The N-EWN Knowledge Series

A Continuing Education Series about Engineering with Nature

Zak Ruehman, PE
Director of Engineering Services
Institute for Resilient Infrastructure Systems
University of Georgia

Natural Asset Management is Asset Management: Evaluating Natural Infrastructure from an Asset Management Perspective

As entities struggle to keep up with the operation, maintenance, and improvement of their built infrastructure, they are turning to asset management strategies to get ahead. This talk will discuss how natural infrastructure can and should be evaluated and integrated into asset management planning, along with strategies to do so. By viewing built infrastructure assets as part of the larger system they function within, rather than individually, it becomes evident how the performance of built assets is intertwined with the performance of connected natural infrastructure. By incorporating natural infrastructure into asset management planning, a more holistic picture of a built asset and how to effectively operate, maintain, and improve it becomes much clearer. This approach not only highlights how important natural assets are to public health and safety, but also where conservation and expansion of natural infrastructure can provide unrealized benefits to the built environment.

Save the date!
Upcoming webinars will take place the 3rd Thursday of the month.

Aug. 20 12:30pm ET
Zak Ruehman, PE, University of Georgia
Natural Asset Management is Asset Management: Evaluating Natural Infrastructure from an Asset Management Perspective

Sep. 17 12:30pm ET
Eddie Brauer, PE and Joanna Curran, PhD, USACE
Engineering With Nature® Engineering Practice Guide for Floodplain Benching Projects

Oct. 15 12:30pm ET
Matt Bilskie, PhD, University of Georgia
Nature-Based Coastal Resilience at Marine Corps Recruit Depot Parris Island: From Concept to Long-Term Monitoring

Register here: https://bit.ly/3gR9ADL **or scan:**

1 Continuing Education Credit (CEC) is available to attendees

Recorded webinars will be posted online at: https://n-ewn.org/resources/n-ewn-knowledge-seminars/

Presented by:

NETWORK FOR ENGINEERING WITH NATURE
LimnoTech Water Environment Scientists Engineers
UNIVERSITY OF GEORGIA
ERDC

Questions? Please contact:
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Outline

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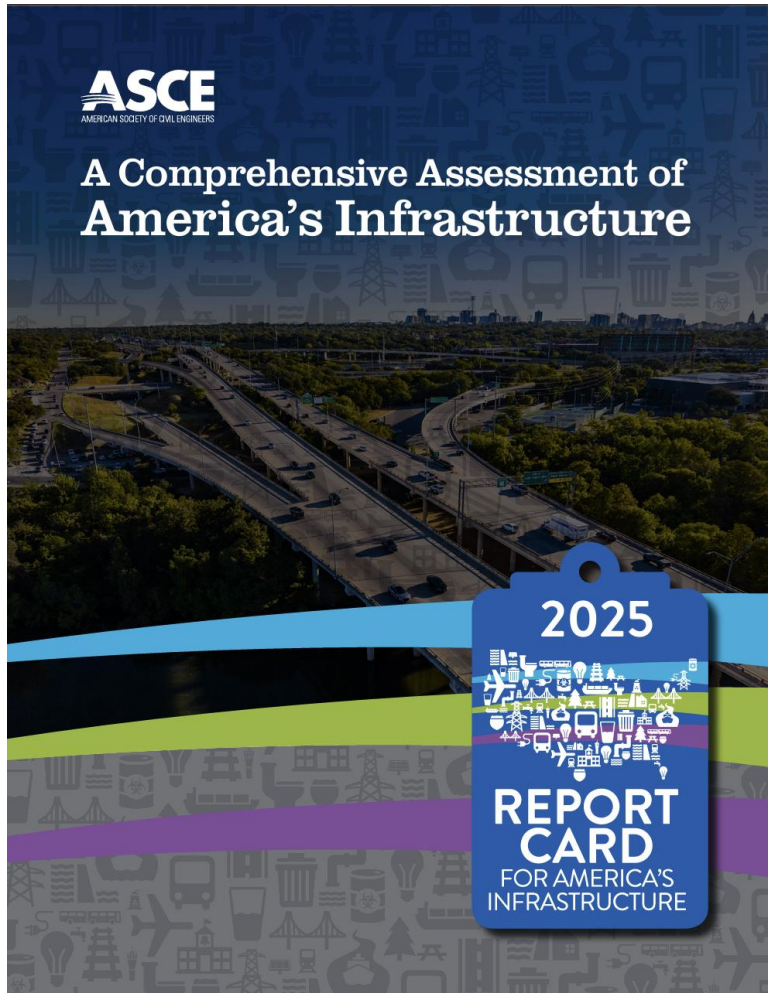
1. Introduction to Infrastructure Asset Management
2. ‘Traditional’ Built Asset Management
3. Natural Infrastructure Asset Management
4. Built and Natural Systems Integrated Asset Management
5. Questions/Open Discussion

Overall Grade: C

Infrastructure Type	Grade
Dams	D+
Drinking Water	C-
Inland Waterways	C-
Levees	D+
Stormwater	D
Wastewater	D+



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What is Infrastructure Asset Management?

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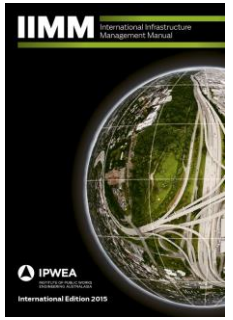
"Asset management is an act of maintaining demanded service level of assets for present and future consumers based on the most economically effective management". (International Infrastructure Management Manual, 6th Edition)



"Asset management is maintaining a desired level of service for what you want your assets to provide at the lowest life cycle cost. Lowest life cycle cost refers to the best appropriate cost for rehabilitating, repairing or replacing an asset. Asset management is implemented through an asset management program and typically includes a written asset management plan." (USEPA)

"Transportation Asset Management is a strategic and systematic process of operating, maintaining, upgrading, and expanding physical assets effectively throughout their lifecycle. It focuses on business and engineering practices for resource allocation and utilization, with the objective of better decision making based upon quality information and well-defined objectives." (FHWA)

U.S. Department of Transportation
Federal Highway Administration

What is Infrastructure Asset Management?

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- Infrastructure is an investible asset and should be managed as such
- Ensures desired levels of service are met throughout lifecycle
- Minimizes lifecycle cost
- Supports data-driven decision making
- Guides strategic allocation of resources

ISO 55000:2024

Infrastructure Asset Lifecycle

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Planning
- Needs assessment
- Master planning
- Cost-benefit analyses
- Environmental impacts
- Desired level-of-service

Construction
- Contractor procurement
- Construction management
- Quality assurance
- As-builts, warranties, etc.

Disposal or Replacement
- End-of-life assessment
- Decommissioning plans
- Environmental considerations
- Replacement strategies

Design
- Design criteria
- Engineering specifications
- O&M considerations
- “Safe-to-Fail”
- Environmental considerations

Operation and Maintenance
- Performance monitoring
- Inspections
- Routine maintenance
- System upgrades
- Major repairs
- System failure

Infrastructure Asset Lifecycle

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**Biggest opportunity for life-cycle cost reduction **

Design
- Design criteria
- Engineering specifications
- O&M considerations
- "Safe-to-Fail"
- Environmental considerations

Operation and Maintenance
- Performance monitoring
- Inspections
- Routine maintenance
- System upgrades
- Major repairs
- System failure

75% of an asset's total cost of ownership is in O&M stage

Challenges of Managing Infrastructure Assets

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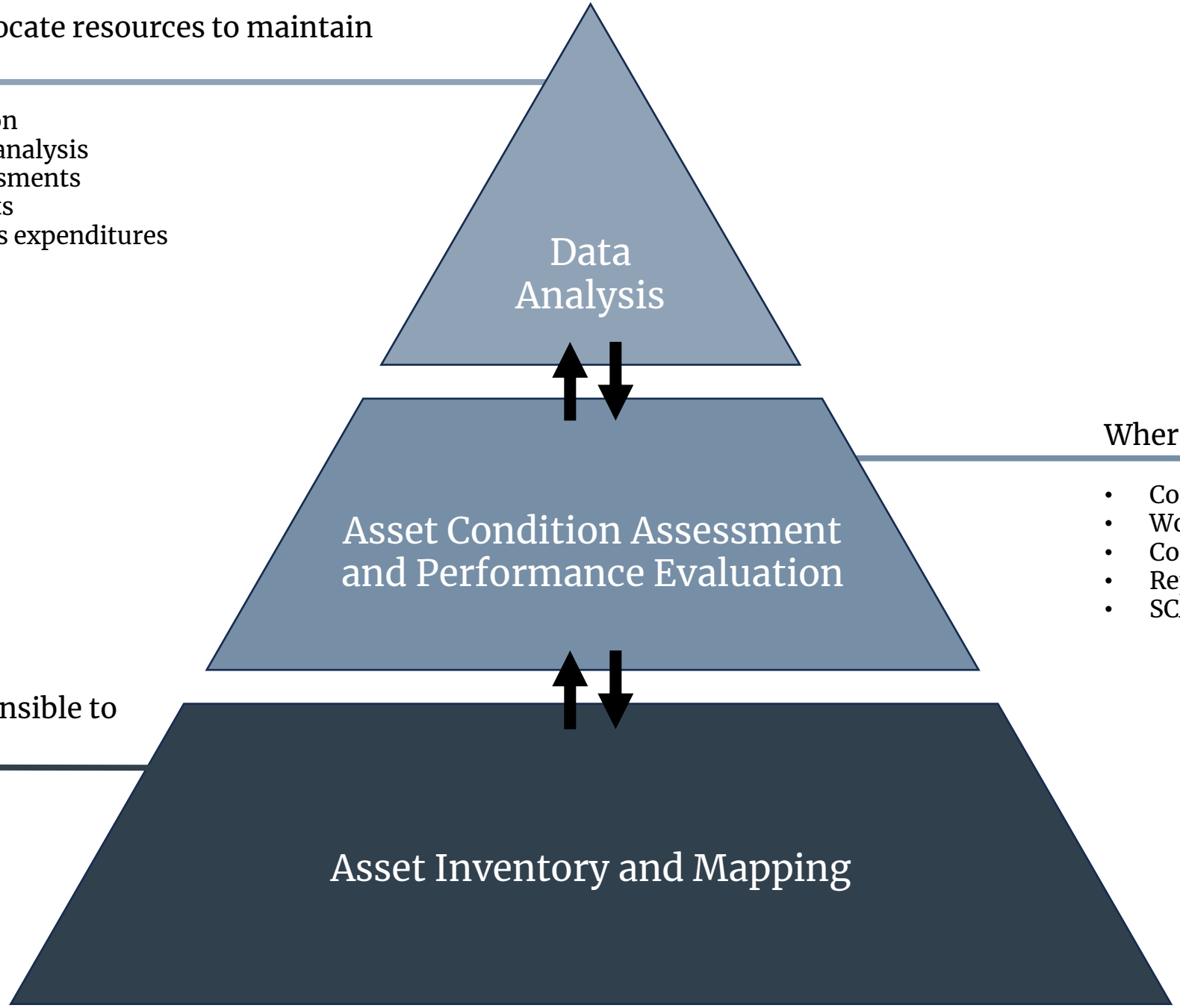
- Unknown asset portfolio
- Unknown condition of assets
- Mapping, inventorying, and assessing is costly
- High number of assets
- Disruptions in service
- Extreme weather pushes infrastructure beyond limits
- Lack of data-driven decision making
- Prioritization of resources
- Run-to-failure, “whack-a-mole”, mode of operation

