Total Maximum Daily Load (TMDL) Green Asset Management Webinar

April 29, 2025

Casey Cannon, Environment & Development Planner

North Central Texas Council of Governments

Webinar Procedures

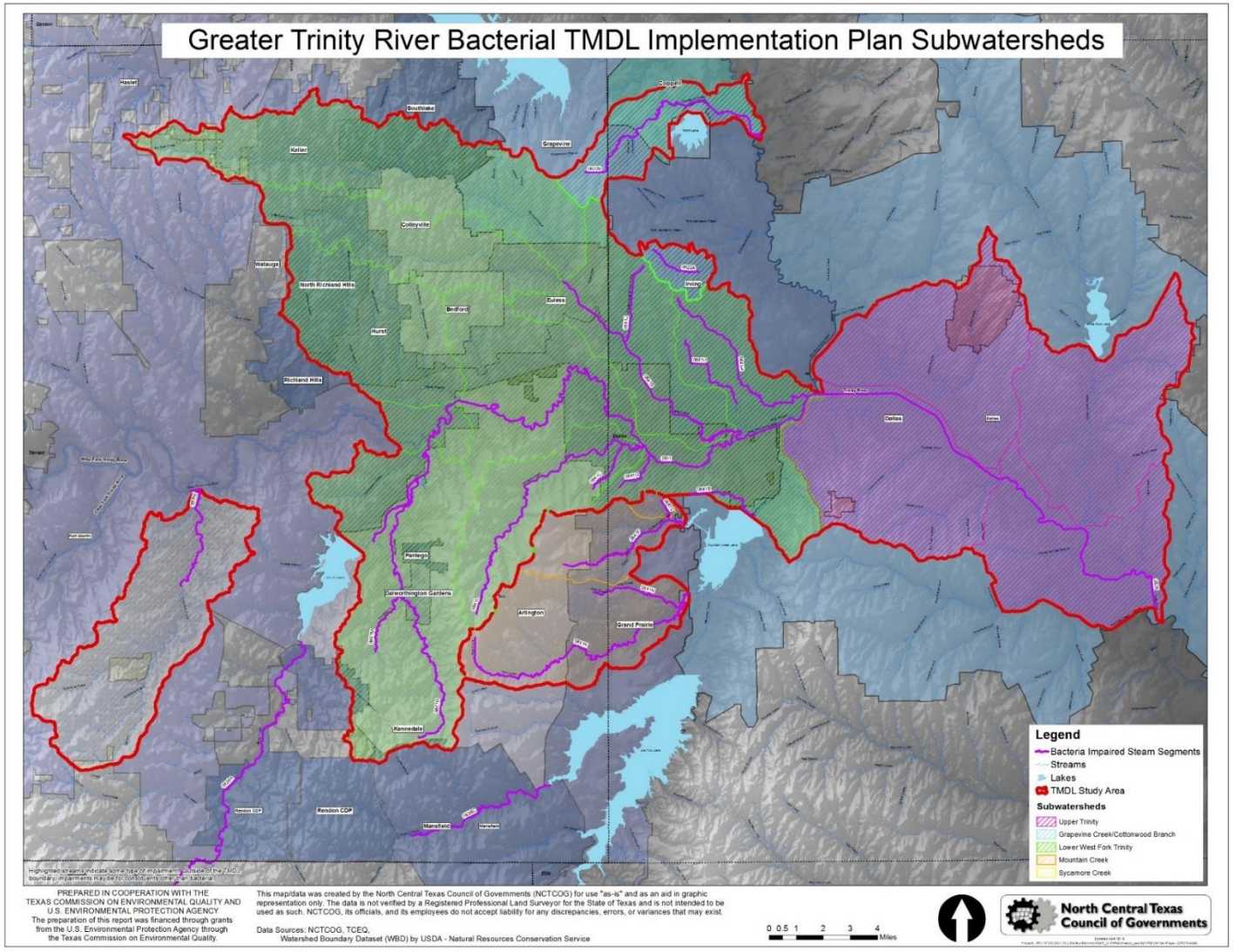
- This webinar will be recorded and posted to the NCTCOG TMDL webpage under the green banner labeled "Workshops"
  - www.nctcog.org/TMDL
- All registrants and attendees will receive an email with the presentation slides and a subsequent email when the recording is posted.
- Please keep your microphone on mute until the Question-and-Answer period at the end of the presentations.
  - Questions can also be typed into the chat box.
- Thank you!

What is the North Central Texas Council of Governments?

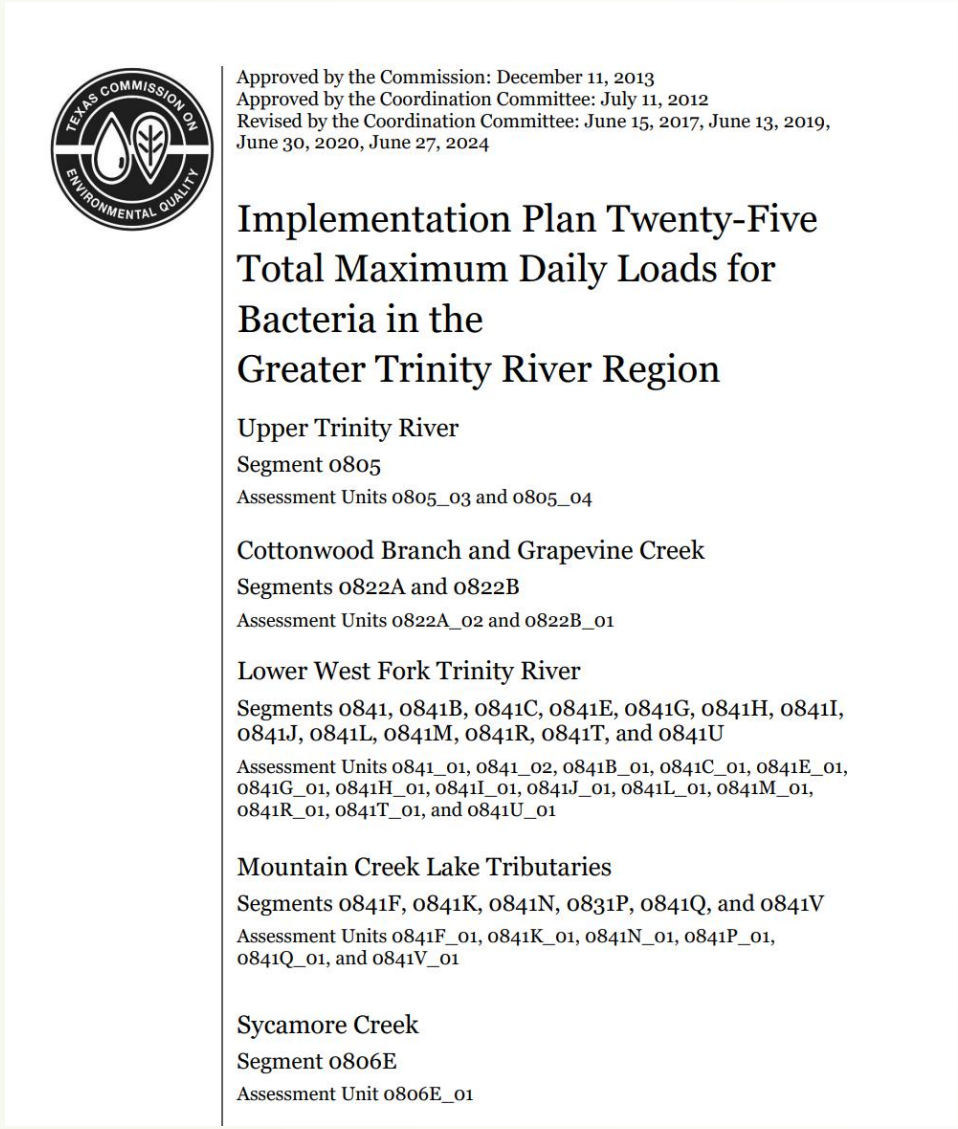
- Voluntary association of local governments
- Established in 1966
- Assists local governments in:
  - Planning for common needs
  - Cooperating for mutual benefit
  - Recognizing regional opportunities
  - Resolving regional problems
  - Making joint decisions

North Central Texas Council of Governments
Environment & Development

Bacteria Impairments in the DFW Metroplex



Total Maximum Daily Load (TMDL) Program



Approved by the Commission: December 11, 2013
Approved by the Coordination Committee: July 11, 2012
Revised by the Coordination Committee: June 15, 2017, June 13, 2019, June 30, 2020, June 27, 2024

Implementation Plan Twenty-Five Total Maximum Daily Loads for Bacteria in the Greater Trinity River Region

Upper Trinity River

Segment 0805

Assessment Units 0805_03 and 0805_04

Cottonwood Branch and Grapevine Creek

Segments 0822A and 0822B

Assessment Units 0822A_02 and 0822B_01

Lower West Fork Trinity River

Segments 0841, 0841B, 0841C, 0841E, 0841G, 0841H, 0841I, 0841J, 0841L, 0841M, 0841R, 0841T, and 0841U

Assessment Units 0841_01, 0841_02, 0841B_01, 0841C_01, 0841E_01, 0841G_01, 0841H_01, 0841I_01, 0841J_01, 0841L_01, 0841M_01, 0841R_01, 0841T_01, and 0841U_01

Mountain Creek Lake Tributaries

Segments 0841F, 0841K, 0841N, 0831P, 0841Q, and 0841V

Assessment Units 0841F_01, 0841K_01, 0841N_01, 0841P_01, 0841Q_01, and 0841V_01

Sycamore Creek

Segment 0806E

Assessment Unit 0806E_01

- 1996 & 2006 bacteria impairments in Dallas-Fort Worth Metroplex on 303(d) List (*Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d))*.
- 2011 & following years saw TCEQ adoption and EPA approval of several *Total Maximum Daily Loads* (TMDLs) in Dallas Fort Worth Metroplex.
- The Implementation Plan (I-Plan) describes implementation strategies, such as Green Infrastructure (GI) in planning and development.

Other Green Infrastructure Initiatives at NCTCOG

- *integrated* Stormwater Management (iSWM)
- Integrating Transportation & Stormwater Infrastructure (TSI)
- Blue-Green-Grey Funding Program

Shannon Sloane Pepper

Southwest Environmental Finance Center (SWEFC) at the University of New Mexico

Asset Management for Green Infrastructure

Introduction & Real-World Applications

In Partnership with North Central Texas Council of Governments

29 April 2025

SOUTHWEST
ENVIRONMENTAL
FINANCE CENTER

Overview

- What is green (and gray) infrastructure?
- Introduction to the 5 Core Components of Integrated Green/Gray Asset Management
  - With case study examples from the City of Tucson Storm to Shade's Asset Management Program
- Resources

Green Infrastructure

What is it and why should you care?

Photo credit: NRCS Oregon

Water/Wastewater/Stormwater Infrastructure

Gray:

Green:

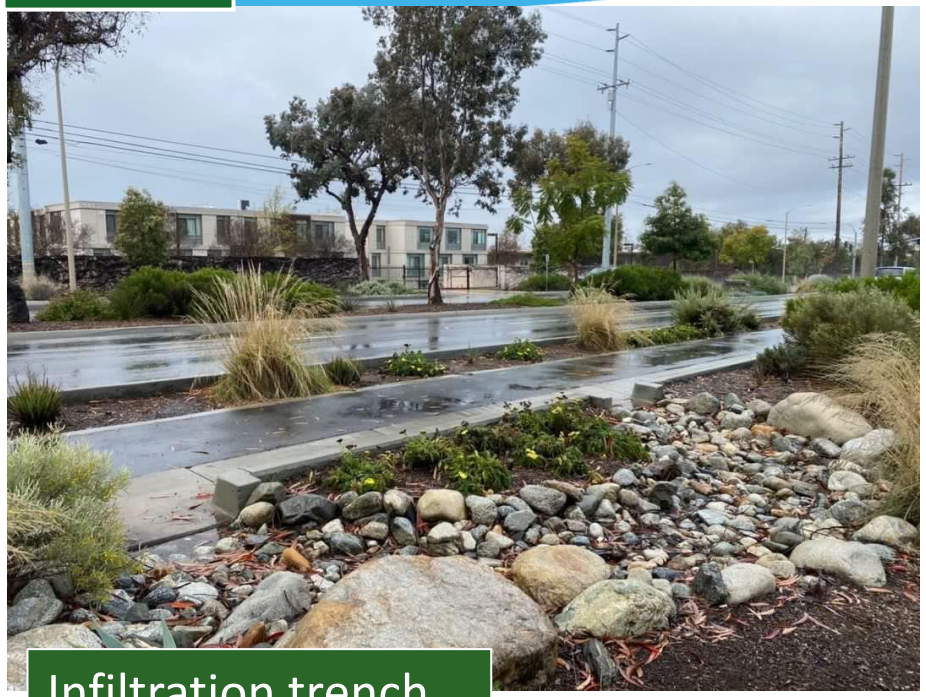
Photo Credits (top-bottom, left-right): Marcel Kortekaas; Wikipedia; Florida Water Daily; Montgomery County Planning Commission; Radcliffe Dacanay; Robert Rogers

Stormwater/Wastewater Infrastructure

Gray

Sewer pipe

Green



Infiltration trench

Some co-benefits of infiltration trench:

- Filtration of water through soil
  - Plant & fungi uptake of pollutants
- Dispersed absorption – stormwater does not make it to treatment plant
- Space for public enjoyment, habitat

Function: Convey storm water away from roads/buildings

Photo credits (left-right): Pam Broviak; Arid LID Coalition

Wastewater Infrastructure

Gray

Wastewater Treatment Plant

Green

Constructed Wetland

Some co-benefits of constructed wetlands:

- Habitat
- Flood mitigation
- Air quality improvement
- Space for public enjoyment and engagement

Function: Treat municipal wastewater & return cleaned water to a nearby water body without harm to humans or the environment

Photo credits (left-right): Water Alternatives; SW EFC

Why Green Infrastructure?

Climate Resiliency

Partnerships

Co-Benefits

Asset Management: Blending Green and Gray for Holistic Decision-Making

What asset management is and how it helps systems make good management decisions about their green and gray assets together

Asset Management is a **framework** designed **to help you** decide **how**, **when** and **where** to spend **limited funds** to achieve the **best results**.

Five Major Components

What service level do you want?

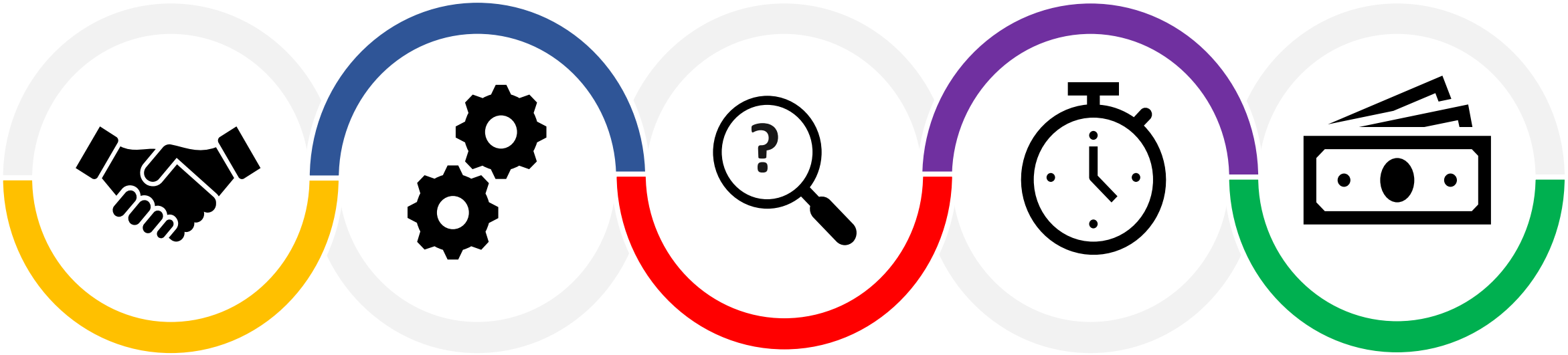
What service do you provide?

Which ones are most critical?

Criticality

Do you have the money to get it all done?

Long-term Funding



What assets do you have?

Current State of the Assets

How do you ensure the assets do their job over their life spans?

Life Cycle Costing

Core Component:

Level of Service

Goals

Level of Service Goals provide strategic direction for managerial, operational, and financial decisions.

- What service levels do your customers/community members want?
- What service levels can you provide?
- How will you measure performance?

Customer Service	System Maintenance	Response Time	Drought/Demand Management
Fewer than 2 complaints received regarding vegetation overgrowth, trash, and/or flooding of green infrastructure per month	The system will inspect and perform routine maintenance on all infiltration planters and rain gardens once a month. Routine maintenance includes weeding, mowing, unclogging, litter removal, and pruning.	System staff will inspect all green infrastructure installations within two weeks after a large storm event to assess damage.	The utility will develop a management plan for stormwater runoff entering streams and other source water to minimize pollutants within 3 years.

