainage area; pressure head needed; maximum slope)
In absence of explicit technical guidance for national-level agencies, technical information was supplemented from the Georgia Stormwater Management Manual Volume 2 (2016) which is listed on EPA's website as a resource for green infrastructure guidance and is commonly regarded among the nation's leading stormwater guidance documents.

Ecological co-benefits
Evaluation considers the ancillary benefits associated with the incorporation of green infrastructure on campus, including the provision of habitat within the green infrastructure and the mitigation of urban heat island effect through the decrease of impervious area or the increase of tree canopy.

Economic considerations
Due to the unavailability of data from the federal government on green infrastructure standards, costs were taken from the Georgia Stormwater Management Manual Volume 2 (2016) and NOAA Guidance for Cost Estimations of Nature Based Solutions (2020). Costs are considered in terms of price per square foot (SF) that is treated by the green infrastructure measure or design option.

Benefit to MS4 Compliance
Evaluation based on the degree to which the green infrastructure either reduces the amount of impervious area or treats the stormwater that generates from impervious area on campus.