How do we efficiently allocate resources to maintain desired service levels?

- Asset system identification
- Data-driven, risk-based analysis
- Opportunity-based assessments
- System-scale assessments
- Prioritization of resources expenditures



Where are our problems?

- Condition ratings
- Work orders
- Complaints
- Repairs
- SCADA

What assets are we responsible to manage?

- Location
- Characteristics
  - Size
  - Material
  - Age
  - etc.
- Ownership

REACTIVE

RUN TO FAILURE

PROACTIVE

TIME-BASED MAINTENANCE

PREDICTIVE

RISK-BASED ASSESSMENT

Risk-Based Approach is Foundational

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What Criteria Should be Incorporated Into a Risk-Based Evaluation?

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PROBABILITY OF FAILURE

- Installation Date
- Material
- Soil Corrosivity
- NASSCO PACP Scores
- Work Order/Issue History
  - Debris Accumulation
  - Sinkholes
  - Drainage Complaints
- Other

CONSEQUENCES OF FAILURE

- Critical Customers
- Proximity to Streams/Wetlands
- Economic Impacts – i.e. Business District
- Public Health
- Street Classification/Agency Coordination
- Proximity to Buried Utilities
- Proximity to Railroad
- Diameter
- Proximity to Buildings
- Depth of Bury
- Proximity to Pavement
- Other

Example: Asset Management Using Remaining Useful Life

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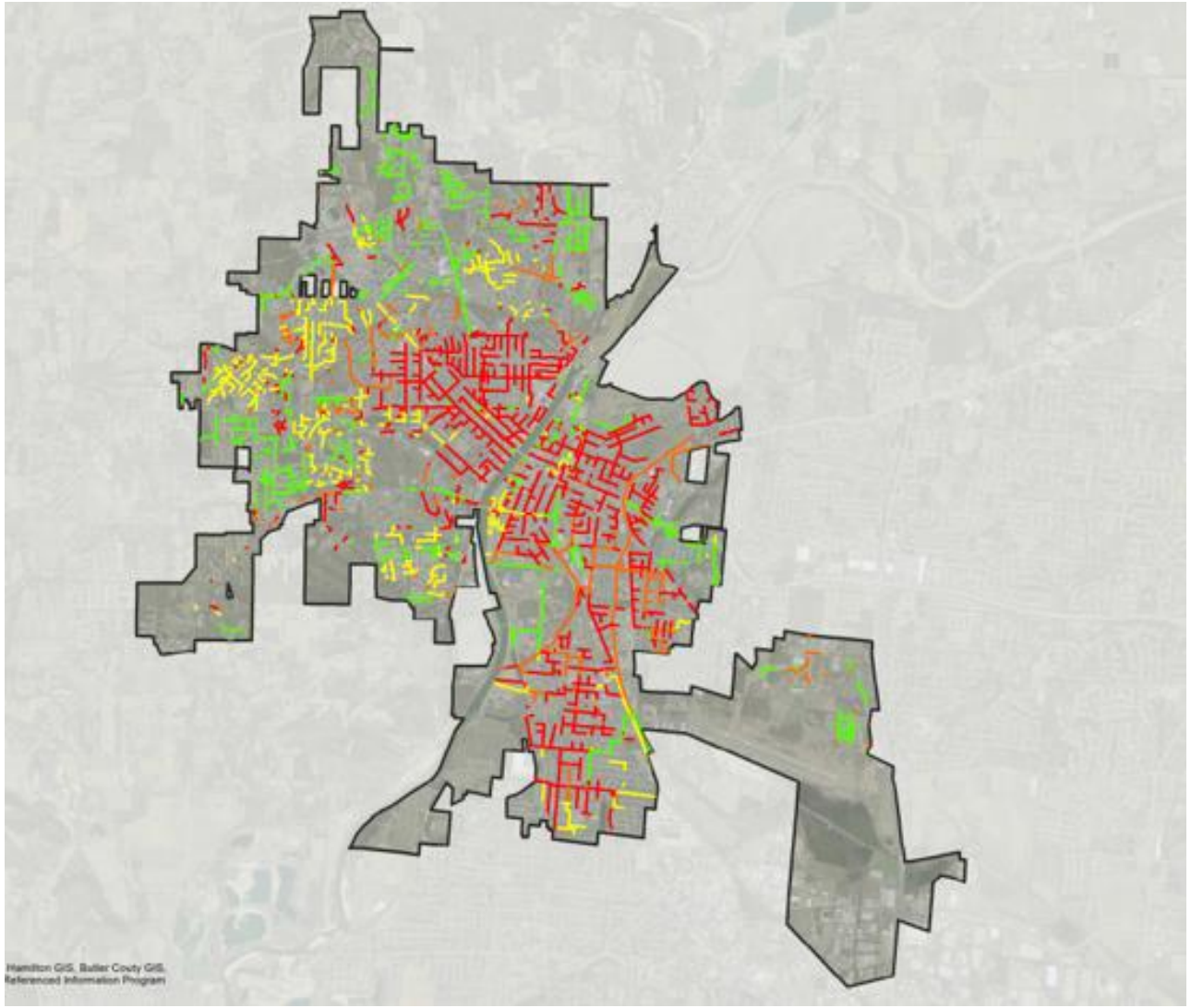

STORM WATER MASTER PLAN

RISK RANKING

Legend

City Boundary

Storm Gravity Main

Useful Life Remaining

- Past Expected Life
- 1 - 20 years
- 21 - 40 years
- 41 - 60 years

Example: Asset Management Using Risk Ranking

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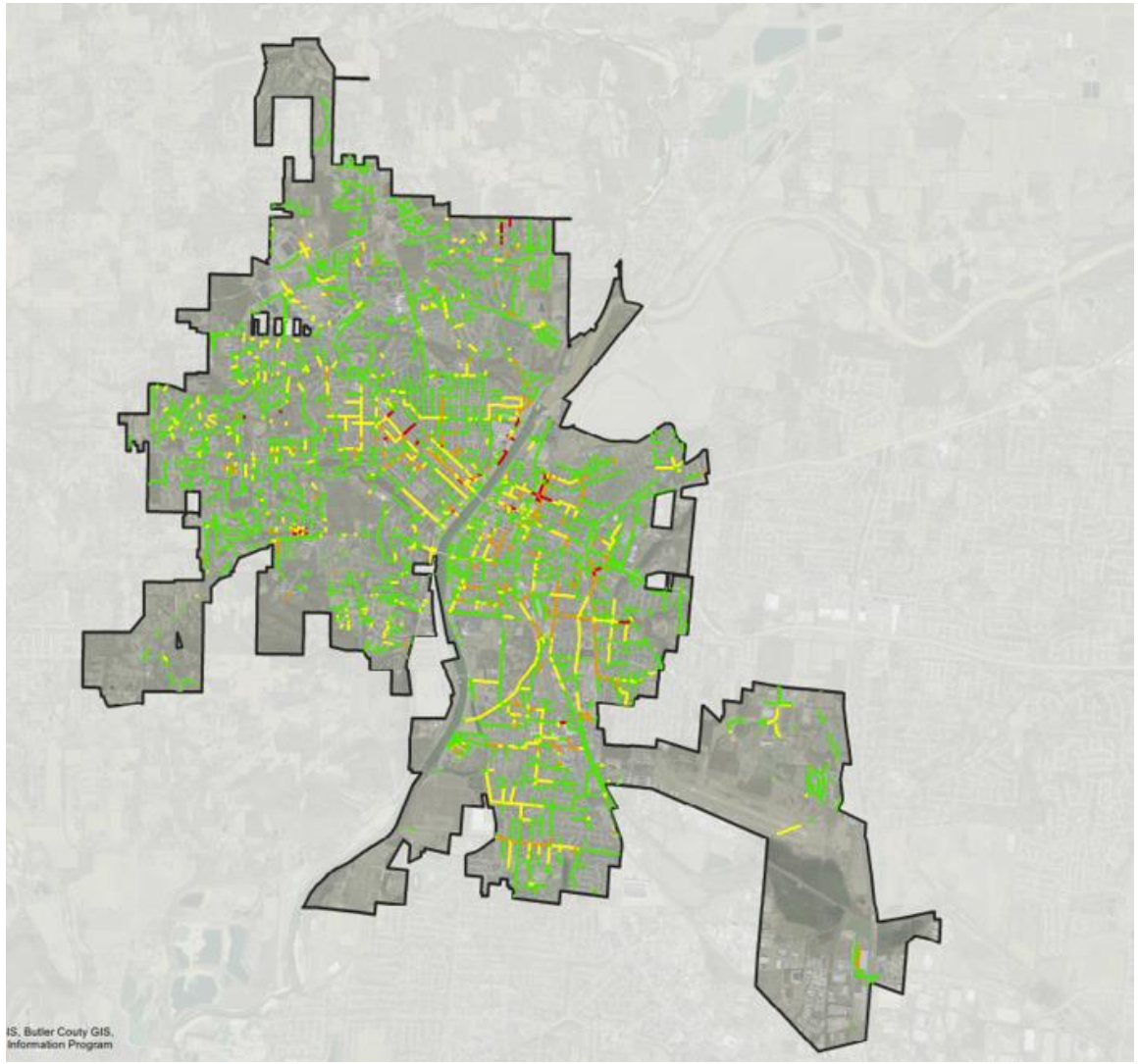