Example: Level of Service Goals

S2S maintains GSI assets to ensure safety by:

- *Infiltrating standing water*
- *Pruning vegetation for site visibility, mobility access and hazards*
- *Preserving structural integrity*
- *Clearing trash, invasive plant species and debris*

Core Component:

Current State of the Assets

Asset Inventory

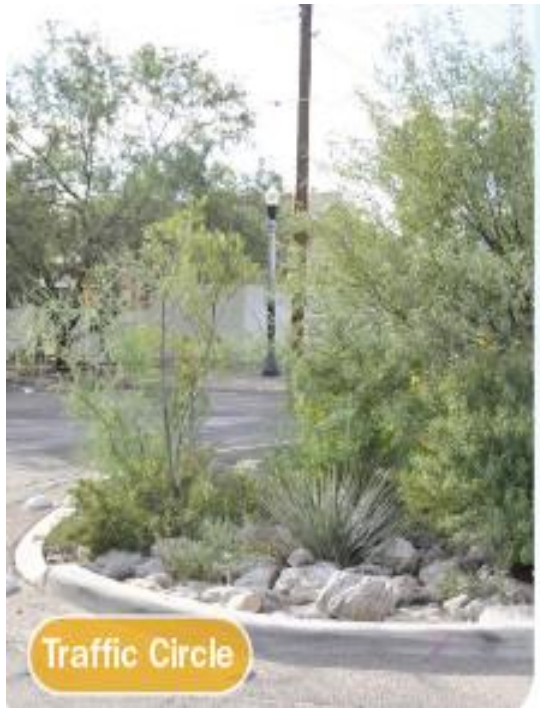
What is the [**Green**] asset?

Is it managed as a whole or by individual component?

Is it replaced as a whole or by components?

What data do you collect about an asset?

The asset can be broken into components



"Parent" Asset

"Child" Assets

CITY OF TUCSON | Storm to Shade

Example Asset Classification: Position

- Physical location where GSI assets sit within others' jurisdictions
- Report on costs for assets located within other departments', divisions', and partner entities' land.

Storm to Shade Program GSI EAM Positions	
Street, GSI	Police, GSI
Parks, GSI	Fire Station, GSI
Ward Office, GSI	Housing (HCD), GSI
Well Site, GSI	TUSD Facility, GSI
Pima County FCD, GSI	Misc. COT Facility, GSI

Ward	FY2024
1	$57,965
2	$0
3	$114,732
4	$24,191
5	$50,588
6	$140,565
Total	**$388,041**

	EAM POSITION	
	Street, Parks, Ward Office	**Pima County RFCD**
FY23	$231,405	$8,951
FY24	$379,499	$48,018

Storm to Shade

Tucson Asset Management System:
Work Order Execution for 810 GSI assets

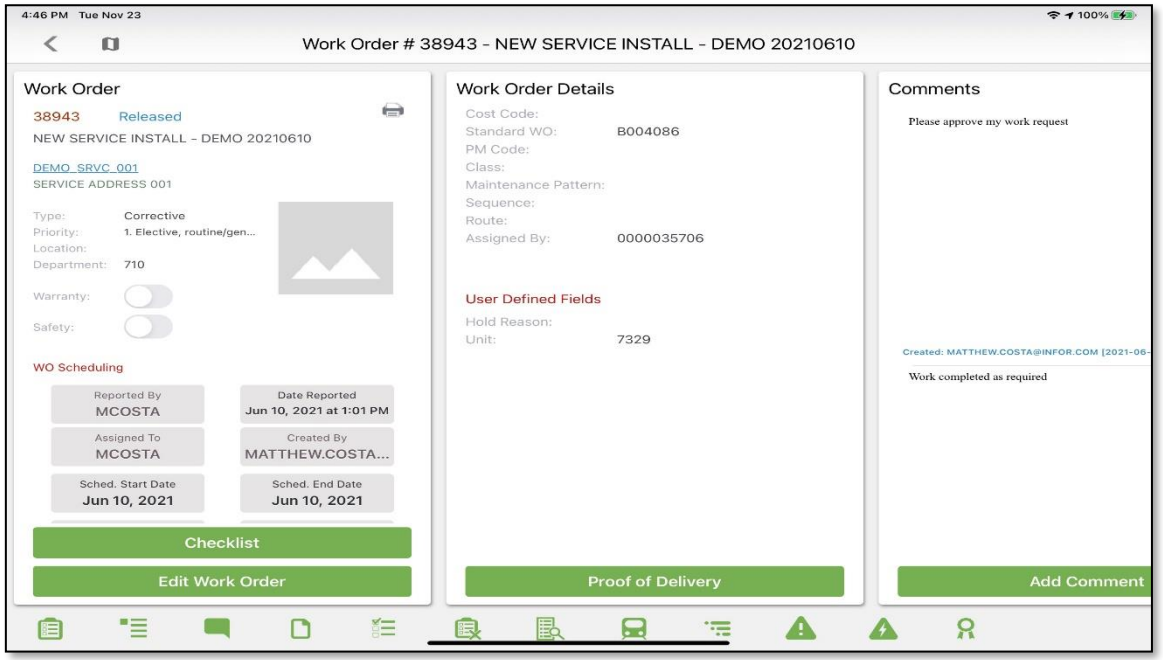
Contractors access Work Orders using Desktop and/or Mobile apps

Work Orders created through:

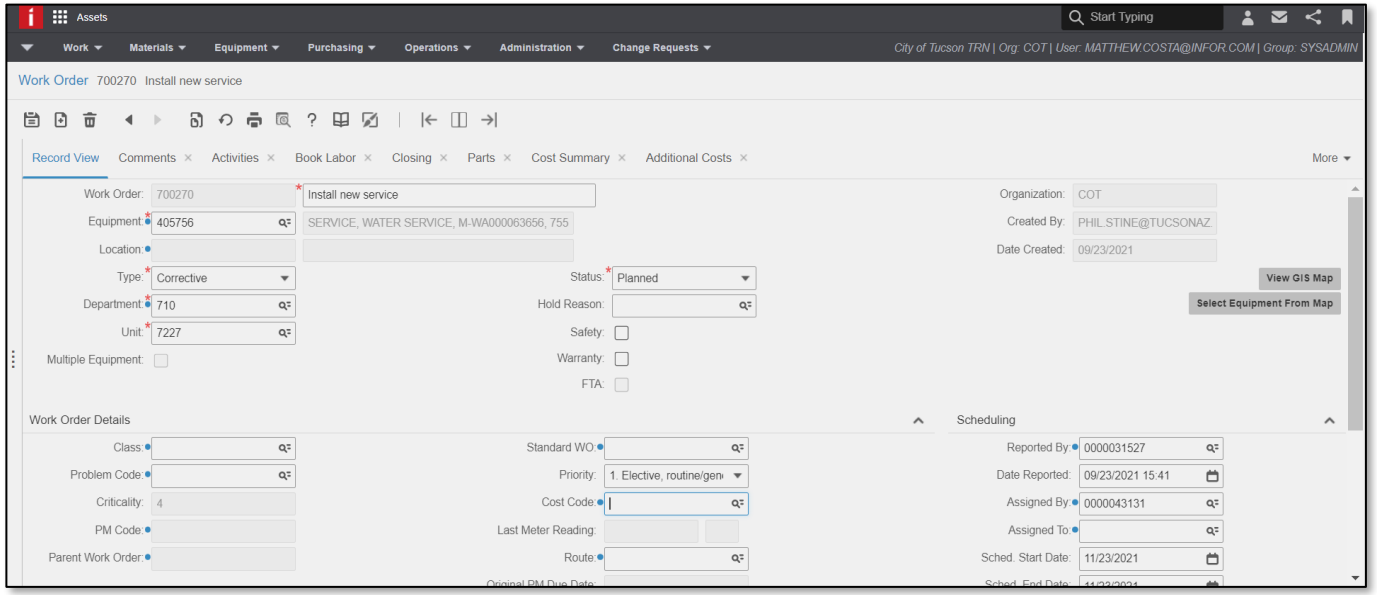
- Scheduled Preventative Maintenance
- Work Requests – Ad hoc / As needed work
- Contractor Checklist-initiated Follow-ups

Workflow driven by the Work Order Status field: *Scheduled, Open, Field Work Complete, Awaiting Invoice, Closed*

Mobile application:



Desktop application:



City of Tucson | GSI Capital Projects

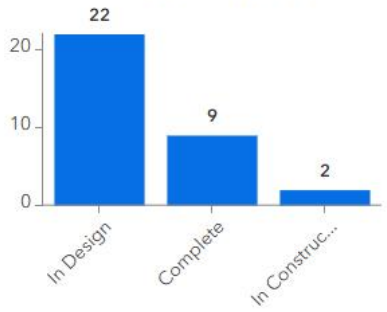
All Projects | Complete | In Construction | In Design | Identified

Storm to Shade

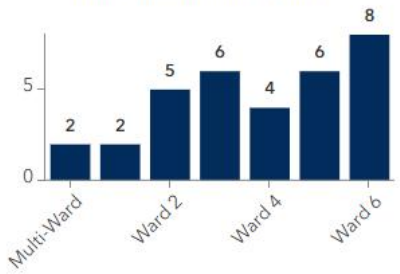
Storm to Shade has **33** new GSI projects in design, construction or completed throughout Tucson.

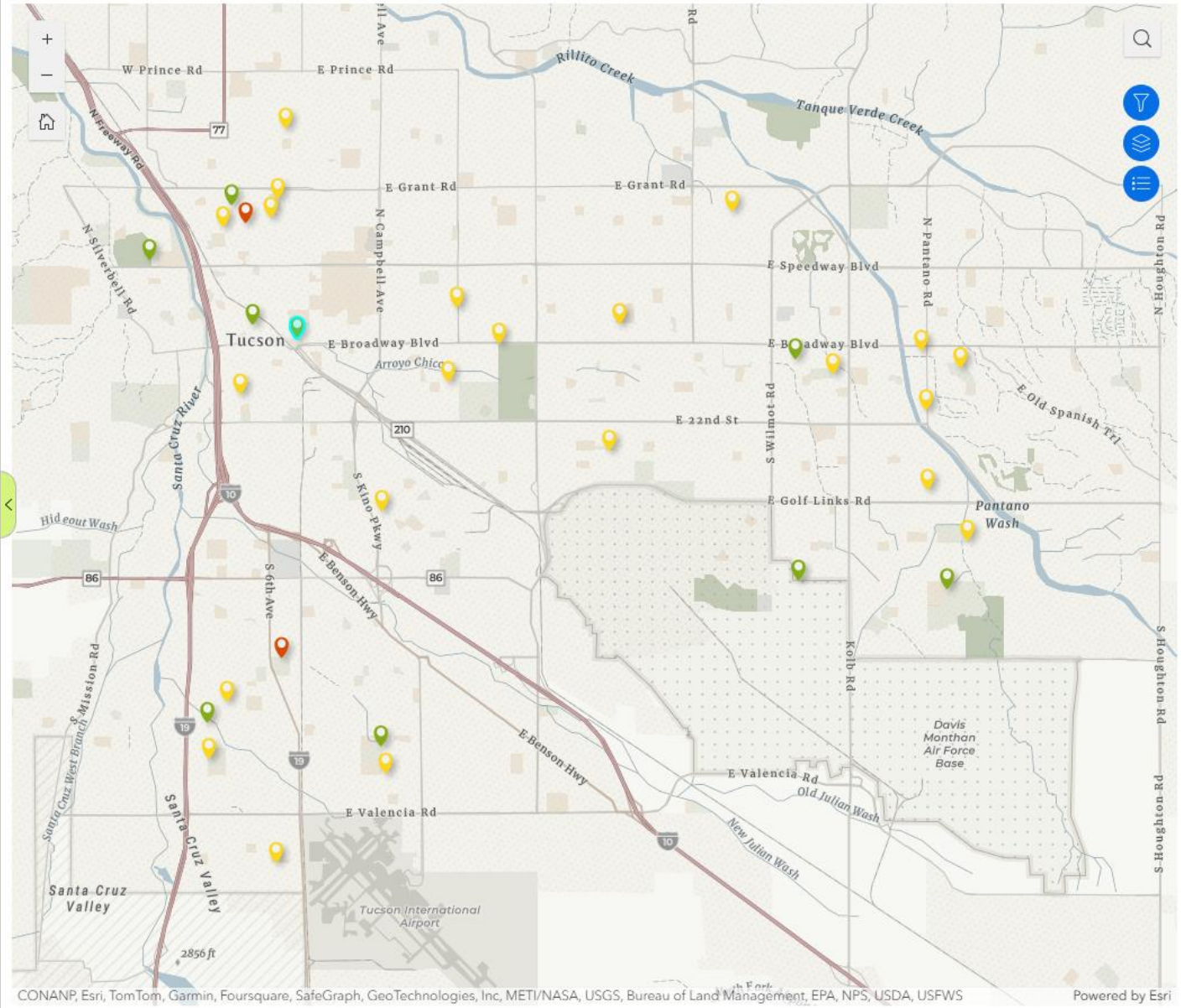
Click on the tabs at the top to see all projects by phase.

Number of Projects by Phase



Number of Projects by Ward





33 GSI Project(s)

Scroll down and click on each to learn more.

Ironhorse Park GSI

Storm to Shade has completed the construction of green stormwater infrastructure in Iron Horse Park. This green stormwater infrastructure installation includes the addition of sidewalk scuppers that allow stormwater running on 10 th Street and 1 st Avenue to enter and fill newly constructed basins irrigating 16 new native trees and dozens of native plants.

Learn More

18th St. & Main Ave.

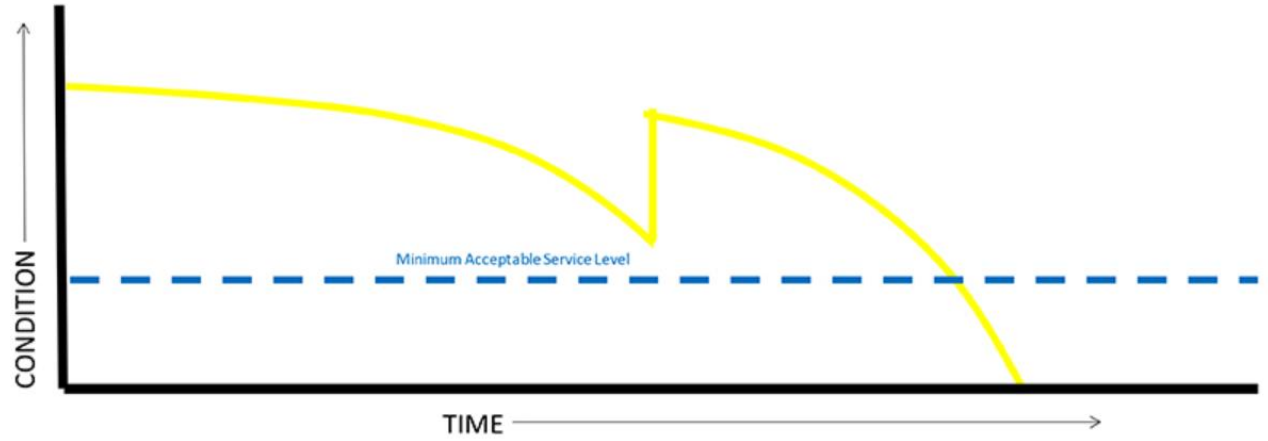
Storm to Shade is funding the design and construction of two in-street traffic-calming green stormwater infrastructure (GSI)

Condition

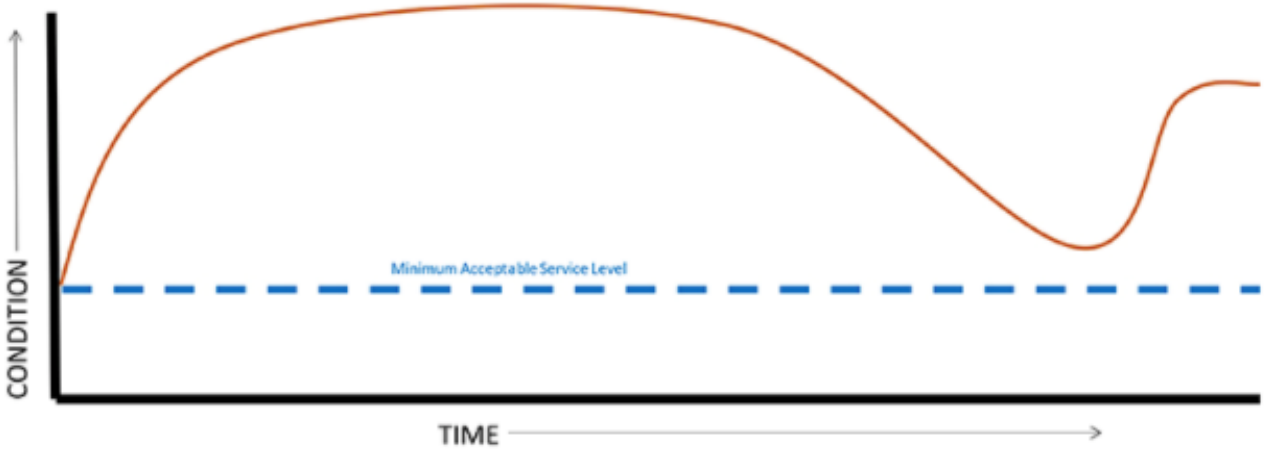
Defines the physical state of the asset at a moment in time

Will help inform useful life remaining, maintenance, interventions, replacement and other asset decisions.