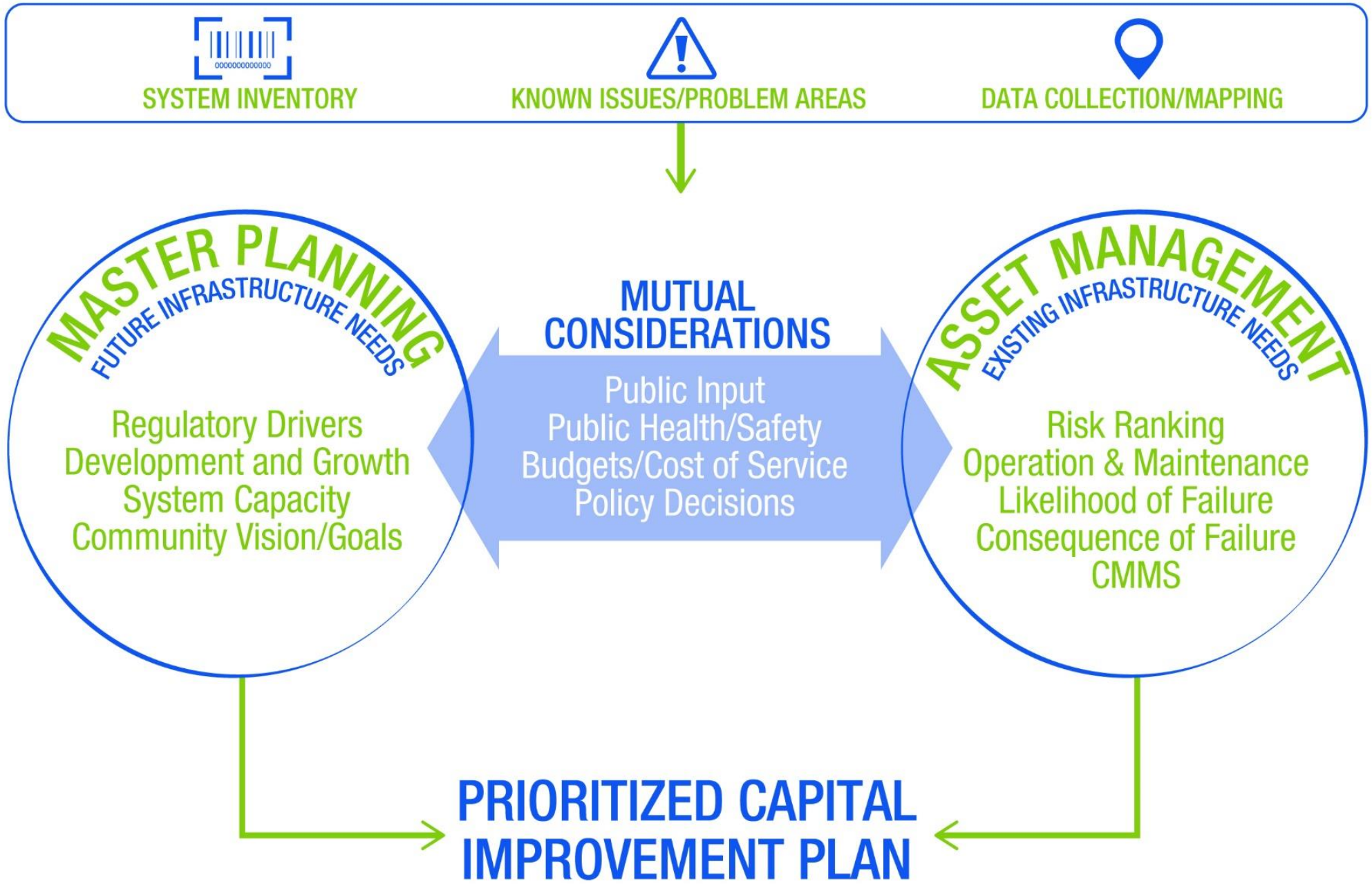

Strand Associates, Inc.

Natural Infrastructure is An Asset Too!

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What Are Natural Assets?

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"Natural assets refer to the stocks of natural resources and/or ecosystems that contribute to the provision of one or more services required for health, well-being, and long-term sustainability of an [organization]."

– **Natural Assets Initiative**

Natural Asset Management (NAM) Expands Upon Traditional Asset Management

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Green Infrastructure (GI)

Nature-based (climate) **Solutions** (Nb[c]S)

Natural Infrastructure (NI)

Low Impact Development (LID)

Natural (GI) Assets	Enhanced (GI) Assets	Engineered (GI) Assets	Grey Infrastructure
• Wetlands	• Rain gardens	• Permeable pavement	• Bridges
• Swamps	• Green roofs and walls	• Rain barrels	• Roads
• Forests	• Bioswales	• Cisterns	• Parking lots
• Meadows	• Street and park trees	• Perforated pipes	• Culverts
• Watercourses	• Naturalized stormwater ponds	• Infiltration trenches	• Pipes
• Lakes and ponds	• Manicured lawns		
• Soils			

Natural Assets Initiative, 2024

ISO 55000:2024 (adapted)

Scoping Natural Assets to be Managed

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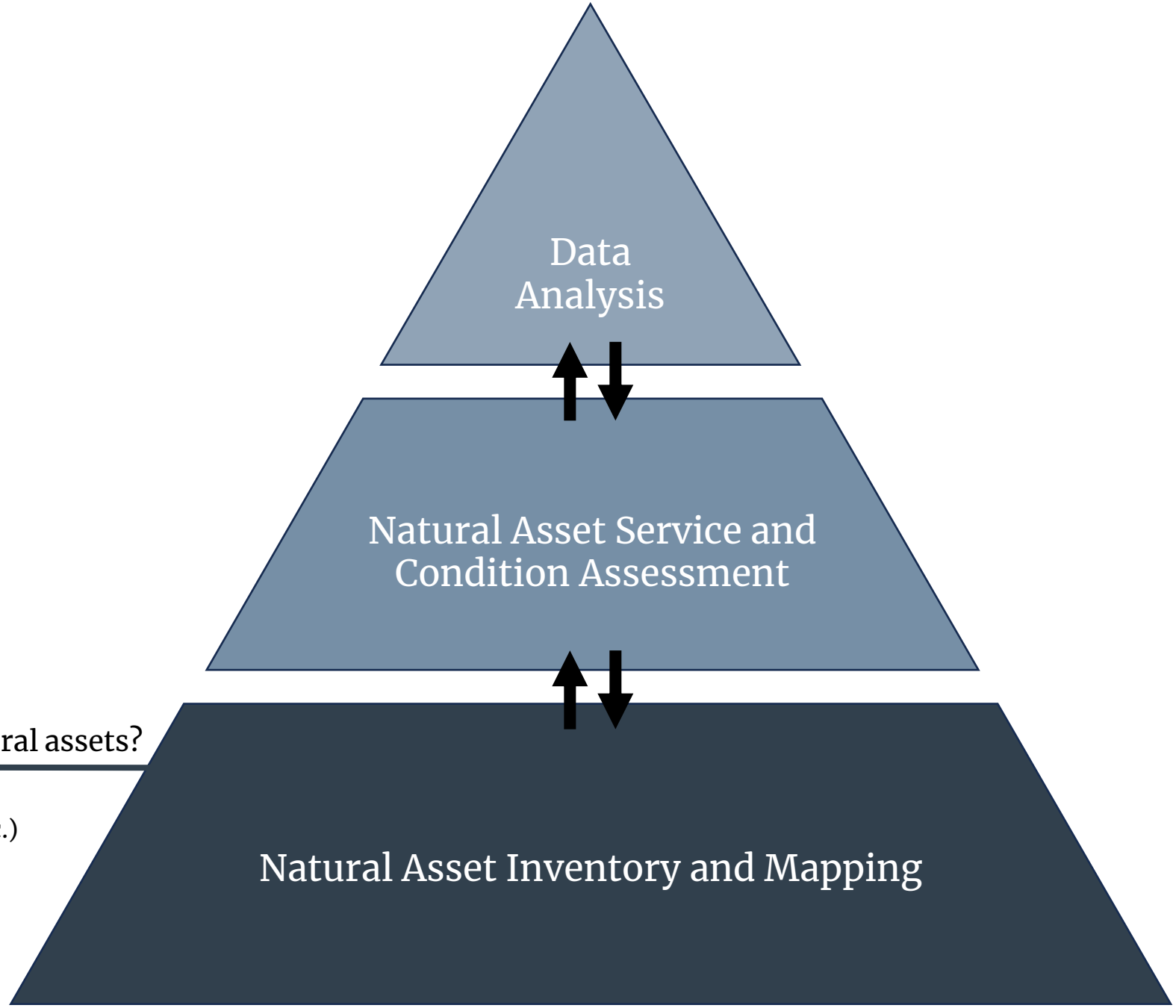
1. **Define NA's to be included**
   - Terrestrial (forests, grasslands, meadows, etc.)
   - Watercourses (rivers and streams)
   - Waterbodies (lakes and ponds)
   - Groundwater or Aquifers
   - Coastal-specific (dunes, marshes, etc.)
2. **Define the boundary in which NA's will be assessed**
   - Entity owned (entirely on entity owned properties)
   - All NA's within a jurisdictional boundary (municipality)
   - All NA's that provide a service (watershed)



Where/what are our natural assets?

- Location/ boundary
- Type (forest, wetland, etc.)
- Ownership

Natural Asset Mapping and Inventory

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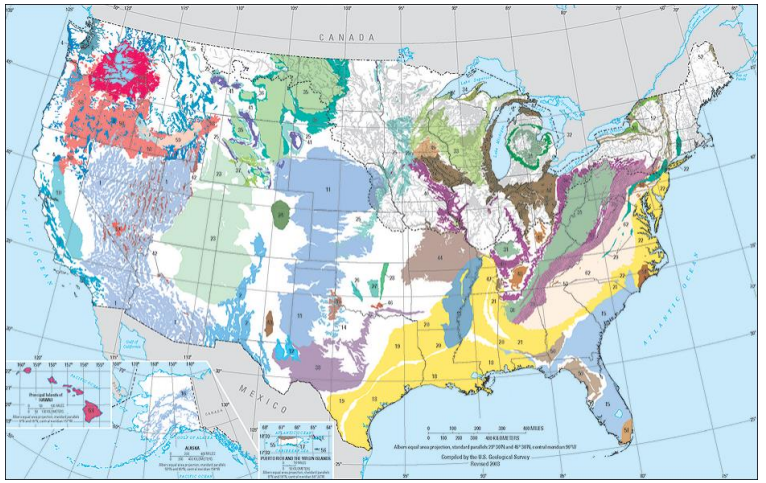
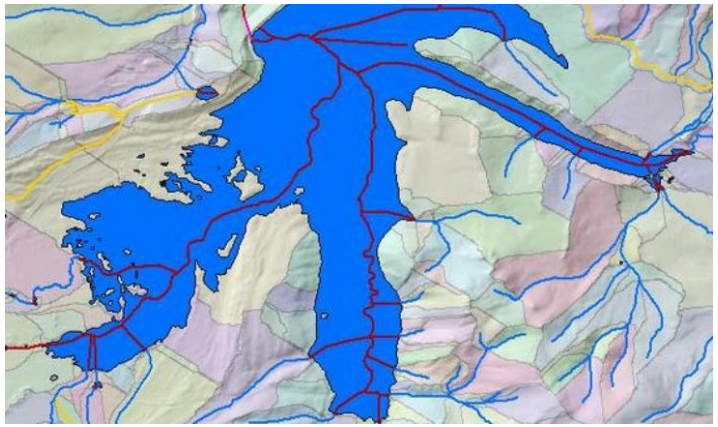
1. Identify datasets

- Landcover classifications
- Aerial Imagery
- Forest Canopy
- National Hydrography Dataset
- USGS Aquifers Map
- Watershed boundaries
- Jurisdictional boundaries



USGS Principal Aquifers of U.S.

Google Earth



USGS NHD

USDA, Treemap

Natural Asset Mapping and Inventory

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2. Categorize Natural Assets and Create Asset Hierarchy

Natural asset categories can help to prioritize management strategies

Asset Class	Asset Type	Components
Natural Assets	Forest	Coniferous Forest
		Deciduous Forest
		Mixed Forest
	Wetland	Swamp
		Marsh
		Peatland
	Waterbody	Lake
		Pond
		Reservoir*

Natural Asset Mapping and Inventory

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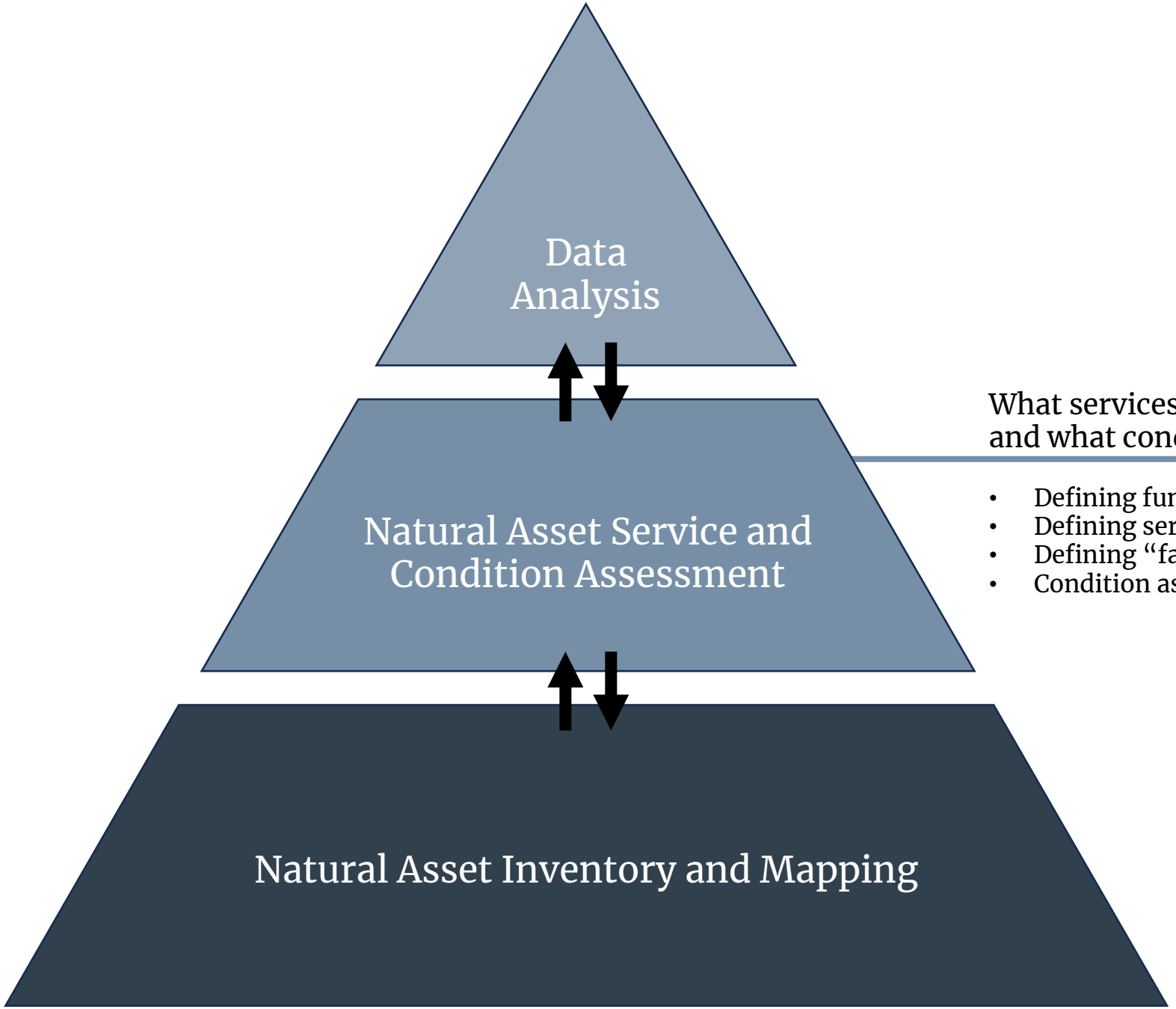
3. Identify Key Attributes for Inventory

- Identification system
- Type (forest, wetland, grassland, etc.)
- Quantity (area, length, etc.)
- Ownership

4. Develop Natural Assets Database

- Geospatial environment is typically the most effective
- Best if it can be integrated into existing asset management database

Asset Class	Asset Type	Asset Subtype	Area (ac)	Ownership
Natural	Forest	Mixed	317	ACC/Private



What services are our NA's providing and what condition are they in?