Condition Curve – Typical *Gray Asset*



Condition Curve – Typical *Green Asset*



Source: SW EFC Green Gray Framework

5 Step Condition Scale: A good starting place for monitoring asset condition ove time

1
2
3
4
5

OR

Excellent
Good
Average
Fair
Poor

OR

A
B
C
D
E

Example Condition Scale for Bioretention Swales and Planters (Vegetation Components):

1. **Vegetation and trees are in very good condition:** excellent vigor in trees with no pests/disease/damage, symmetrical tree growth; desirable vegetation makes up >90% of soil area; excellent vigor in vegetation; weeds cover <25% of soil area.

2. **Vegetation and trees can wait for routine maintenance and/or pruning**: average vigor in trees with no pests/disease/damage, minor asymmetry in tree form; desirable vegetation covers 75%-89% of soil area; average vigor in vegetation; weeds cover 25%-49% of soil area.

3. **Vegetation and trees require priority maintenance, pruning, irrigation and/or weeding**: fair vigor in trees with minor pests/disease/damage, minor defects in tree form; desirable vegetation covers 50%-74% of soil area; fair vigor in vegetation; weeds cover 50%-74% of soil area.

4. **Vegetation and trees require high priority weeding, irrigation and lower priority replanting**: poor vigor in trees with significant pests/disease/damage and significant growth defects; desirable vegetation covers 25%-49% of soil area; poor vigor in vegetation; weeds cover 75%-89% of soil area.

5. **Vegetation and/or tree require replacement with high priority**: Trees are dead or nearly dead and not able to be saved; desirable vegetation covers <25% of soil area; vegetation is dead or nearly dead and not able to be saved; weeds cover >90% of soil area.

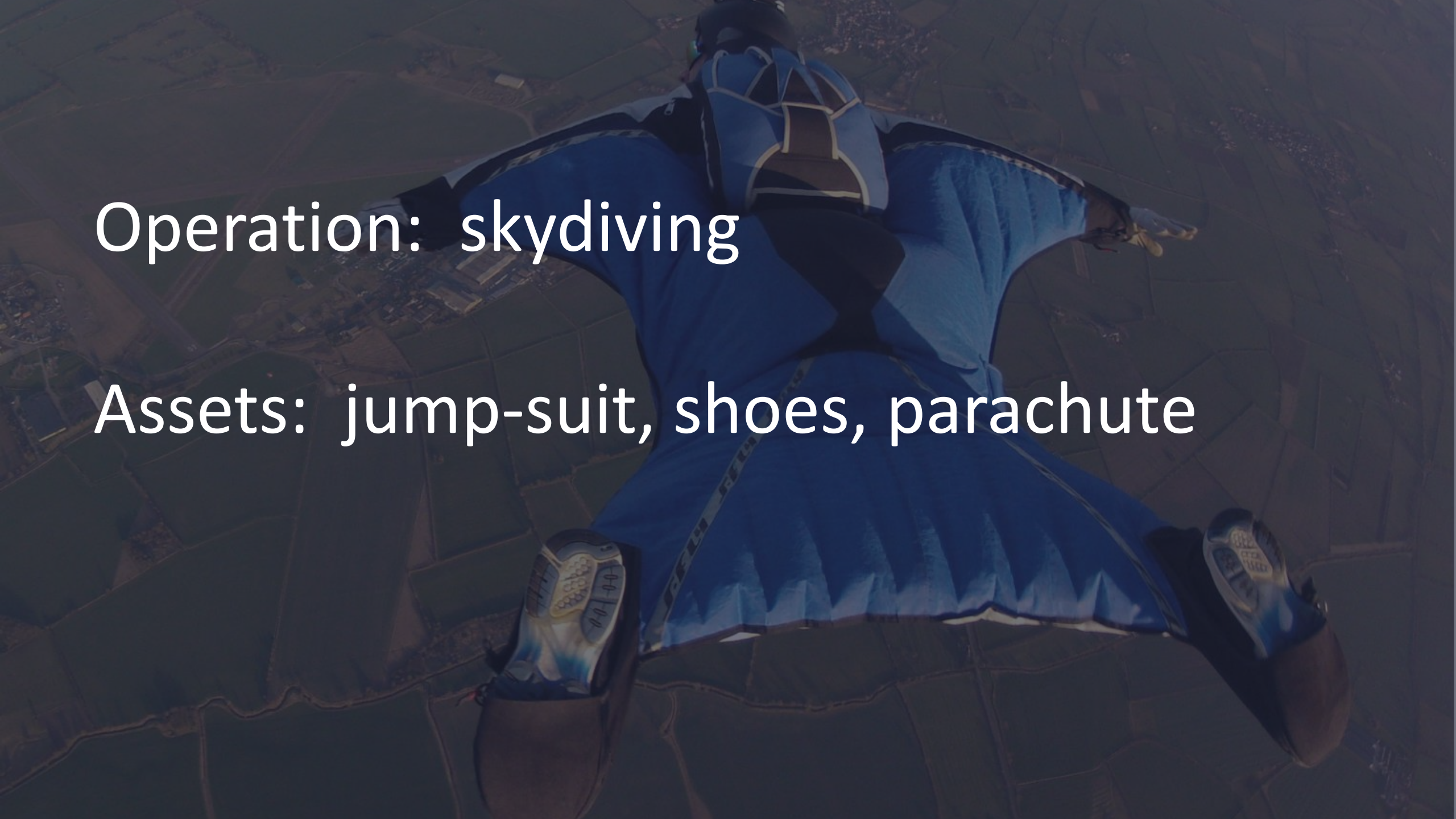
Core Component:

Criticality

Risk

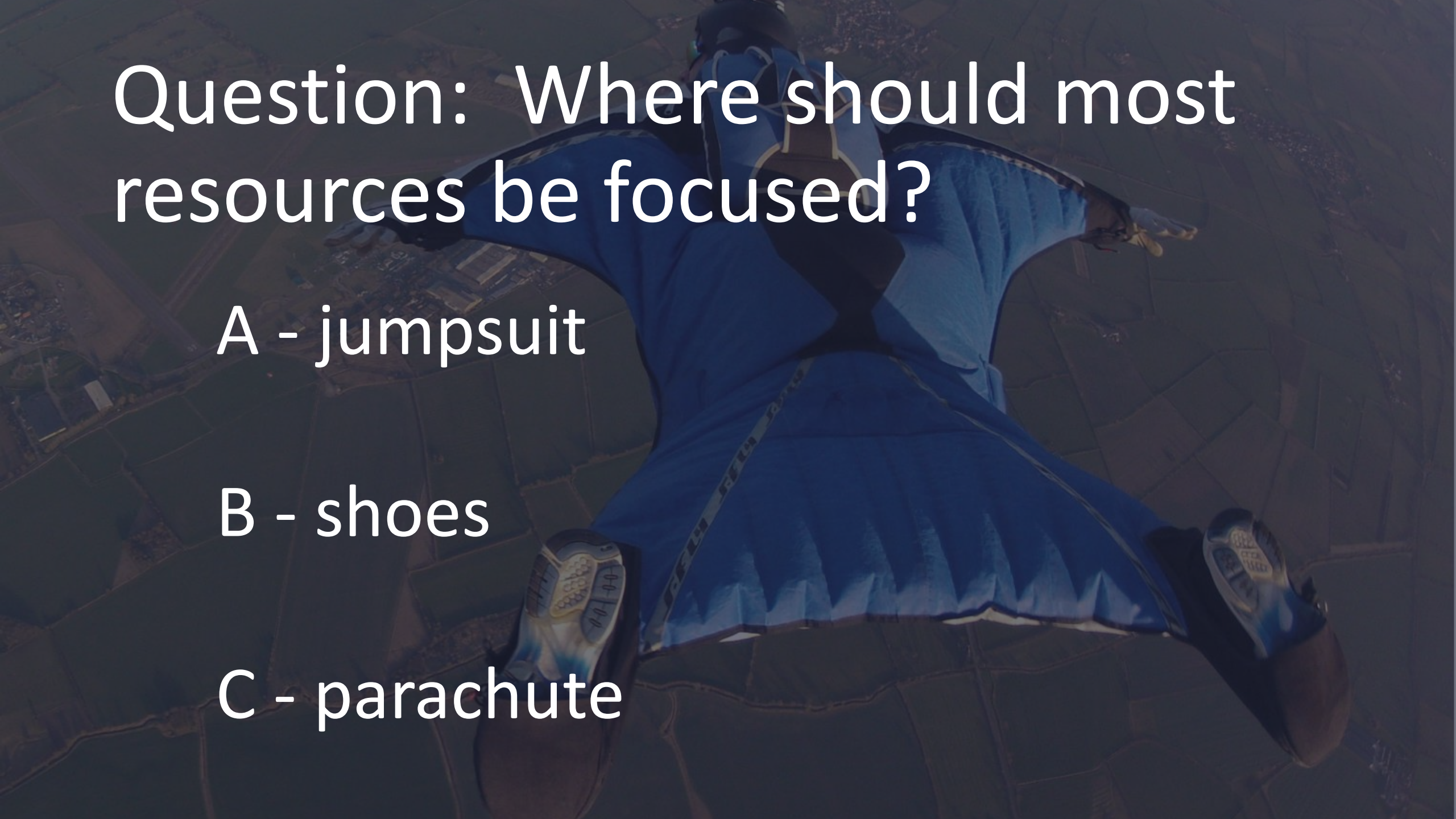
Understanding and determining the risk for each of your assets in order to prioritize activities that are most critical to your system.


Let’s look
at a
simple
example



Operation: skydiving

Assets: jump-suit, shoes, parachute



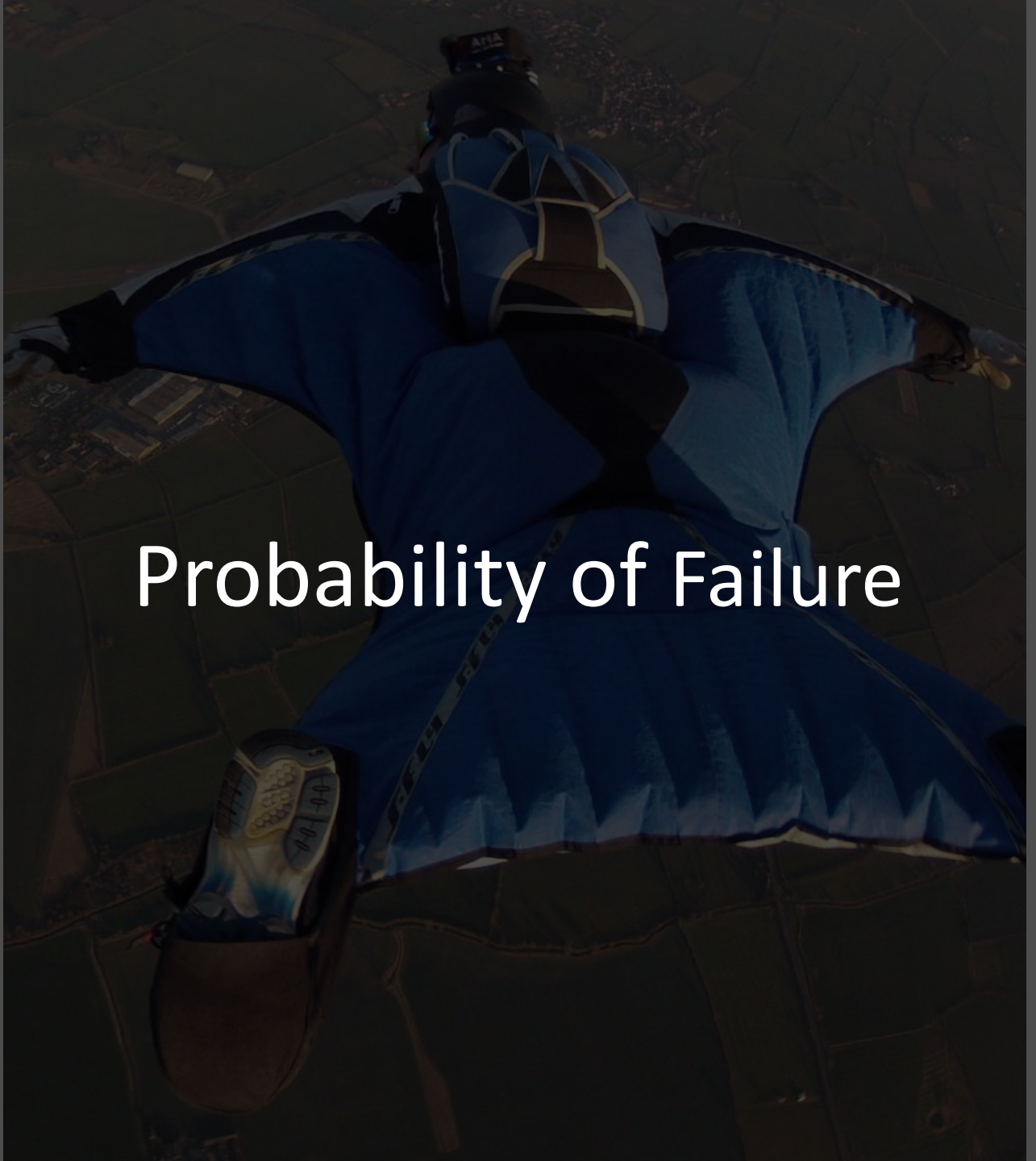
Question: Where should most resources be focused?

A - jumpsuit

B - shoes

C - parachute

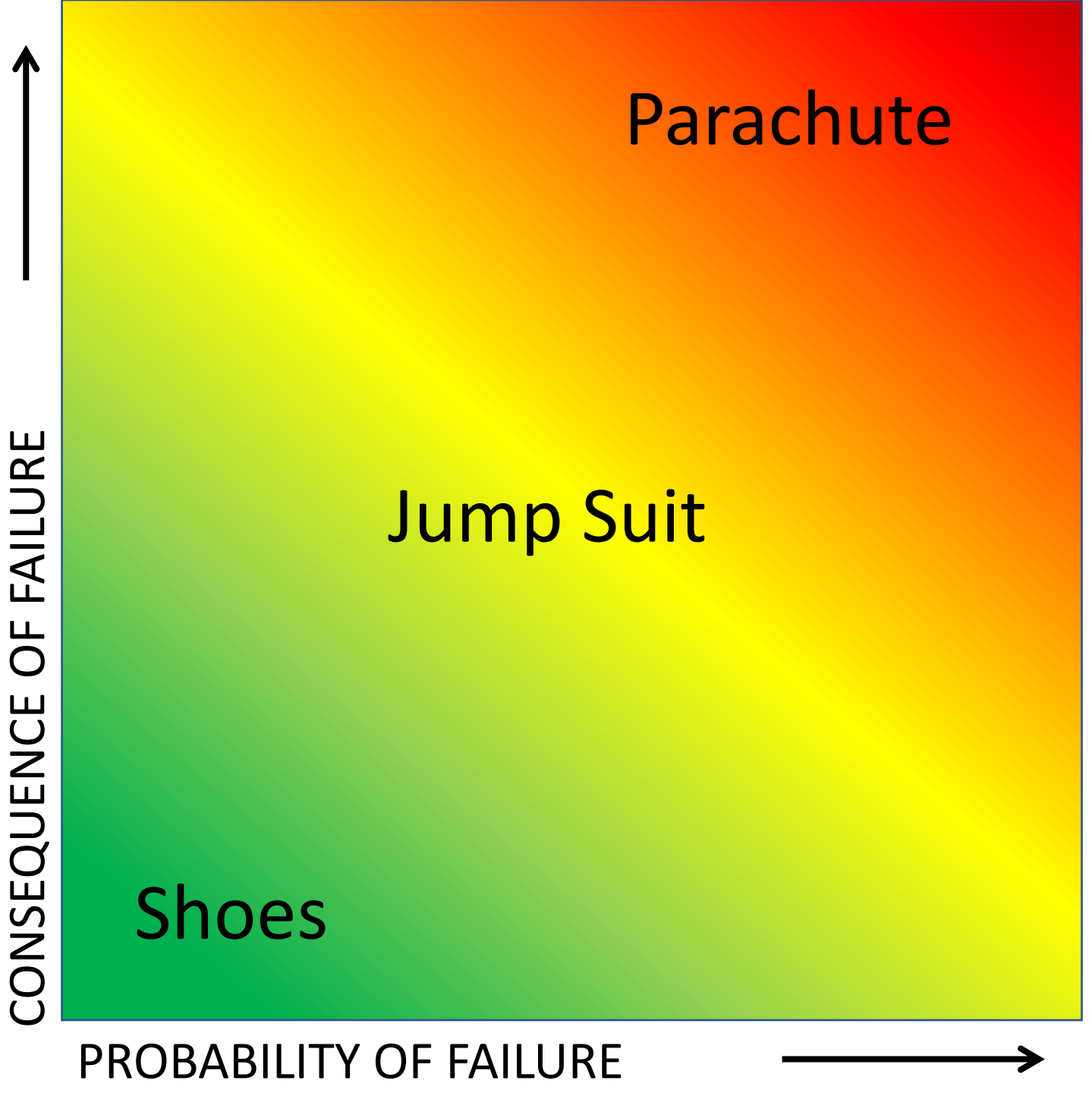
Answer:



Probability of Failure

Consequence of Failure

How we would manage these assets based on the risk



Mortality/Degradation of Green Assets can look like…

Infiltration Basin: vegetation death, invasive species, inlet blocked, debris clogging drain, sediment trap clogged or disturbed, compacted soils, irrigation access caps missing or damaged

Permeable Pavement: clogged joints or pores, ponding, underdrain deteriorated

Factors influencing the **probability of failure** of Permeable Pavement

- Low levels of preventative maintenance
- Construction
- Weather (freeze-thaw cycle)
- Traffic load/type
- Location

Consequence of failure for Permeable Pavement

- Clogged pavements (without overflow) causing overland flow into private property, potentially causing damages
- Financial impacts for required repairs
- Closing/restricting roadways or parking lots
- Tripping hazards for users, potentially causing injuries
- Loss of public support or confidence

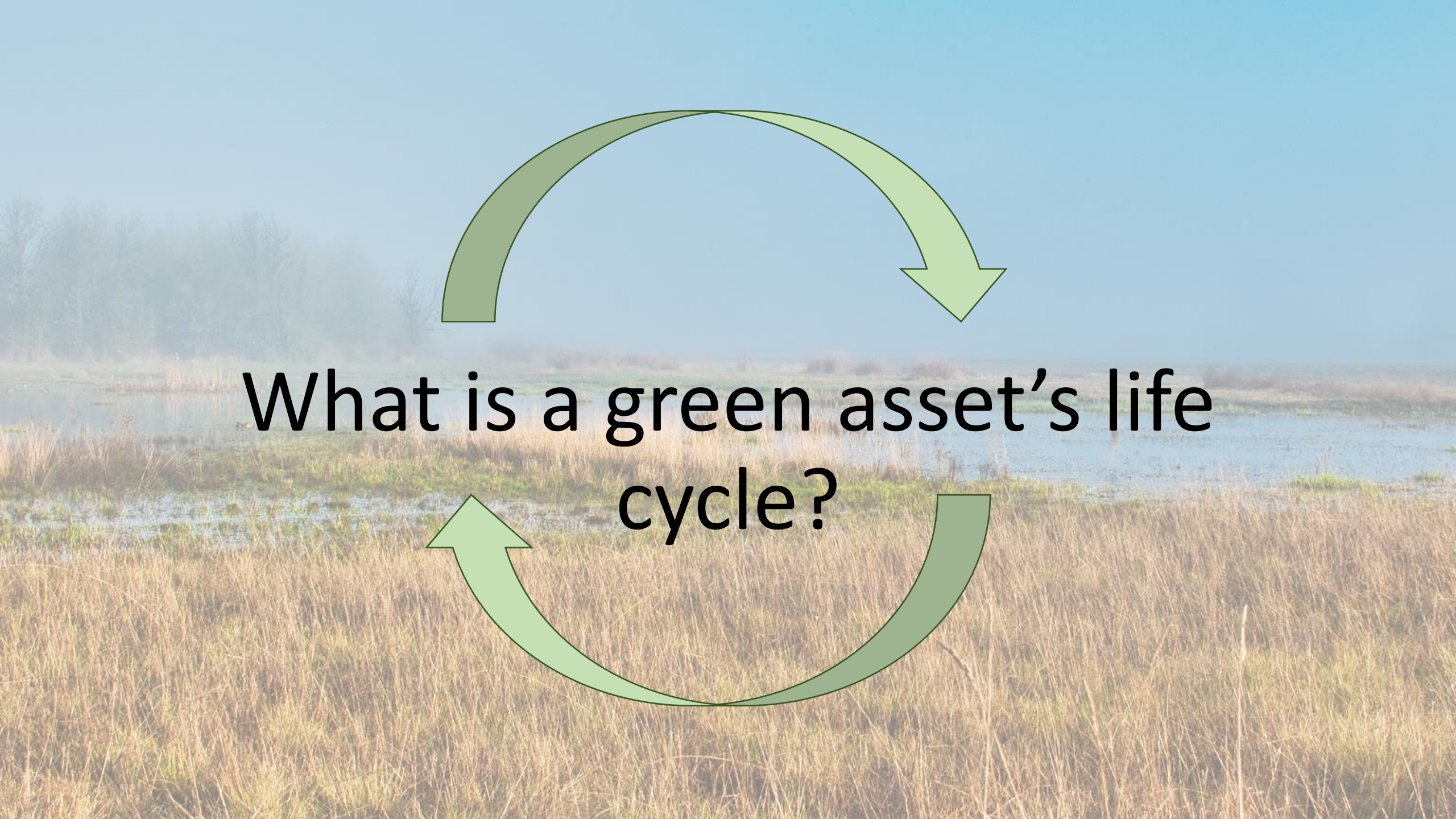
Core Component:

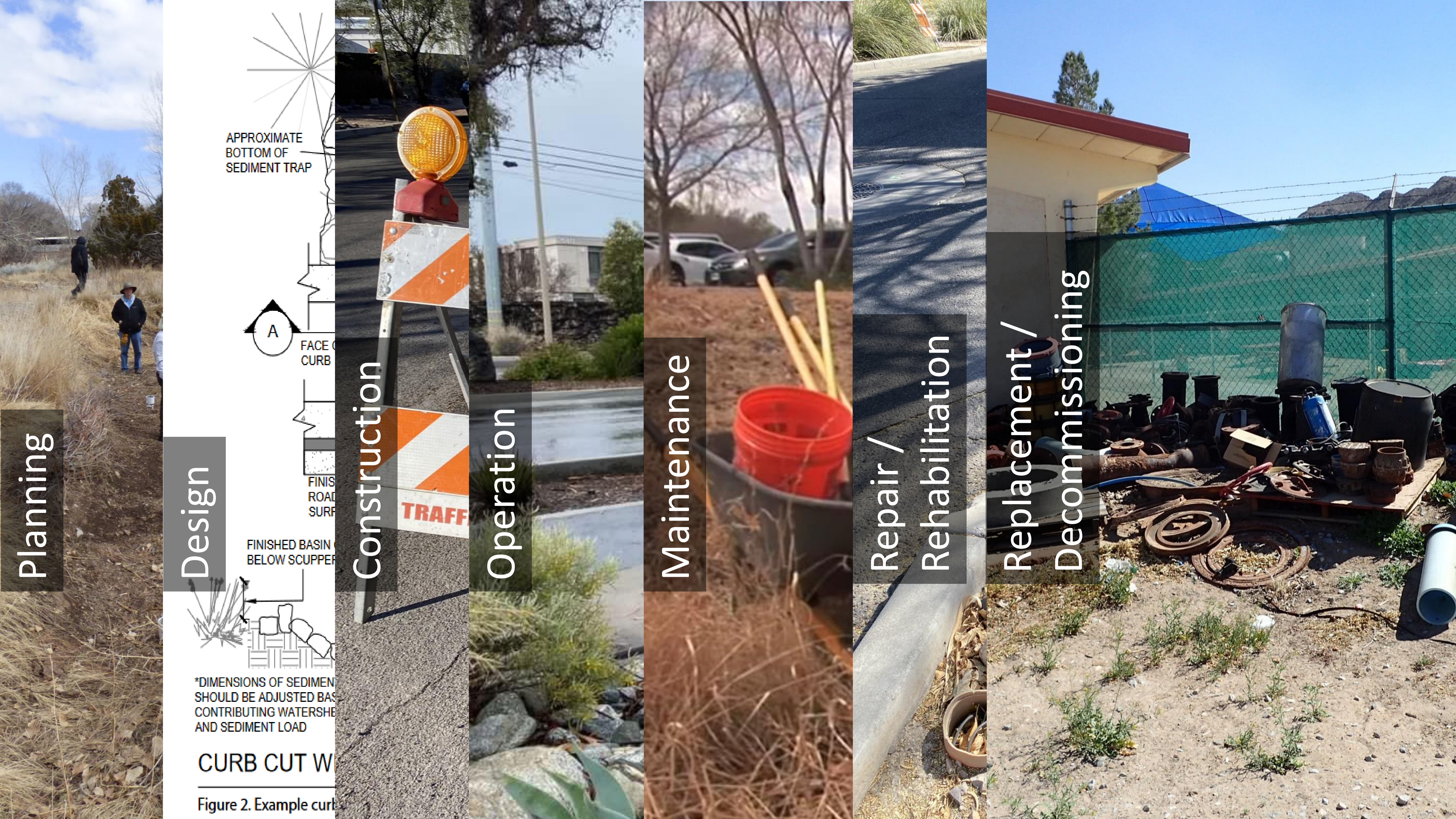
Life Cycle Costing

Costs the asset will incur over its lifespan

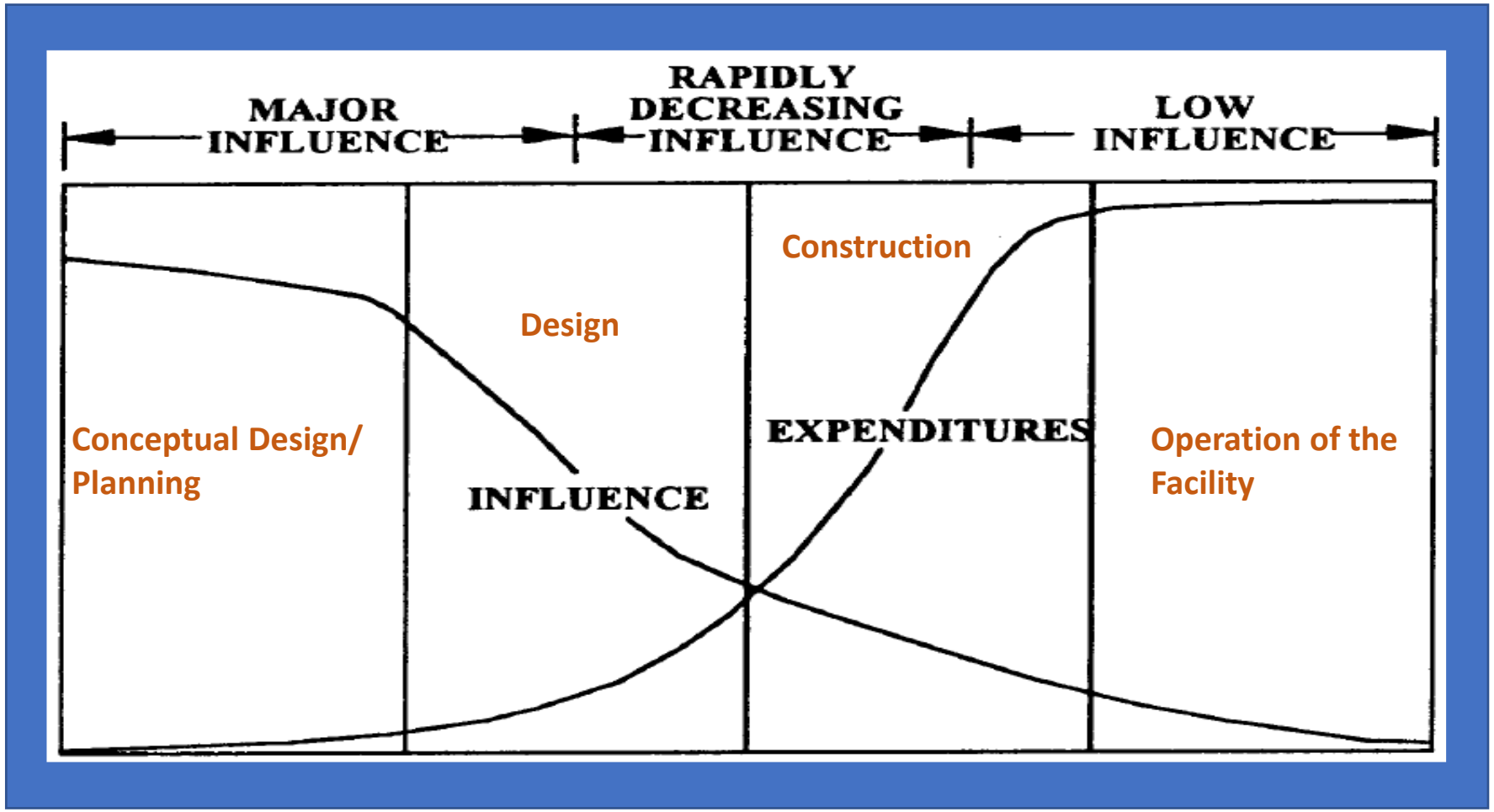
Costs can include: planning, design, acquisition, installation, maintenance, rehabilitation, replacement, retirement/disposal

Natural assets don't have some of these costs (won't be replaced)


What is a green asset’s life cycle?

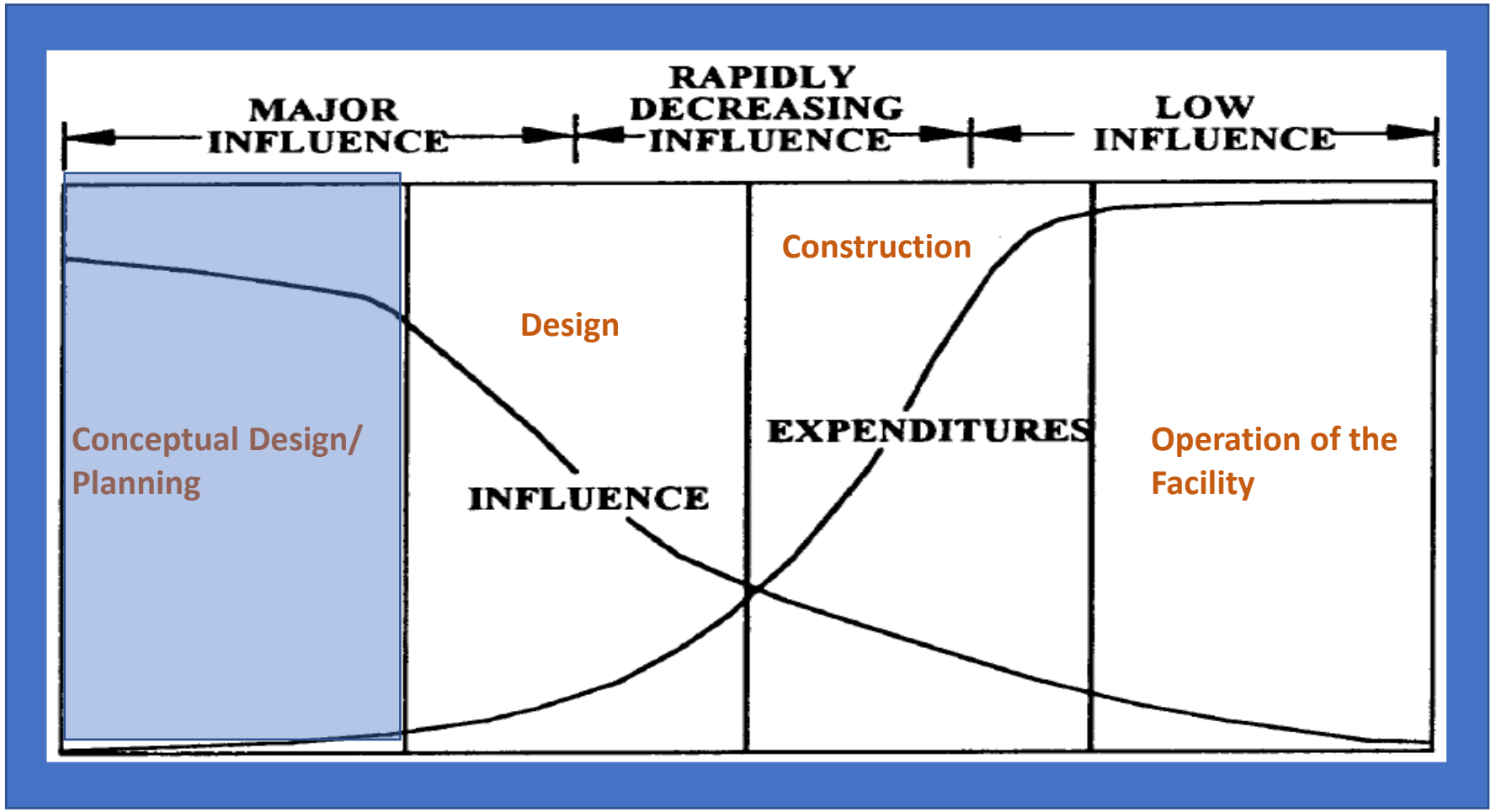

Planning
Design
APPROXIMATE BOTTOM OF SEDIMENT TRAP
Construction
Operation
Maintenance
Repair / Rehabilitation
Replacement / Decommissioning

An Asset's Life Starts During the Planning Phase



Source: Gibson and Hamilton (1994) Analysis of pre-project planning effort and success variables for capital facility projects. Construction Industry Institute Source Document 105.

Initial Planning: Most Influence, Least Cost



Source: Gibson and Hamilton (1994) Analysis of pre-project planning effort and success variables for capital facility projects. Construction Industry Institute Source Document 105.

Operations and Maintenance (O&M)

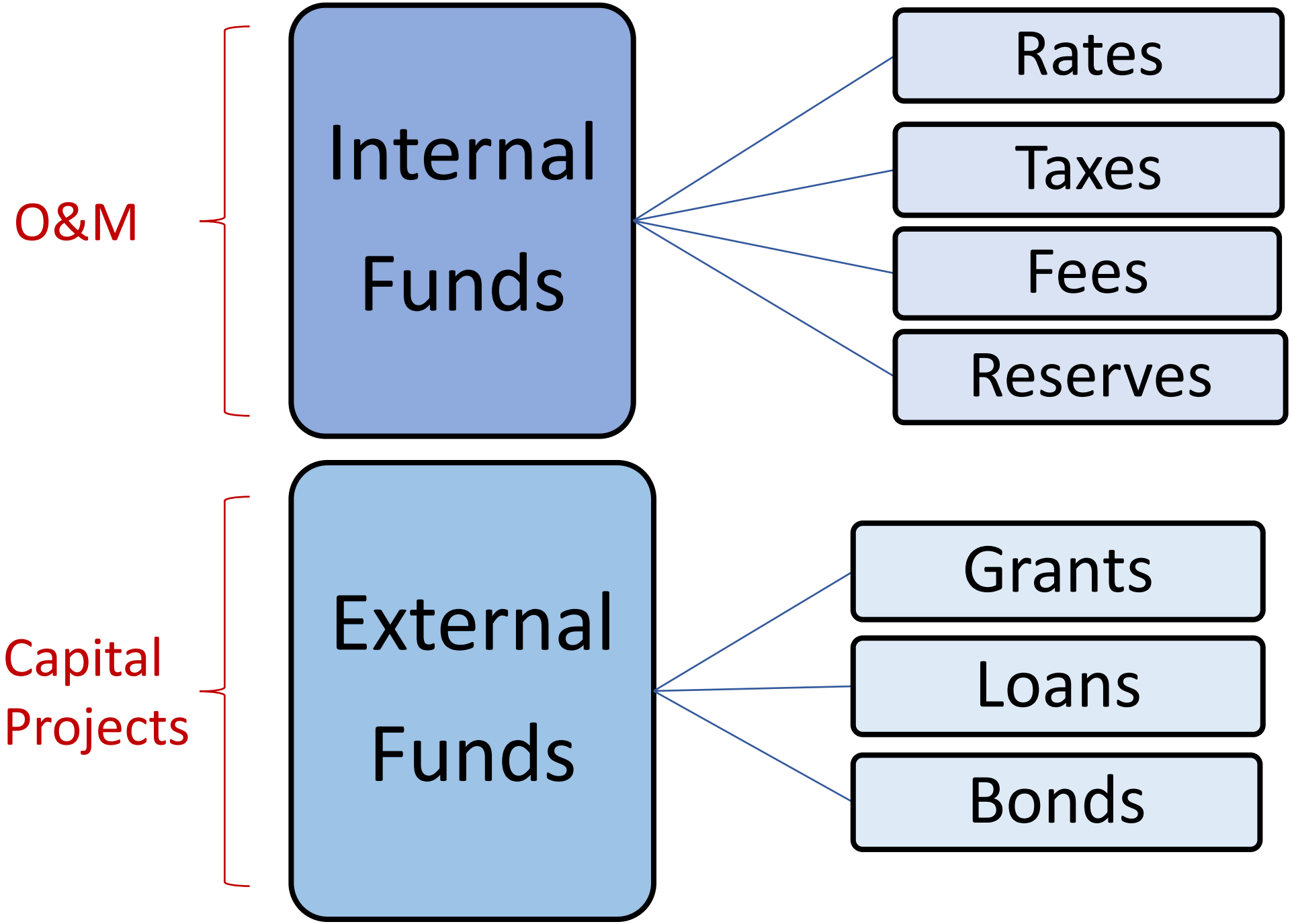
- Maintenance may take a different type of skill set, may need different staff for green vs gray assets
- The operation part of green infrastructure tends to be relatively simple. Almost all of the assets are passive operation

Core Component:

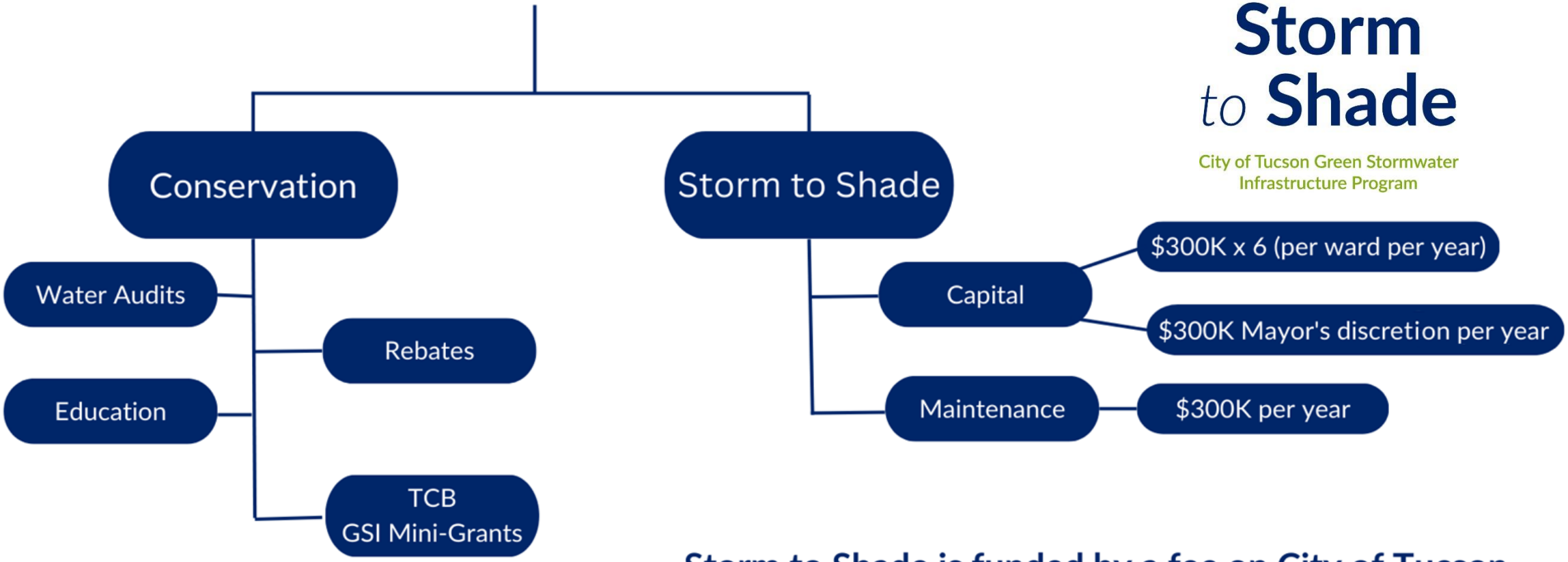
Long-Term Funding

The money you need to get it all done

In order to maintain the desired level of service for the lowest life cycle cost, a system must have a sustainable, long-term funding strategy.


O&M
Internal Funds
Rates
Taxes
Fees
Reserves
Capital Projects
External Funds
Grants
Loans
Bonds

Conservation and Stormwater Resources



Storm to Shade

City of Tucson Green Stormwater Infrastructure Program

Storm to Shade is funded by a fee on City of Tucson utility bill based assessed at .13 per CCF averaging $1 per month for the average household.

Storm to Shade
City of Tucson Green Stormwater Infrastructure Program

To truly claim an "equitable approach [to green infrastructure], we have to make sure our GSI investments are installed *with* dedicated maintenance capacity.

Building without dedicated maintenance capacity may leave communities with another type of burden.

Maintenance Capacity:

- $

  Do you have the funds to pay people to maintain your green infrastructure?

- Knowledge

  Does the staff know how to maintain green infrastructure, specifically?

- Systems

  Do you have a way to track **maintenance** and **asset condition** over time?

Level of Service Goals | Glenn St 46 Chicane Case Study

PM = $138,800
Herbicide = $15,900
Seed Cost/lb = $145

Oct 2022, 2 yrs after install - Before S2S initiated preventative maintenance (PM)*: invasive plants, sediment clogs, pooling*

Jan 2024, 2 yrs preventative maintenance: *Invasives under control and infiltration restored after 5 rounds of seasonal maintenance, 8 herbicide treatments, & 1 yr native seed dispersal*

April 2025, 3.5 yrs PM: *Native seed thriving amidst controlled invasives*

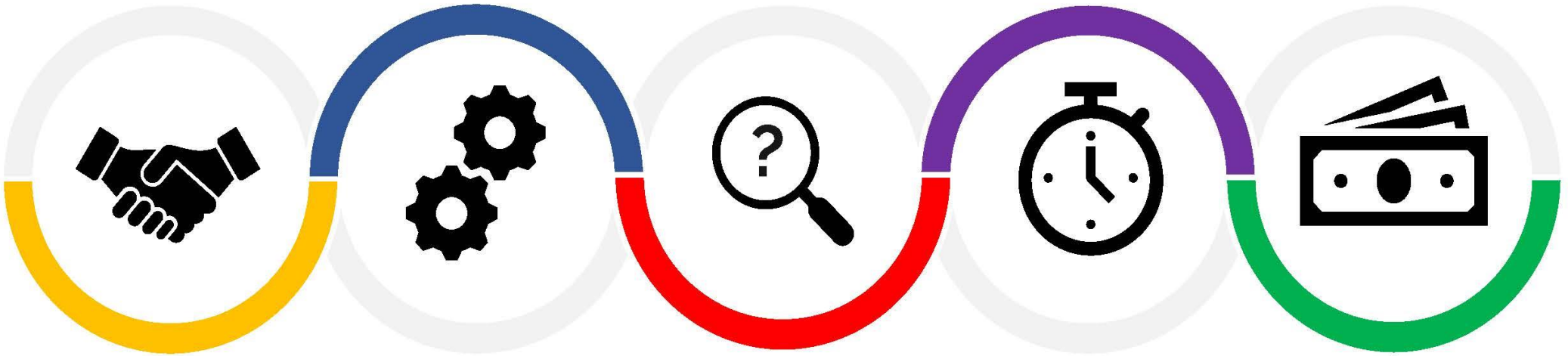
CITY OF TUCSON | Storm to Shade

Five Major Components

Level of Service

Criticality

Long-term Funding



Current State of the Assets

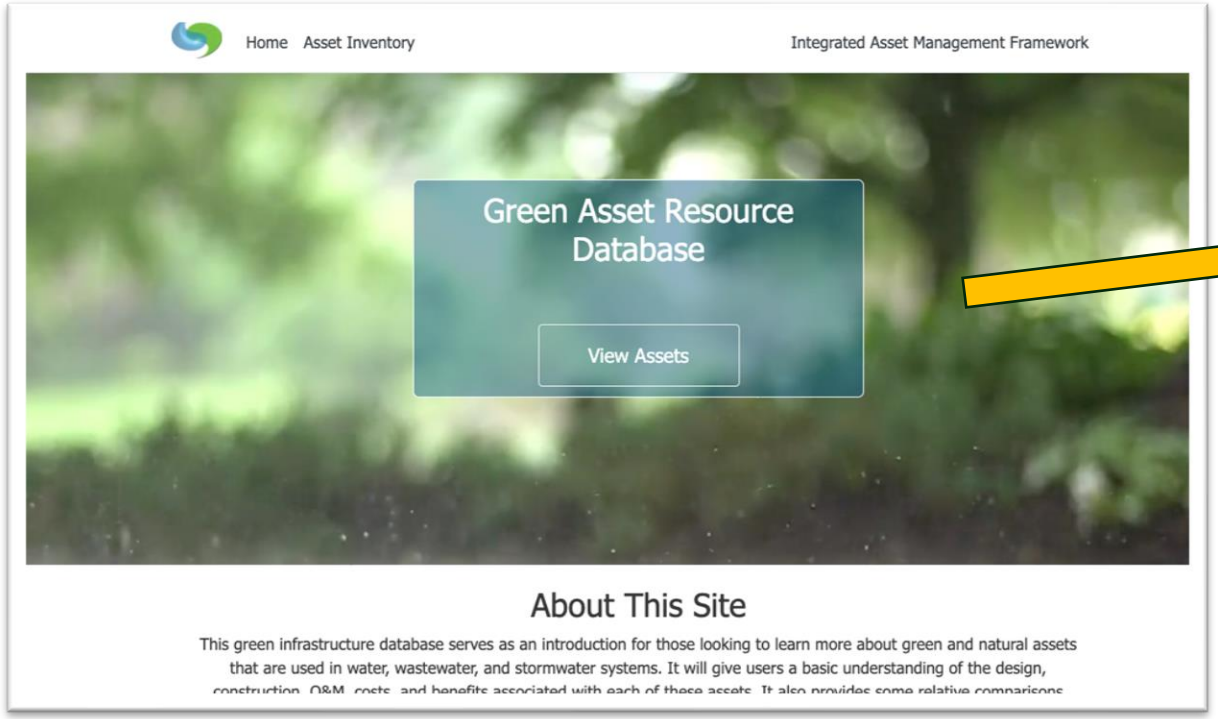
Life Cycle Costing

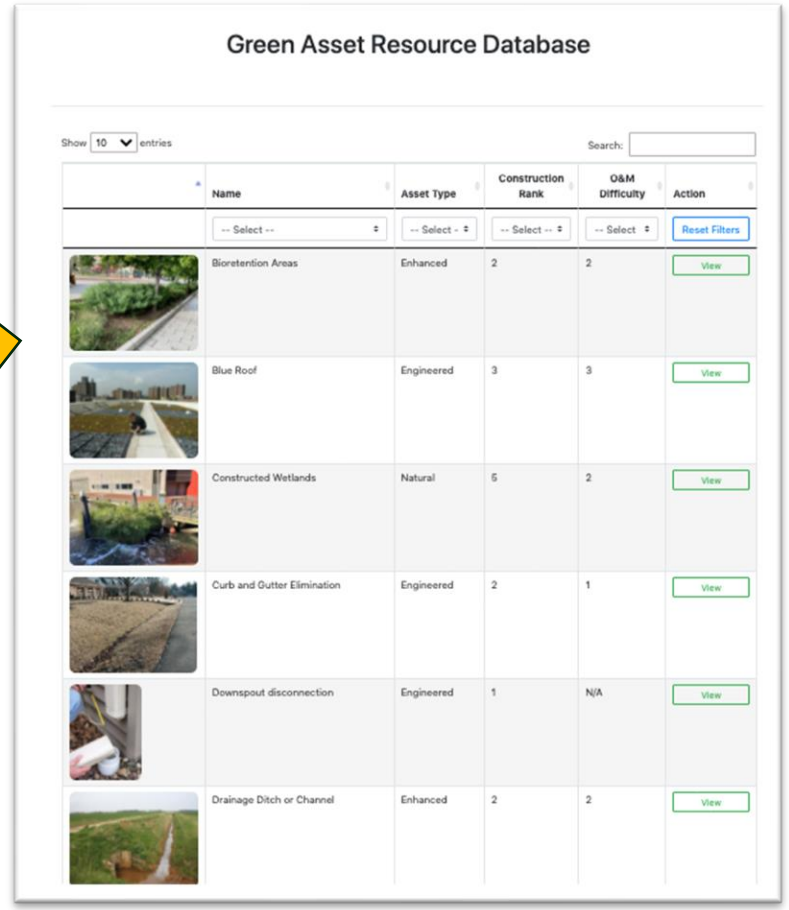
Want help with asset management at your system/community? Talk to us! →

https://efcnetwork.org/get-help

Additional Resources

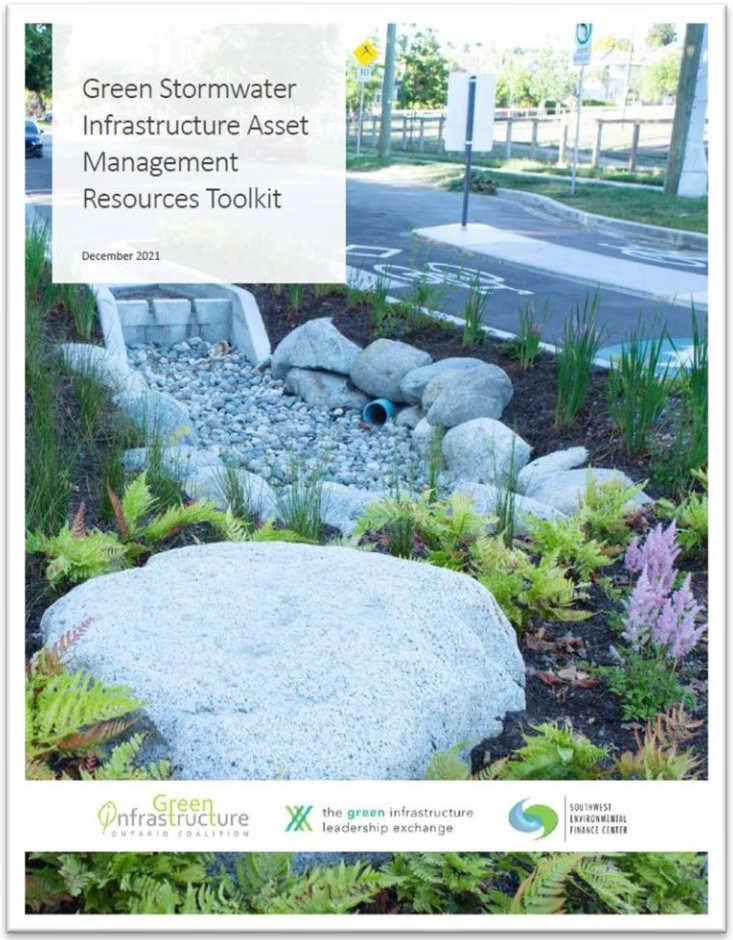
Integrated Asset Management Framework & Green Asset Resource Database





https://swefcapps.unm.edu/gardb

Green Stormwater Infrastructure Asset Management Resources Toolkit



https://greeninfrastructureontario.org/app/uploads/2022/01/GSI-AM-Resources-Toolkit-Final-Dec-17.pdf

GSI Operations & Maintenance Manual & Video Series

https://aridlidcoalition.org/index.php/gsi-maintenance

City of Tucson - Storm to Shade Resources

- Green Stormwater Infrastructure Maintenance Pocket Guide (English and Spanish)
- GSI Low Impact Development Standard Details and Site Guidelines
- Storm to Shade Pilot Program Report

https://climateaction.tucsonaz.gov/pages/s2s-resources

Thanks for tuning in!