- Defining functions and benefits
- Defining services
- Defining "failure"
- Condition assessments

Natural Asset Service and Condition Assessment

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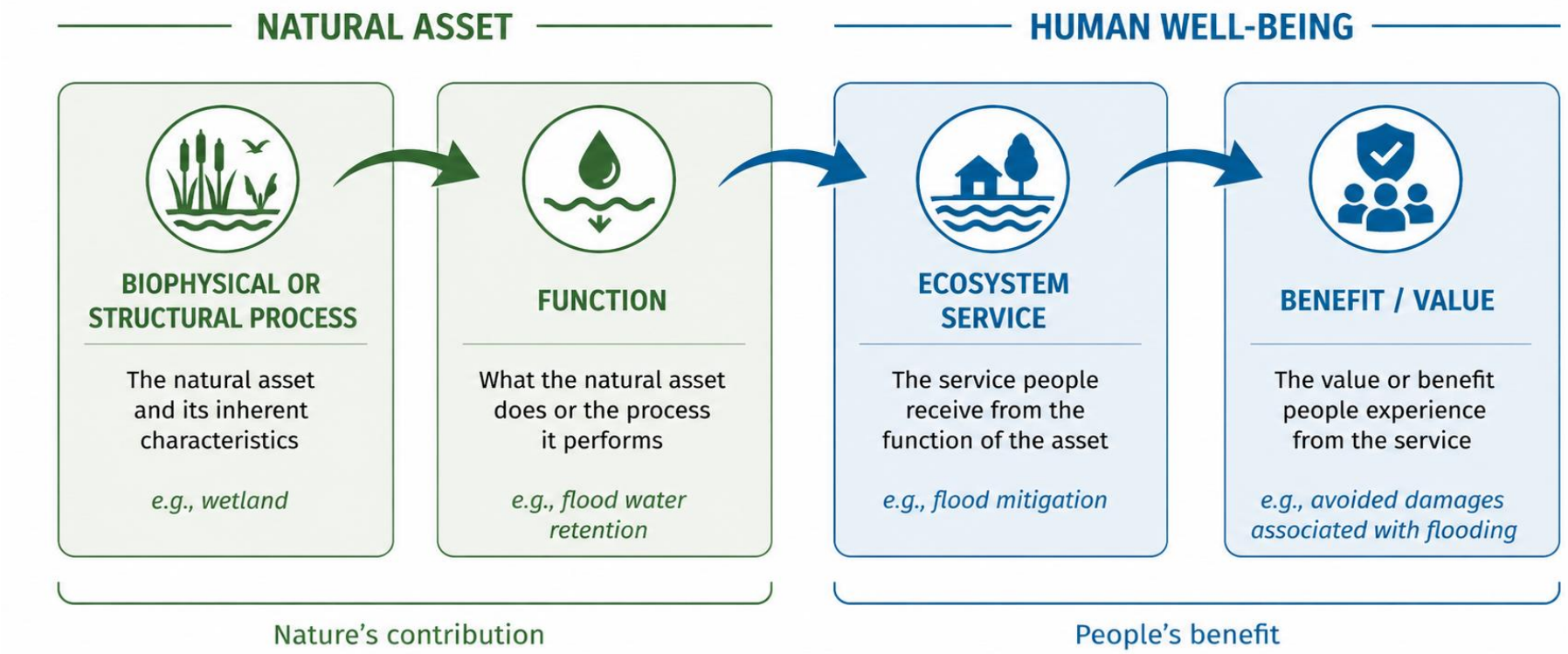
1. Determine and map services provided by natural assets



Adapted from Natural Assets Initiative, 2024

NATURAL ASSET		HUMAN-WELL-BEING	
Biophysical or Structural Process	Function	Ecosystem Service	Benefit/Value
Wetland 	 Flood water retention	 Flood mitigation	 Avoided damages associated with flooding
Aquifer 	 Groundwater storage	 Water supply	 Source of water
Dunes 	 Wave energy absorbtion	 Wave energy dissipation	 Protection to built infrastructure

Natural Asset Service and Condition Assessment

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2. **Determine, criteria, indicators, measures, and metrics for service and condition assessment**
   - Forests: Size, tree density, species diversity, fragmentation, etc.
3. **Develop scoring criteria**
   - Complex: Score 1-5 with specific metrics for each score
   - Simple: Excellent, good, fair, poor
4. **Perform service and condition assessment**
   - Field-based
   - Desktop
   - Anecdotal and local knowledge
   - Other initiatives

Service Category	Services
Public Health/Safety	Flood Mitigation
	Water Quality
Recreation	Hiking
	Education
	Nature Access
Ecological	T&E Species Habitat
	Biodiversity
	Invasive Species

Natural Asset Service and Condition Assessment

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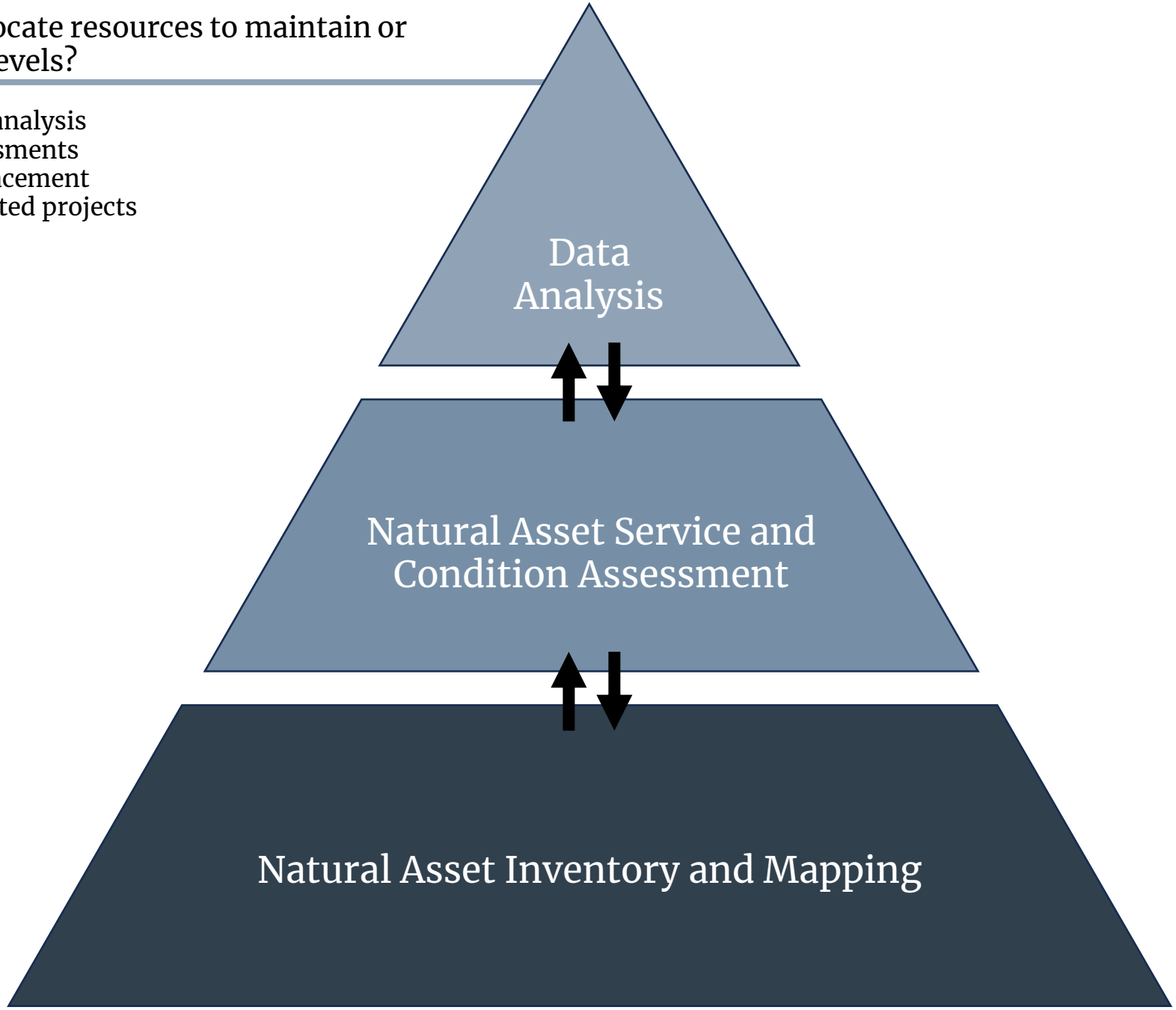
Asset Class	Asset Type	Asset Subtype	Area (ac)	Ownership	Watershed	Flood Mitigation Value	Water Quality Value	Recreational Value	Condition	Fragmentation	T&E Species Habitat
Natural	Forest	Mixed	317	ACC/Private	Trail Creek	High	Medium	Low	Good	Low	Excellent

How do we efficiently allocate resources to maintain or increase desired service levels?