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https://climateaction.tucsonaz.gov/pages/gsi

Fouad Jaber, Ph.D., P.E.

Texas A&M AgriLife, Dallas Extension

Green Asset Management in North Texas

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Professor and Extension Specialist
Biological and Agricultural Engineering
Texas A&M AgriLife Extension
Dallas Research and Extension Center

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Biological & Agricultural Engineering
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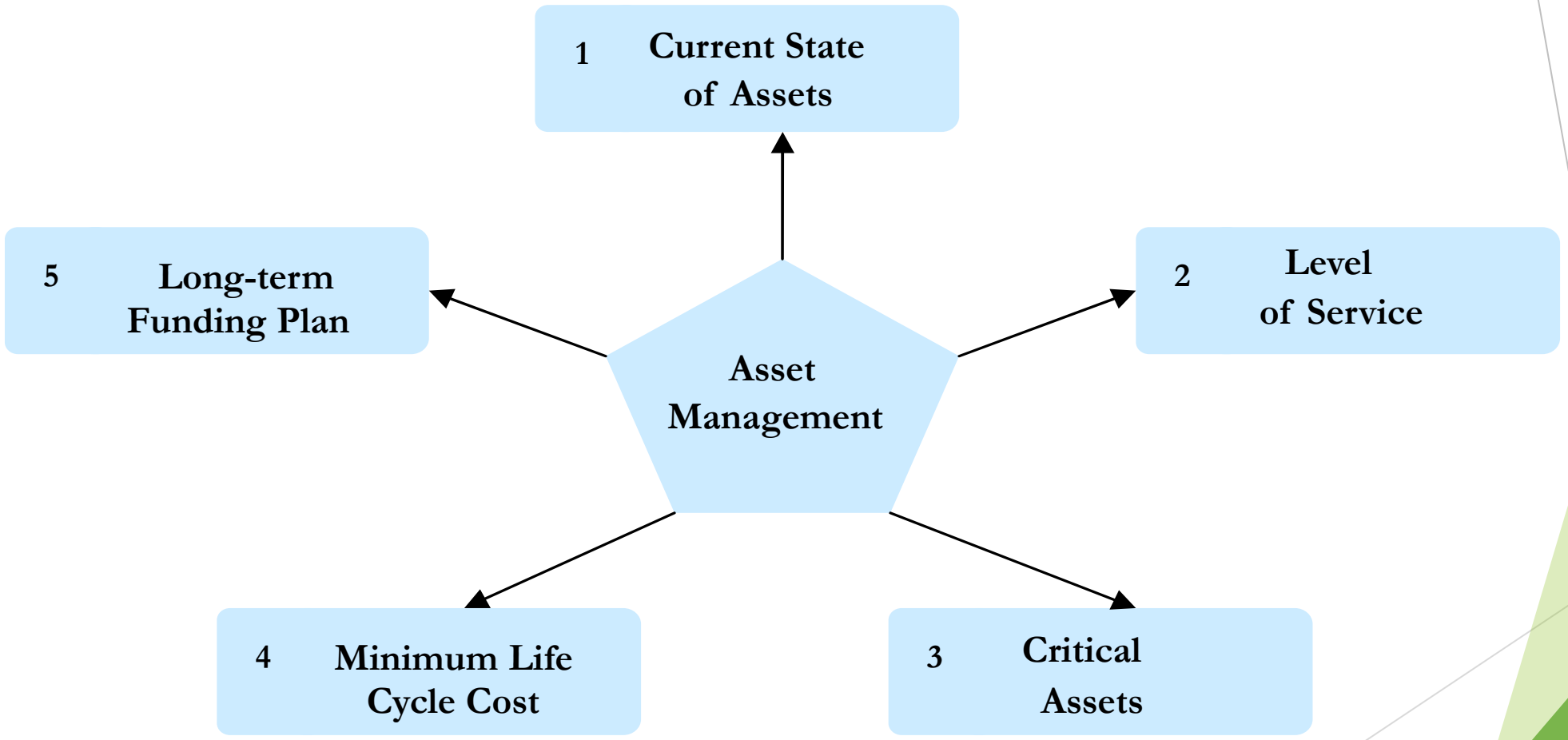
What is Asset Management?

"…asset management methods account for and link inventory, condition, service levels, useful life, and repair costs to produce insights regarding where, how much, and when to invest in system maintenance, rehabilitation and replacement." (AMSA, 2002, p. 7)

The Five Steps of Asset Management



Green Asset Management

- Applying principles of asset management to GSI
- Developing tools to apply asset management to GSI
- Testing the methodology
- Developing Manual

EPA United States Environmental Protection Agency

Texas A&M AgriLife Extension

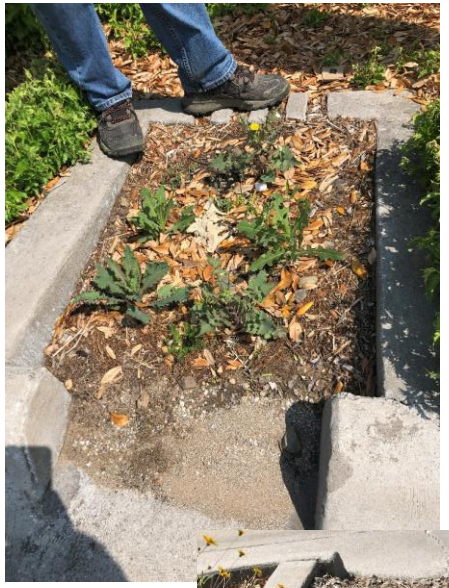
US Army Corps of Engineers

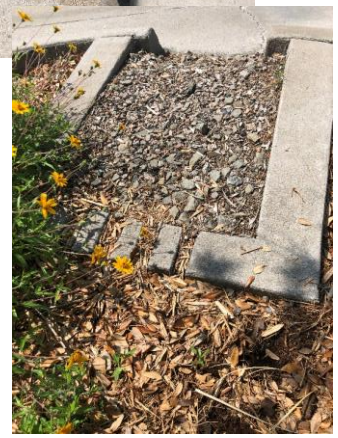
Southwest Environmental Finance Center

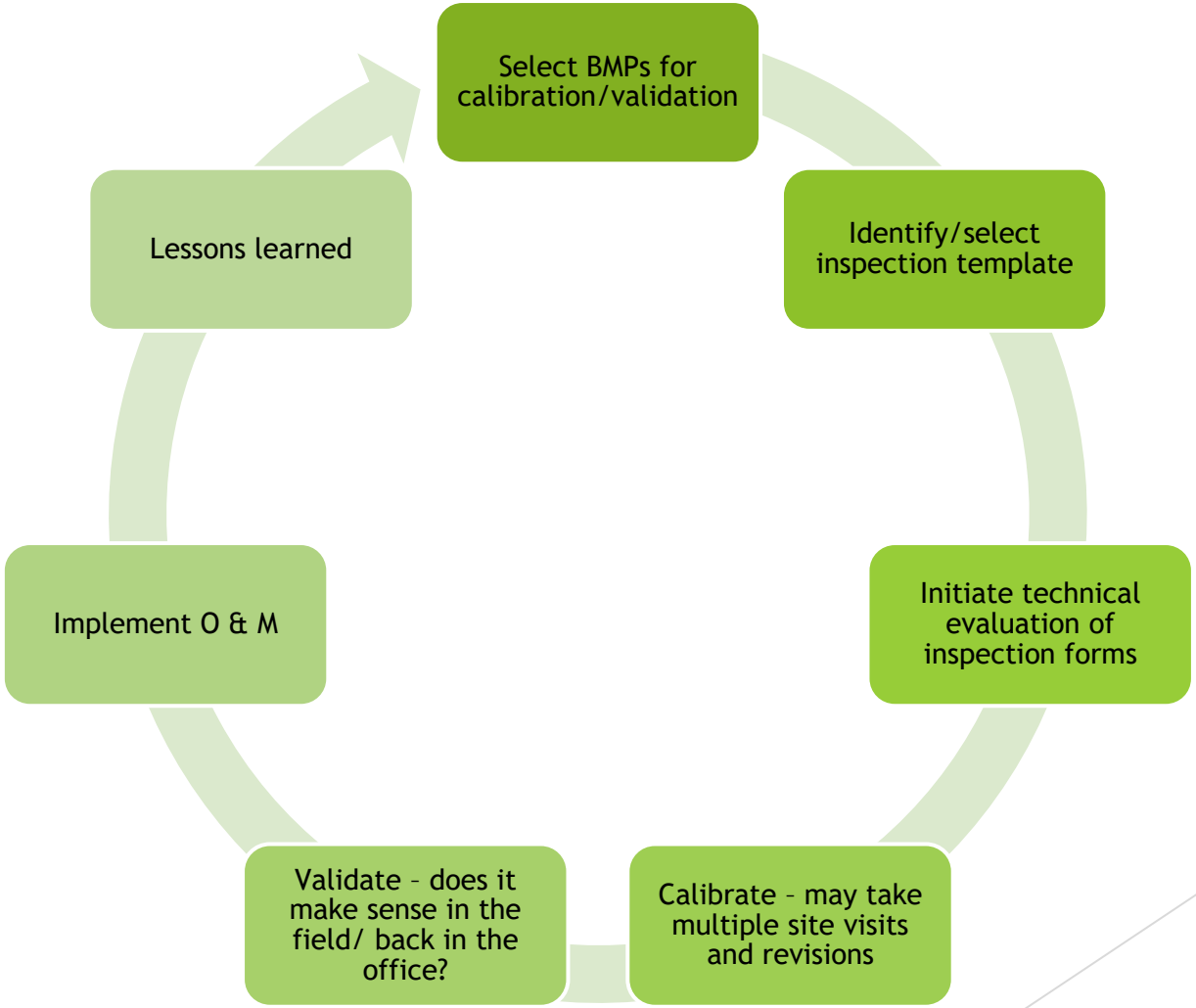
City of Denton

North Central Texas Council of Governments

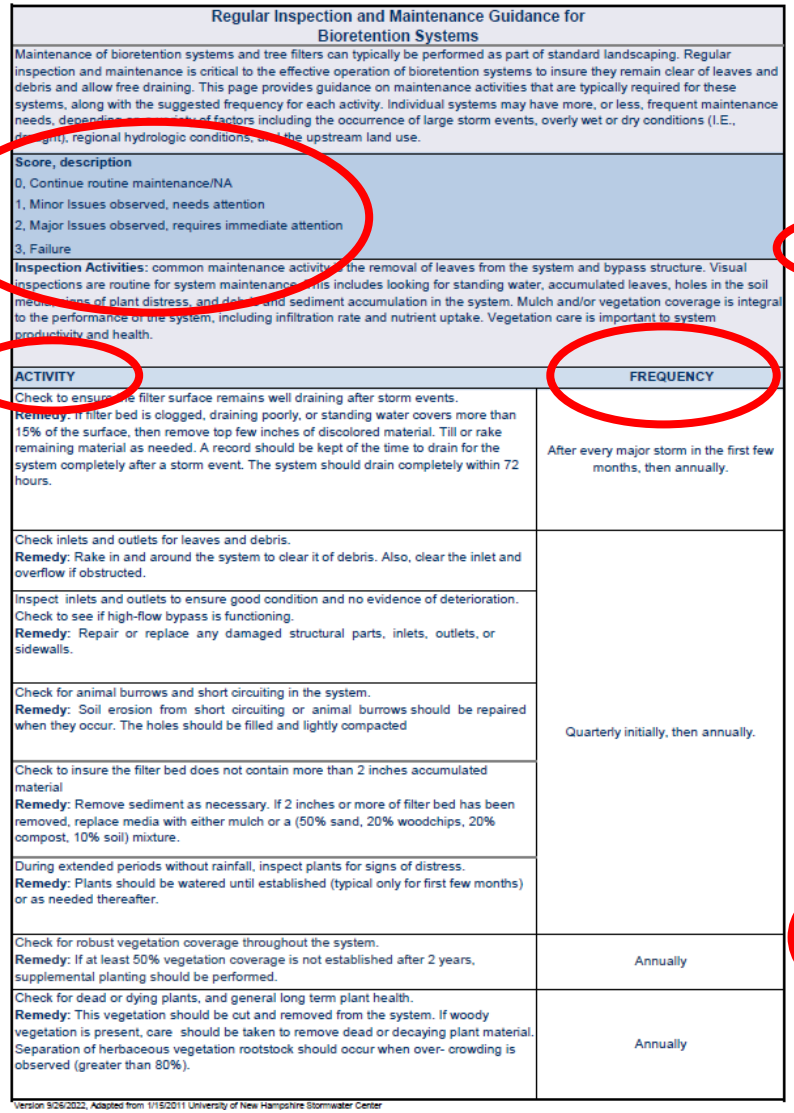
BMP Inspection Form Development Process







Bioretention systems



Regular Inspection and Maintenance Guidance for Bioretention Systems

Maintenance of bioretention systems and tree filters can typically be performed as part of standard landscaping. Regular inspection and maintenance is critical to the effective operation of bioretention systems to insure they remain clear of leaves and debris and allow free draining. This page provides guidance on maintenance activities that are typically required for these systems, along with the suggested frequency for each activity. Individual systems may have more, or less, frequent maintenance needs, depending on a variety of factors including the occurrence of large storm events, overly wet or dry conditions (I.E., drought), regional hydrologic conditions, and the upstream land use.

Score, description

0, Continue routine maintenance/NA

1, Minor Issues observed, needs attention

2, Major Issues observed, requires immediate attention

3, Failure

Inspection Activities: common maintenance activities the removal of leaves from the system and bypass structure. Visual inspections are routine for system maintenance. This includes looking for standing water, accumulated leaves, holes in the soil media, signs of plant distress, and debris and sediment accumulation in the system. Mulch and/or vegetation coverage is integral to the performance of the system, including infiltration rate and nutrient uptake. Vegetation care is important to system productivity and health.

ACTIVITY	FREQUENCY
Check to ensure the filter surface remains well draining after storm events. **Remedy:** If filter bed is clogged, draining poorly, or standing water covers more than 15% of the surface, then remove top few inches of discolored material. Till or rake remaining material as needed. A record should be kept of the time to drain for the system completely after a storm event. The system should drain completely within 72 hours.	After every major storm in the first few months, then annually.
Check inlets and outlets for leaves and debris. **Remedy:** Rake in and around the system to clear it of debris. Also, clear the inlet and overflow if obstructed.	Quarterly initially, then annually.
Inspect inlets and outlets to ensure good condition and no evidence of deterioration. Check to see if high-flow bypass is functioning. **Remedy:** Repair or replace any damaged structural parts, inlets, outlets, or sidewalls.	
Check for animal burrows and short circuiting in the system. **Remedy:** Soil erosion from short circuiting or animal burrows should be repaired when they occur. The holes should be filled and lightly compacted	
Check to insure the filter bed does not contain more than 2 inches accumulated material **Remedy:** Remove sediment as necessary. If 2 inches or more of filter bed has been removed, replace media with either mulch or a (50% sand, 20% woodchips, 20% compost, 10% soil) mixture.	
During extended periods without rainfall, inspect plants for signs of distress. **Remedy:** Plants should be watered until established (typical only for first few months) or as needed thereafter.	
Check for robust vegetation coverage throughout the system. **Remedy:** If at least 50% vegetation coverage is not established after 2 years, supplemental planting should be performed.	Annually
Check for dead or dying plants, and general long term plant health. **Remedy:** This vegetation should be cut and removed from the system. If woody vegetation is present, care should be taken to remove dead or decaying plant material. Separation of herbaceous vegetation rootstock should occur when over- crowding is observed (greater than 80%).	Annually

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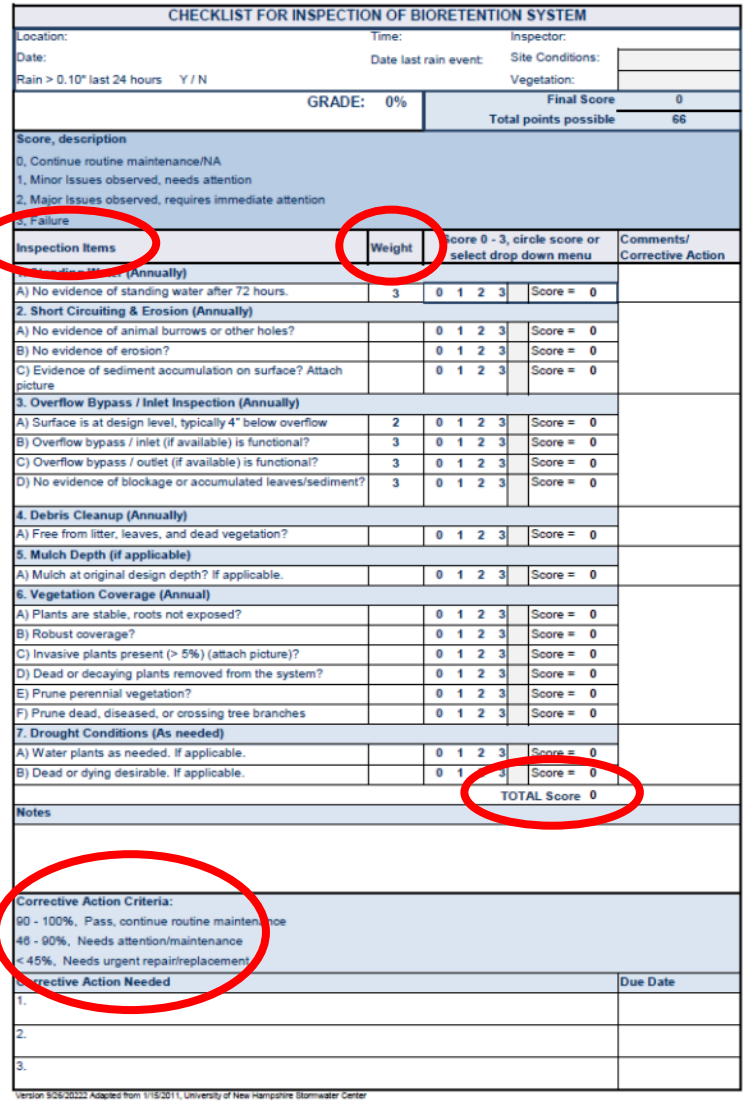

CHECKLIST FOR INSPECTION OF BIORETENTION SYSTEM

Location: Time: Inspector:

Date: Date last rain event: Site Conditions:

Rain > 0.10" last 24 hours Y / N Vegetation:

GRADE: 0% Final Score 0

Total points possible 66

Score, description

0, Continue routine maintenance/NA

1, Minor Issues observed, needs attention

2, Major Issues observed, requires immediate attention

3, Failure

Inspection Items	Weight	Score 0 - 3, circle score or select drop down menu	Comments/ Corrective Action
1. Standing Water (Annually)			
A) No evidence of standing water after 72 hours.	3	0 1 2 3 Score = 0	
2. Short Circuiting & Erosion (Annually)			
A) No evidence of animal burrows or other holes?		0 1 2 3 Score = 0	
B) No evidence of erosion?		0 1 2 3 Score = 0	
C) Evidence of sediment accumulation on surface? Attach picture		0 1 2 3 Score = 0	
3. Overflow Bypass / Inlet Inspection (Annually)			
A) Surface is at design level, typically 4" below overflow	2	0 1 2 3 Score = 0	
B) Overflow bypass / inlet (if available) is functional?	3	0 1 2 3 Score = 0	
C) Overflow bypass / outlet (if available) is functional?	3	0 1 2 3 Score = 0	
D) No evidence of blockage or accumulated leaves/sediment?	3	0 1 2 3 Score = 0	
4. Debris Cleanup (Annually)			
A) Free from litter, leaves, and dead vegetation?		0 1 2 3 Score = 0	
5. Mulch Depth (if applicable)			
A) Mulch at original design depth? If applicable.		0 1 2 3 Score = 0	
6. Vegetation Coverage (Annual)			
A) Plants are stable, roots not exposed?		0 1 2 3 Score = 0	
B) Robust coverage?		0 1 2 3 Score = 0	
C) Invasive plants present (> 5%) (attach picture)?		0 1 2 3 Score = 0	
D) Dead or decaying plants removed from the system?		0 1 2 3 Score = 0	
E) Prune perennial vegetation?		0 1 2 3 Score = 0	
F) Prune dead, diseased, or crossing tree branches		0 1 2 3 Score = 0	
7. Drought Conditions (As needed)			
A) Water plants as needed. If applicable.		0 1 2 3 Score = 0	
B) Dead or dying desirable. If applicable.		0 1 2 3 Score = 0	
		TOTAL Score 0	

Notes

Corrective Action Criteria:

90 - 100%, Pass, continue routine maintenance

46 - 90%, Needs attention/maintenance

< 45%, Needs urgent repair/replacement

Corrective Action Needed	Due Date
1.	
2.	
3.	

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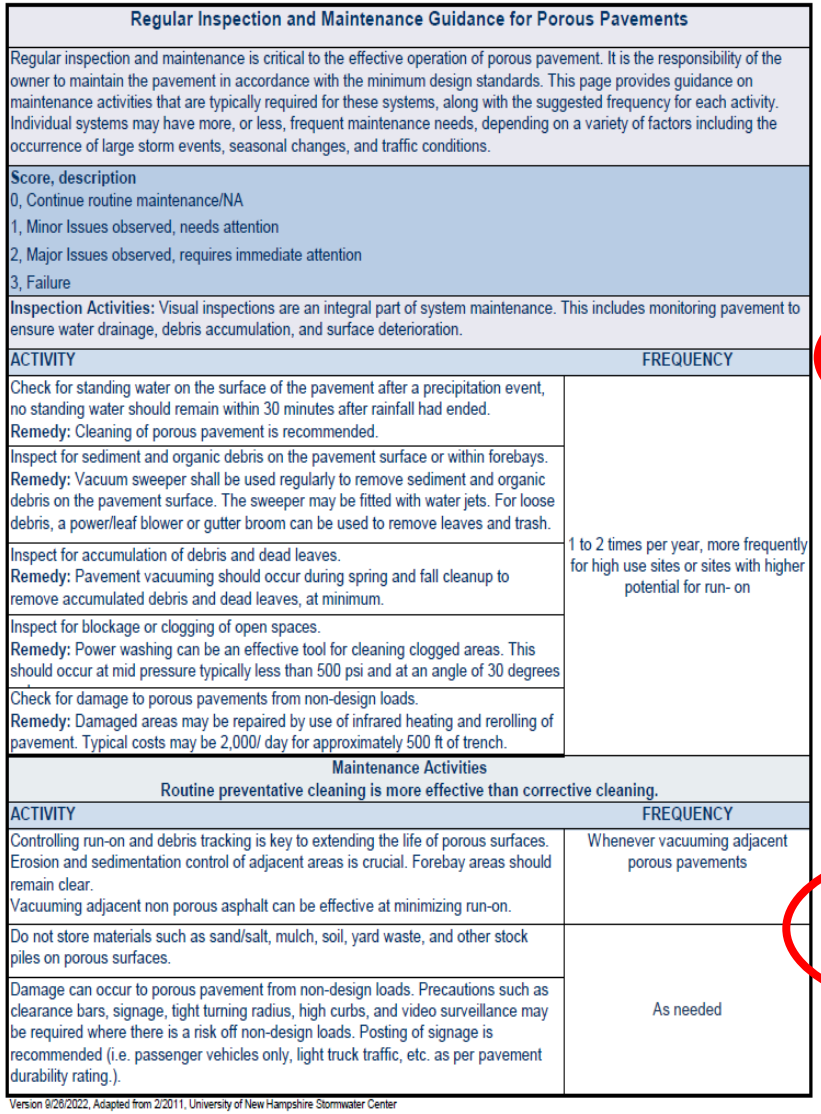
- Guidance
  - Scoring system
  - Activity
  - Frequency
- Checklist
  - Inspection items
  - Weight
  - Score
  - Comments/corrective action
  - Total Score

Porous Pavements



Regular Inspection and Maintenance Guidance for Porous Pavements

Regular inspection and maintenance is critical to the effective operation of porous pavement. It is the responsibility of the owner to maintain the pavement in accordance with the minimum design standards. This page provides guidance on maintenance activities that are typically required for these systems, along with the suggested frequency for each activity. Individual systems may have more, or less, frequent maintenance needs, depending on a variety of factors including the occurrence of large storm events, seasonal changes, and traffic conditions.

Score, description
0, Continue routine maintenance/NA
1, Minor Issues observed, needs attention
2, Major Issues observed, requires immediate attention
3, Failure

Inspection Activities: Visual inspections are an integral part of system maintenance. This includes monitoring pavement to ensure water drainage, debris accumulation, and surface deterioration.

ACTIVITY	FREQUENCY
Check for standing water on the surface of the pavement after a precipitation event, no standing water should remain within 30 minutes after rainfall had ended. **Remedy:** Cleaning of porous pavement is recommended.	1 to 2 times per year, more frequently for high use sites or sites with higher potential for run- on
Inspect for sediment and organic debris on the pavement surface or within forebays. **Remedy:** Vacuum sweeper shall be used regularly to remove sediment and organic debris on the pavement surface. The sweeper may be fitted with water jets. For loose debris, a power/leaf blower or gutter broom can be used to remove leaves and trash.	
Inspect for accumulation of debris and dead leaves. **Remedy:** Pavement vacuuming should occur during spring and fall cleanup to remove accumulated debris and dead leaves, at minimum.	
Inspect for blockage or clogging of open spaces. **Remedy:** Power washing can be an effective tool for cleaning clogged areas. This should occur at mid pressure typically less than 500 psi and at an angle of 30 degrees	
Check for damage to porous pavements from non-design loads. **Remedy:** Damaged areas may be repaired by use of infrared heating and rerolling of pavement. Typical costs may be 2,000/ day for approximately 500 ft of trench.	

Maintenance Activities
Routine preventative cleaning is more effective than corrective cleaning.

ACTIVITY	FREQUENCY
Controlling run-on and debris tracking is key to extending the life of porous surfaces. Erosion and sedimentation control of adjacent areas is crucial. Forebay areas should remain clear. Vacuuming adjacent non porous asphalt can be effective at minimizing run-on.	Whenever vacuuming adjacent porous pavements
Do not store materials such as sand/salt, mulch, soil, yard waste, and other stock piles on porous surfaces.	As needed
Damage can occur to porous pavement from non-design loads. Precautions such as clearance bars, signage, tight turning radius, high curbs, and video surveillance may be required where there is a risk off non-design loads. Posting of signage is recommended (i.e. passenger vehicles only, light truck traffic, etc. as per pavement durability rating.).	

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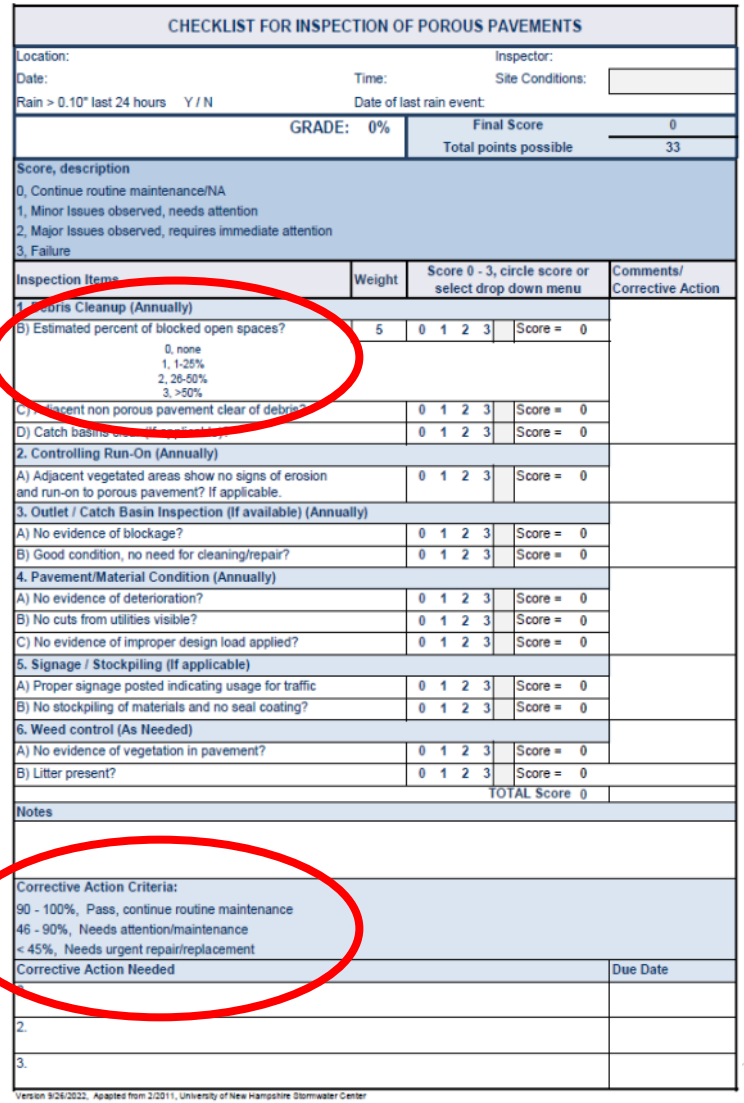

CHECKLIST FOR INSPECTION OF POROUS PAVEMENTS

Location: Inspector:
Date: Time: Site Conditions:
Rain > 0.10" last 24 hours Y / N Date of last rain event:

GRADE: 0% | Final Score 0 | Total points possible 33

Score, description
0, Continue routine maintenance/NA
1, Minor Issues observed, needs attention
2, Major Issues observed, requires immediate attention
3, Failure

Inspection Items	Weight	Score 0 - 3, circle score or select drop down menu	Comments/ Corrective Action
1. Debris Cleanup (Annually)			
B) Estimated percent of blocked open spaces? 0, none 1, 1-25% 2, 26-50% 3, >50%	5	0 1 2 3 Score = 0	
C) Adjacent non porous pavement clear of debris?		0 1 2 3 Score = 0	
D) Catch basins clear (if applicable)?		0 1 2 3 Score = 0	
2. Controlling Run-On (Annually)			
A) Adjacent vegetated areas show no signs of erosion and run-on to porous pavement? If applicable.		0 1 2 3 Score = 0	
3. Outlet / Catch Basin Inspection (If available) (Annually)			
A) No evidence of blockage?		0 1 2 3 Score = 0	
B) Good condition, no need for cleaning/repair?		0 1 2 3 Score = 0	
4. Pavement/Material Condition (Annually)			
A) No evidence of deterioration?		0 1 2 3 Score = 0	
B) No cuts from utilities visible?		0 1 2 3 Score = 0	
C) No evidence of improper design load applied?		0 1 2 3 Score = 0	
5. Signage / Stockpiling (If applicable)			
A) Proper signage posted indicating usage for traffic		0 1 2 3 Score = 0	
B) No stockpiling of materials and no seal coating?		0 1 2 3 Score = 0	
6. Weed control (As Needed)			
A) No evidence of vegetation in pavement?		0 1 2 3 Score = 0	
B) Litter present?		0 1 2 3 Score = 0	
		TOTAL Score 0	

Notes

Corrective Action Criteria:
90 - 100%, Pass, continue routine maintenance
46 - 90%, Needs attention/maintenance
< 45%, Needs urgent repair/replacement

Corrective Action Needed	Due Date
1.	
2.	
3.	