- Data-driven, risk-based analysis
- Opportunity-based assessments
- Cost of natural asset replacement
- Cost of maintenance-related projects



Data Analysis

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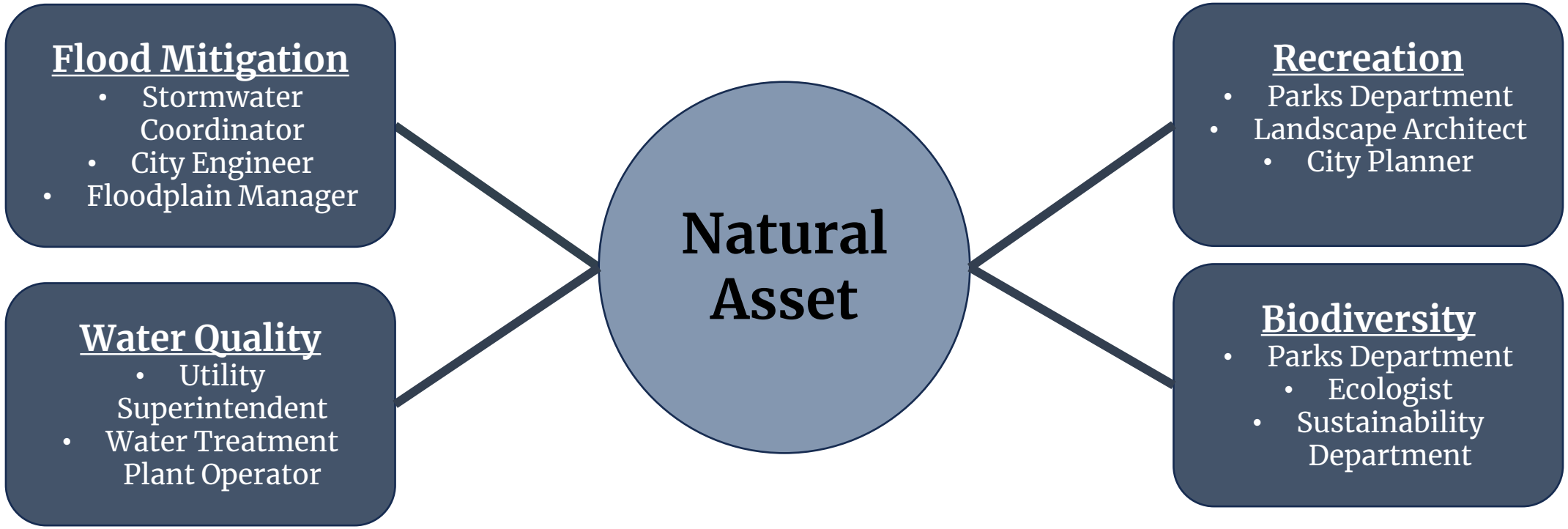
1. **Determine scope of analysis**
   - Flood mitigation, water quality, recreation, biodiversity, multiple
   - Who should perform the analysis?
   - Risk- or opportunity-based? Both?



Data Analysis

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2. Perform analysis, identify ‘critical’ natural assets that provide desired service

Flood Mitigation Example

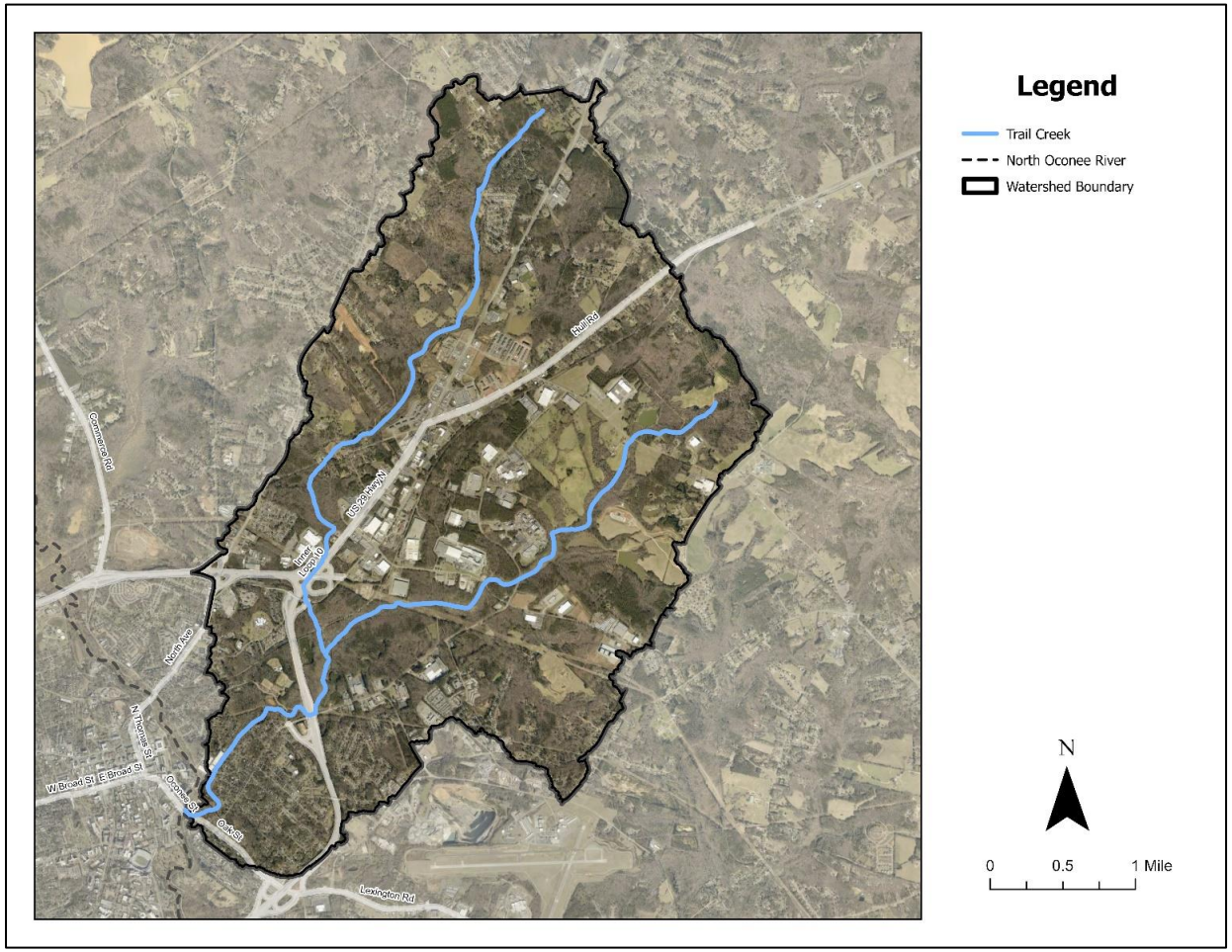
1. Known areas that flood often? Areas where flood protection is critical?