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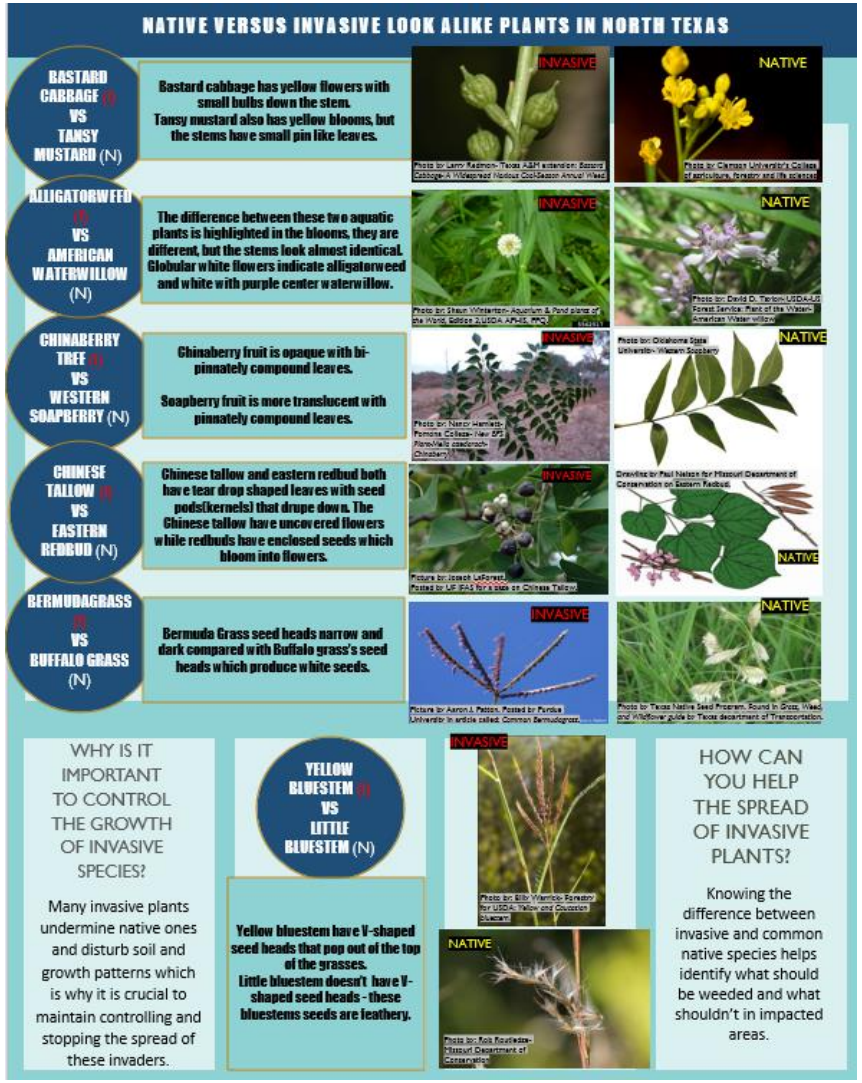
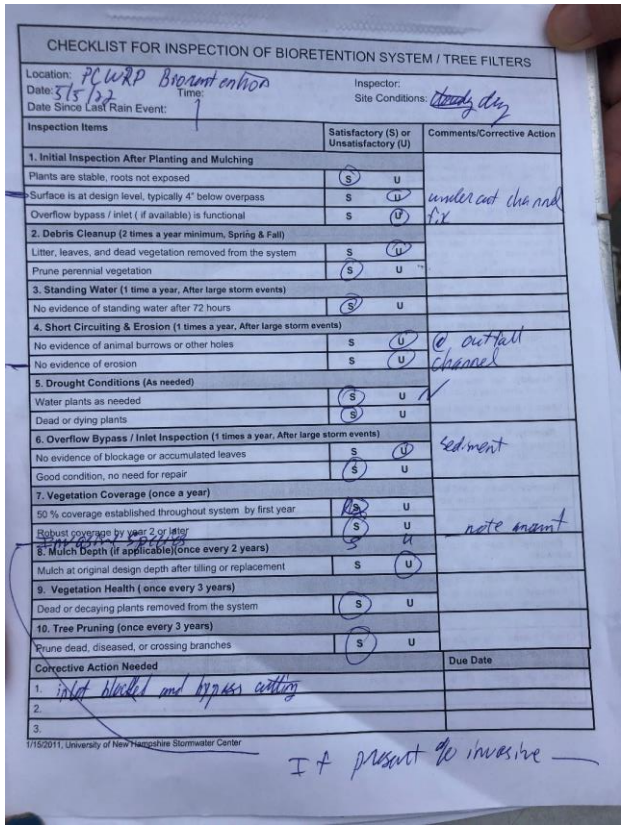
- Inspection Item Example
  - Estimated % of blocked open spaces
    - Scored 1 – 3
      - 0 = none
      - 1 = 1 - 25%,
      - 2 = 25 - 50%,
      - 3 = >50%,
- Corrective Action Criteria
  - 90 – 100% Pass
  - 46 – 90% Needs attention
  - < 45% Needs urgent repair or replacement

Supplemental documents for inspections



Lessons Learned

- Keep it simple
- Know your team
- Test and re-test your sheets



CHECKLIST FOR INSPECTION OF BIORETENTION SYSTEM / TREE FILTERS

Location: PCWRP Bioretention Inspector:
Date: 3/5/22 Time: Site Conditions: cloudy day
Date Since Last Rain Event: 1

Inspection Items	Satisfactory (S) or Unsatisfactory (U)	Comments/Corrective Action
1. Initial Inspection After Planting and Mulching		
Plants are stable, roots not exposed	S U	
Surface is at design level, typically 4" below overpass	S U	undercut channel fix
Overflow bypass / inlet (if available) is functional	S U	
2. Debris Cleanup (2 times a year minimum, Spring & Fall)		
Litter, leaves, and dead vegetation removed from the system	S U	
Prune perennial vegetation	S U	
3. Standing Water (1 time a year, After large storm events)		
No evidence of standing water after 72 hours	S U	
4. Short Circuiting & Erosion (1 times a year, After large storm events)		
No evidence of animal burrows or other holes	S U	@ outfall channel
No evidence of erosion	S U	
5. Drought Conditions (As needed)		
Water plants as needed	S U	
Dead or dying plants	S U	
6. Overflow Bypass / Inlet Inspection (1 times a year, After large storm events)		
No evidence of blockage or accumulated leaves	S U	sediment
Good condition, no need for repair	S U	
7. Vegetation Coverage (once a year)		
50 % coverage established throughout system by first year	S U	note amount
Robust coverage by year 2 or later	S U	
8. Mulch Depth (if applicable)(once every 2 years)		
Mulch at original design depth after tilling or replacement	S U	
9. Vegetation Health (once every 3 years)		
Dead or decaying plants removed from the system	S U	
10. Tree Pruning (once every 3 years)		
Prune dead, diseased, or crossing branches	S U	

Corrective Action Needed	Due Date
1. inlet blocked and bypass eroding	
2.	
3.	

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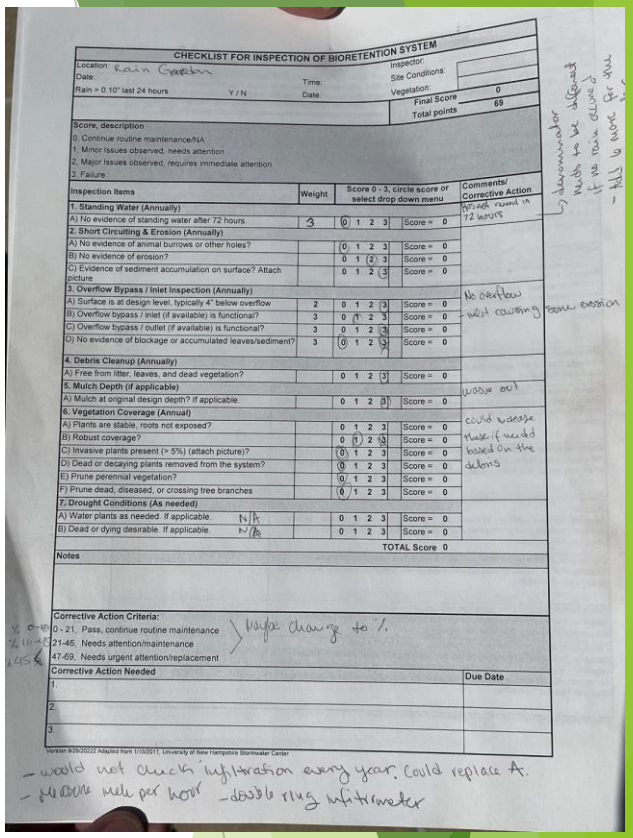
If present do invasive



CHECKLIST FOR INSPECTION OF BIORETENTION SYSTEM

Location: Rain Garden Inspector:
Date: Time: Site Conditions:
Rain > 0.10" last 24 hours Y / N Date: Vegetation: 0
Final Score 69
Total points

Score, description
0. Continue routine maintenance/NA
1. Minor issues observed, needs attention
2. Major issues observed, requires immediate attention
3. Failure

Inspection Items	Weight	Score 0 - 3, circle score or select drop down menu	Comments/ Corrective Action
1. Standing Water (Annually)			
A) No evidence of standing water after 72 hours.	3	(0) 1 2 3 Score = 0	
2. Short Circuiting & Erosion (Annually)			
A) No evidence of animal burrows or other holes?		(0) 1 2 3 Score = 0	
B) No evidence of erosion?		0 1 (2) 3 Score = 0	
C) Evidence of sediment accumulation on surface? Attach picture		0 1 2 (3) Score = 0	
3. Overflow Bypass / Inlet Inspection (Annually)			
A) Surface is at design level, typically 4" below overflow	2	0 1 2 (3) Score = 0	
B) Overflow bypass / inlet (if available) is functional?	3	0 1 2 (3) Score = 0	
C) Overflow bypass / outlet (if available) is functional?	3	0 1 2 (3) Score = 0	
D) No evidence of blockage or accumulated leaves/sediment?	3	(0) 1 2 3 Score = 0	
4. Debris Cleanup (Annually)			
A) Free from litter, leaves, and dead vegetation?		0 1 2 (3) Score = 0	
5. Mulch Depth (if applicable)			
A) Mulch at original design depth? If applicable.		0 1 2 (3) Score = 0	
6. Vegetation Coverage (Annual)			
A) Plants are stable, roots not exposed?		(0) 1 2 3 Score = 0	
B) Robust coverage?		0 (1) 2 3 Score = 0	
C) Invasive plants present (> 5%) (attach picture)?		(0) 1 2 3 Score = 0	
D) Dead or decaying plants removed from the system?		(0) 1 2 3 Score = 0	
E) Prune perennial vegetation?		(0) 1 2 3 Score = 0	
F) Prune dead, diseased, or crossing tree branches		(0) 1 2 3 Score = 0	
7. Drought Conditions (As needed)			
A) Water plants as needed. If applicable. N/A		0 1 2 3 Score = 0	
B) Dead or dying desirable. If applicable. N/A		0 1 2 3 Score = 0	
		TOTAL Score 0	

Notes

Corrective Action Criteria:
0 - 21, Pass, continue routine maintenance
21-46, Needs attention/maintenance
47-69, Needs urgent attention/replacement

Corrective Action Needed	Due Date
1.	
2.	
3.	

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- would not check infiltration every year. Could replace A.
- needs 1 inch per hour - double ring infiltrometer

Criticality

How important the GI BMP is to water quality, water quantity reduction and the co-benefits related to the triple bottom line of economic, social, and environmental benefits

Consequence of failure – Risk analysis to determine water quality and water quantity reduction levels of service lost if GI BMP fails

Regulatory impact: e.g. Asset I part of a TMDL implementation plan

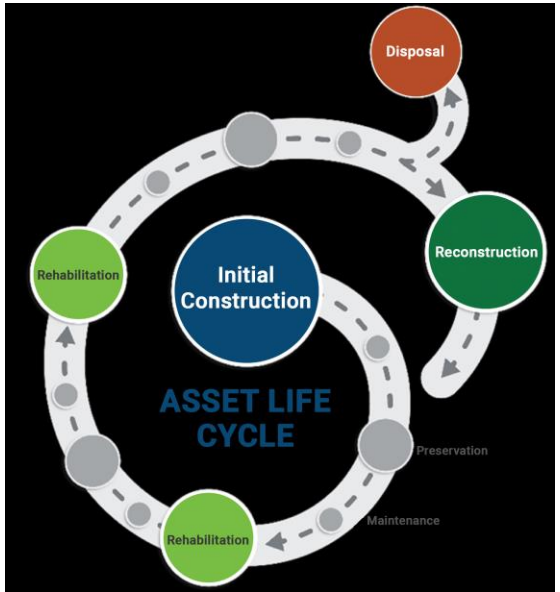
Identifier of BMP	Criticality	Consequence of Failure	Area vulnerable to flooding	Potential TMDL impact

Minimum Life Cycle Costs

What alternative strategies exist for managing Operation and Maintenance (O&M), personnel, and capital budget accounts?

What strategies are the most feasible for my organization?

What are the costs of renewal, rehabilitation, and replacement for critical assets?



AASHTO TAM Guide

Long-Term Funding

- Do we have enough funding to maintain the assets for our required level of service?
- Is our source of funding sustainable for long-term needs?

- Revising the funding structure.
- Funding a dedicated reserve from current revenues (i.e., creating an asset annuity).
- Financing asset rehabilitation, repair, and replacement through borrowing or other financial assistance.

(EPA Asset Management: A Best Practices Guide, 2008).

Conclusions

- Applying asset management (AM) principles to green assets can help cities use a familiar methodologies to
  - Maintain
  - Repair
  - Replace and guarantee funding of GSI
- Most AM software allow for Green asset integration
- Local inspection and criticality criteria need to be developed

Community-Science Partnership to Enhance Stormwater Management and Equity

Texas A&M AgriLife Extension

NSF

Texas Water Resources Institute
make every drop count

UNT

Piloting a Regional Vision

- Planning Phase: October 2022 - April 2023 Pilot Project in Denton.
- **Community Science Working Group**, representatives from the City of Denton and environmental and community groups, to advise project development
- Execute a series of **workshops for local stakeholders** to develop, refine, and evaluate the CGAM Tool for the city
- The project aims to reduce local stormwater flooding, establish new community connections, and launch the tailored CGAM tool for the City of Denton

Community Green Asset Management Tool: A Pilot Project

- We addressed these challenges by incorporating community priorities into an **asset management framework for BGI**
- This approach manages **infrastructure assets** by minimizing costs of owning, operating, and maintaining them
- Developed and piloted a **Community Green Asset Management (CGAM) Tool** that reflects local concerns, priorities, and values associated with BGI

Online Interactive Platform (Hub)

Current Storymap Example:
https://arcg.is/1ePDLm0

CIVIC Innovation: Dent

Nature-based solutions to flooding and water qu
in North Texas

Hub Platform:
Interactive tools for co-development of data with local communities

- Community Citizen Science Projects
- Educational Modules
- Training Workshops
- Interactive Signage
- K-12 and Undergraduate classroom materials

Blue-green Infrastructure (BGI) site in downtown Denton, TX

Flooding is a concern in cities all over the country, especially in areas with rapid growth. Some of these cities, like Denton, are using nature-based solutions to help solve the problem.

By installing green spaces - like strips between roads full of native plants or trees, or driveways with porous pavements, or low-lying areas with rock channels or mulch - instead of concrete to slow down water, these sites can greatly reduce flooding. Creating places to allow water to sink into the soil limits flood damage to nearby homes and businesses, and helps that water to go back into our rivers and lakes, improving water quality in the process.

Sounds like a win-win, right? Not everyone agrees. Despite growing evidence of success for flood control and water filtration, getting support to build these sites can be challenging. To explore these challenges, we're putting together a team of community stakeholders to share their perspectives about exisiting and future sites for Denton.

C-GAM Tool for BGI - Pilot Testing

C-GAM Survey Tool 1.0

Prototype of the C-GAM survey evaluation tool for pilot testing by CIVIC Volunteers.

https://survey123.arcgis.com

This project is funded by the National Science Foundation

For more information about the CIVIC Innovation project in Denton, fill out the interest form below to join our mailing list

CIVIC Innovation Denton BGI Project Interest Form

Sign up here to receive additional information and project updates.

https://survey123.arcgis.com

Have data to contribute to the project? Fill out the survey below and it will appear on our community map!

Denton BGI Site Survey - CIVIC Project

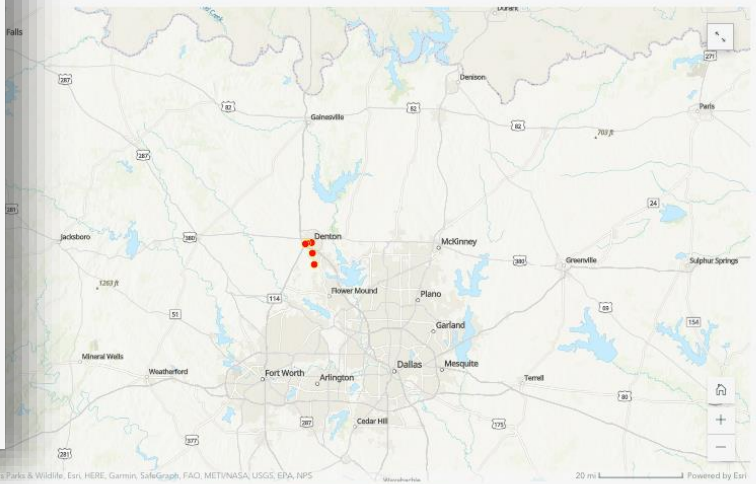
Description content for the survey

First Name*

Last Name*

Date (of site visit)*

Denton Area BGI Site Survey



Denton Area BGI Site Survey Community Map

Want to learn more about Blue-Green Infrastructure?

Click on the Resource Library below to find online resources

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