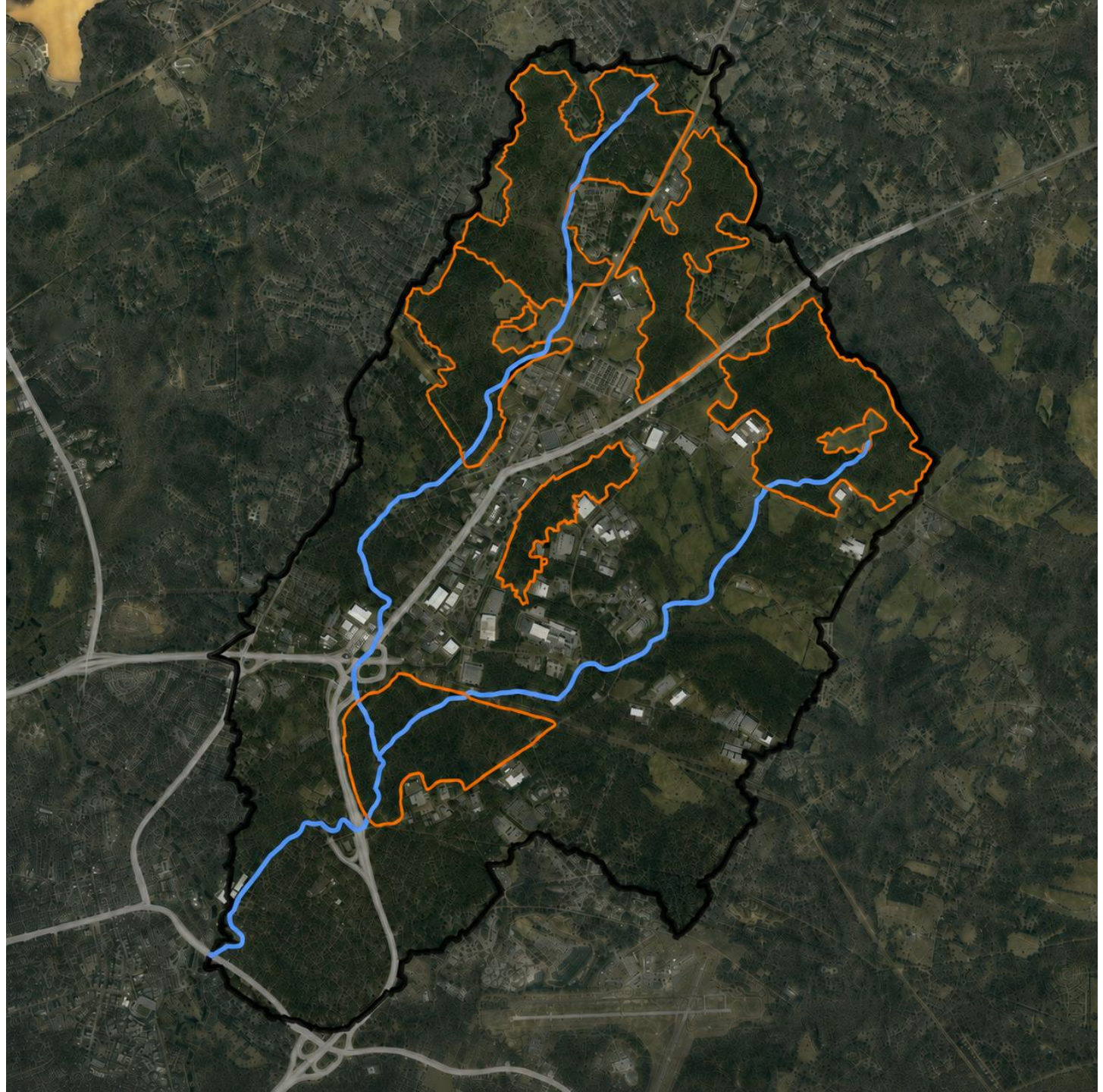
   Branch Street, Chicopee Complex

2. Identify watershed

   Trail Creek

3. Identify ‘contiguous’ natural assets with ‘high’ flood mitigation value.





Data Analysis

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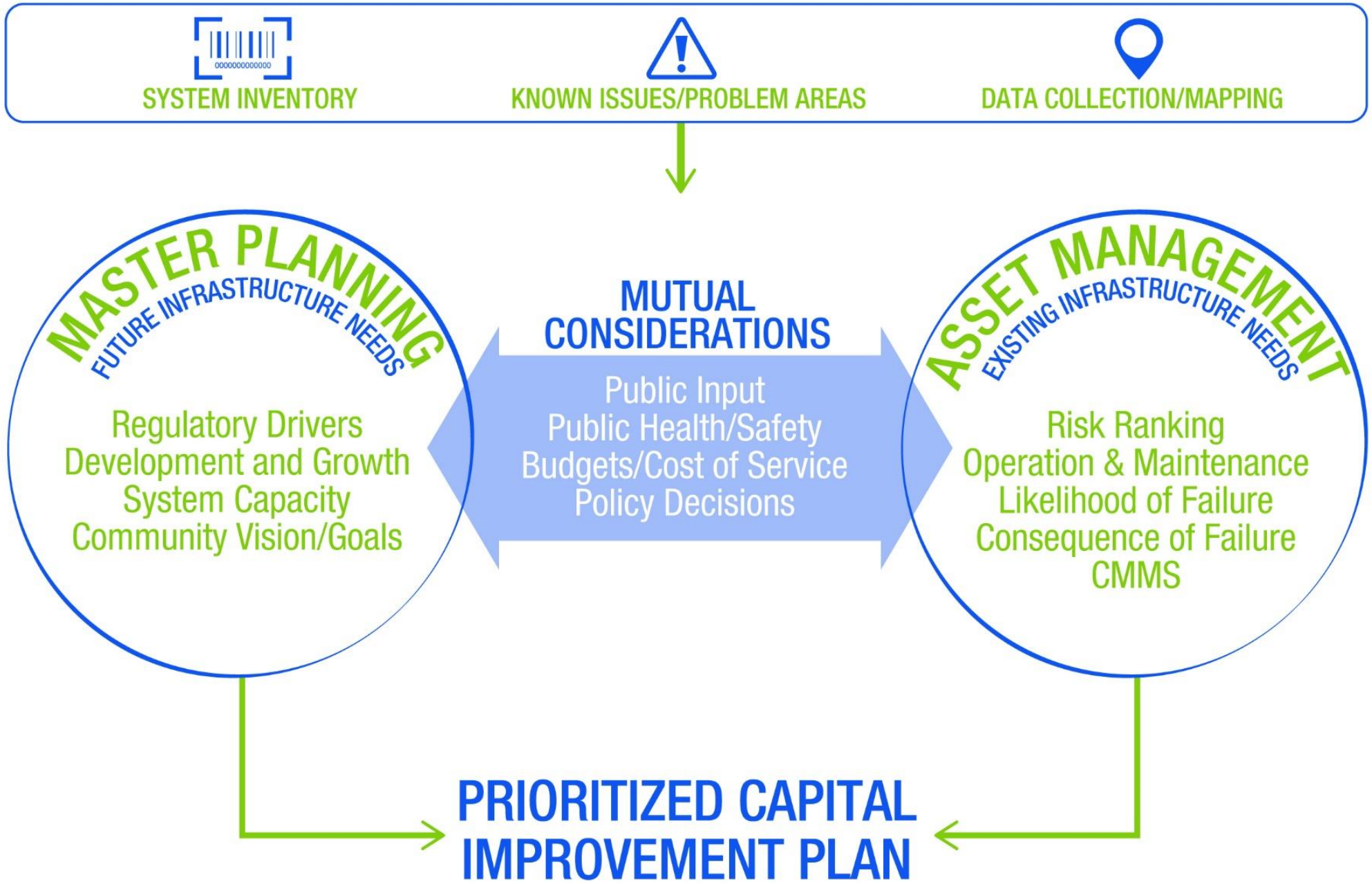
4. **Develop plan of action for most critical or multi-benefit critical assets.**
    - What critical natural assets do we own? Which do we not own?
    - Should/could we try to acquire those we don't own?
    - What is the lifecycle of the critical natural asset? What does the management plan look like?
    - What is the cost of the services provided?
    - How do we maintain services from critical natural assets?
        - Education/awareness
        - Reforestation
        - Continued forest health surveys
        - Conservation
5. **Develop "projects" with cost estimates.**
6. **Update Natural Asset Management plan every ~5-years**



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"Assets rely on a system of interdependencies to operate."

"When identifying critical assets, consider the resilience of individual assets in the context of the system as a whole."

– **Managing Infrastructure Assets for Sustainable Development, United Nations**

The Aperture in Which We Manage Built Infrastructure Assets Matters

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- Performance of built infrastructure assets is influenced by natural assets
- Traditional IAM strategies often do not adequately account for the "system"
- We are not adequately managing our built infrastructure assets if we are not considering natural infrastructure assets

Case Study: Georgia Hurricane Evacuation Route

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Installation Date: 2010
Drainage Area: 1306-acres

Different Aperture, Different Management Conclusions

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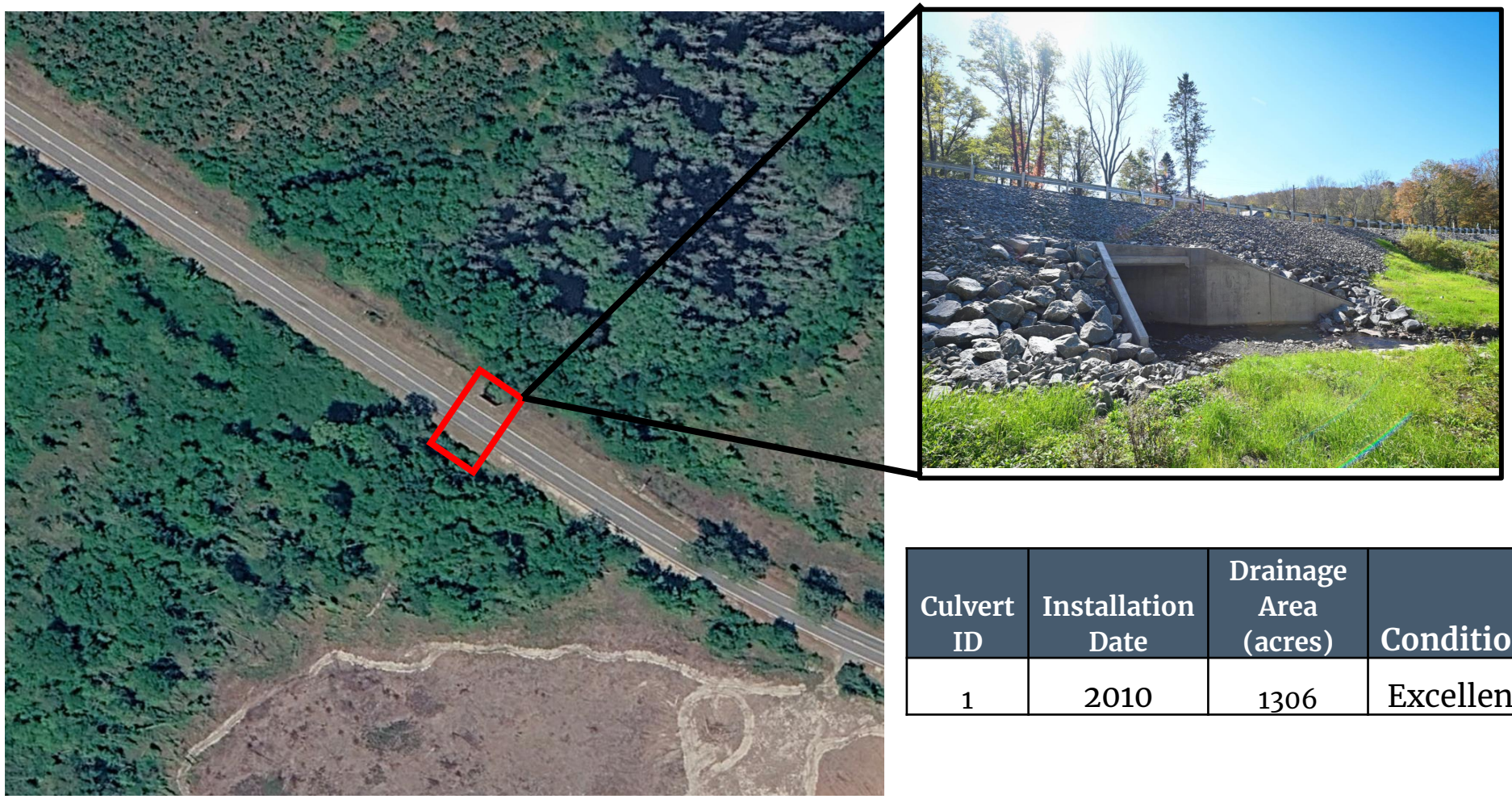

Culvert ID	Installation Date	Drainage Area (acres)	Condition	Probability of Failure	Risk Score
1	2010	1306	Excellent	1	1

Different Aperture, Different Management Conclusions

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Culvert ID	Installation Date	Drainage Area (acres)	Condition	Geomorphic Risk Score	Probability of Failure	Risk Score
1	2010	1306	Excellent	3	2	2

Different Aperture, Different Management Conclusions

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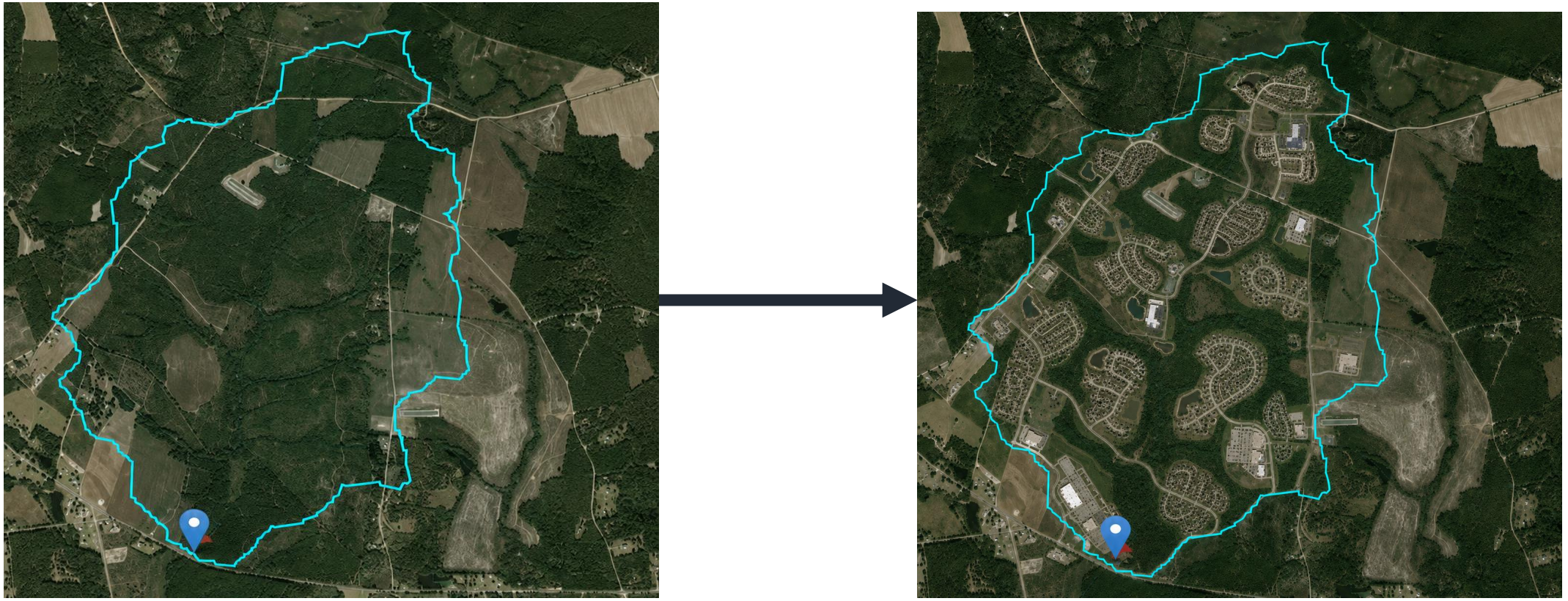

Different Aperture, Different Management Conclusions

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Culvert ID	Installation Date	Drainage Area (acres)	Condition	Land Use Change Score	Geomorphic Risk Score	Probability of Failure	Risk Score
1	2010	218	Excellent	5	4	4	4

Different Aperture, Different Management Conclusions

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Assessment
Low Risk

Assessment
Medium Risk

Assessment
High Risk

Case Study: Georgia Hurricane Evacuation Route

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Case Study: Georgia Hurricane Evacuation Route

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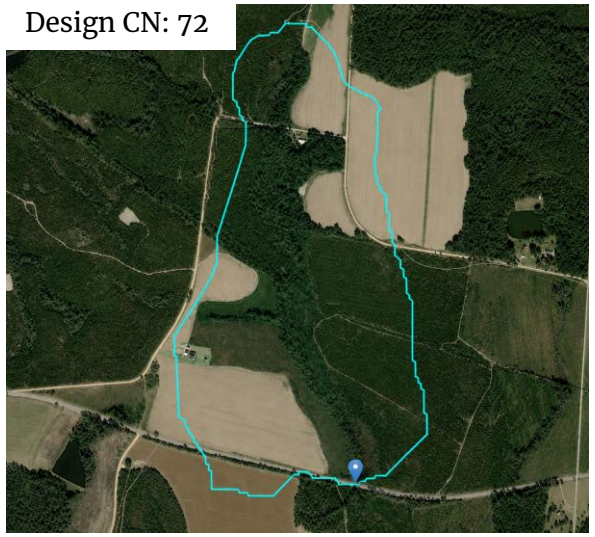

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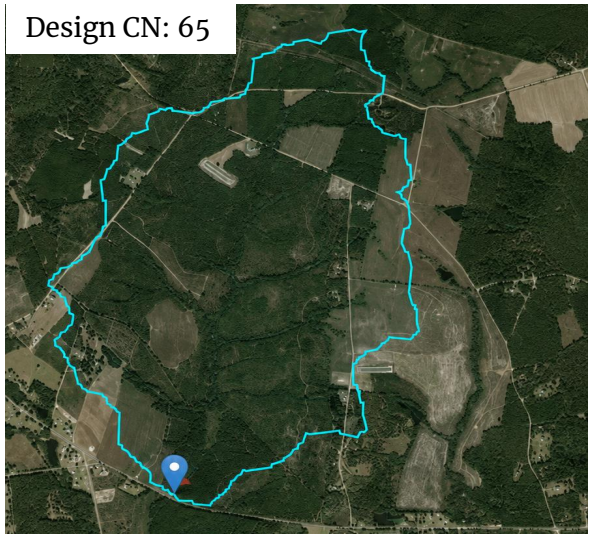

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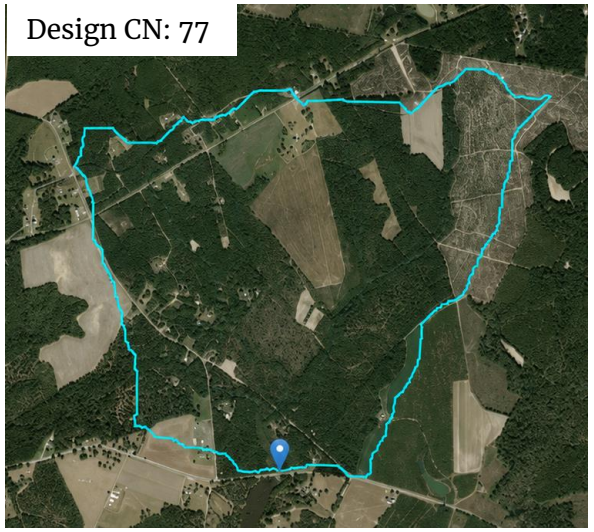

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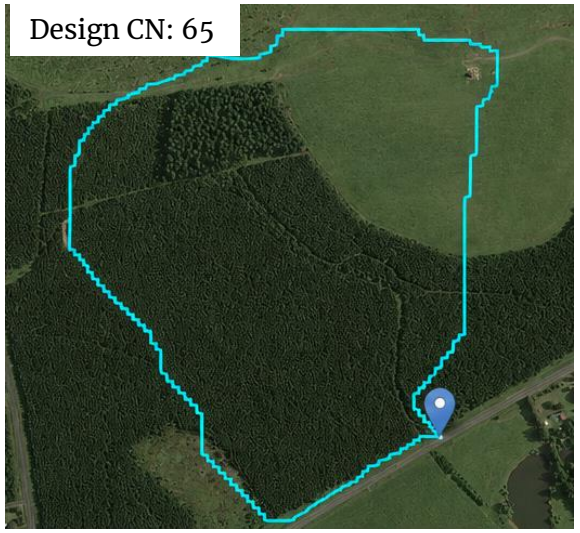

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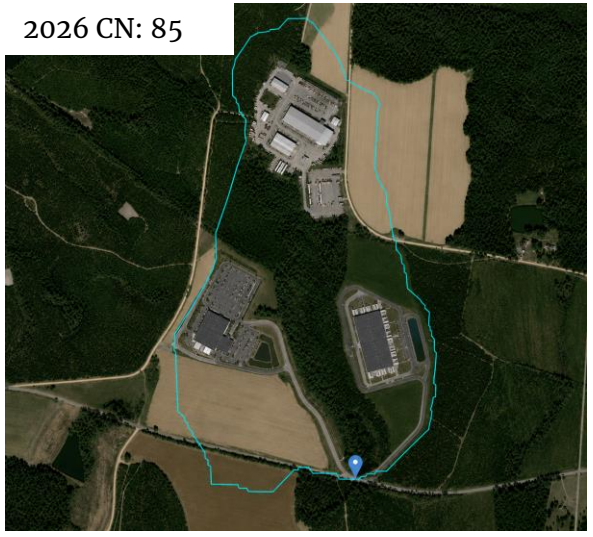

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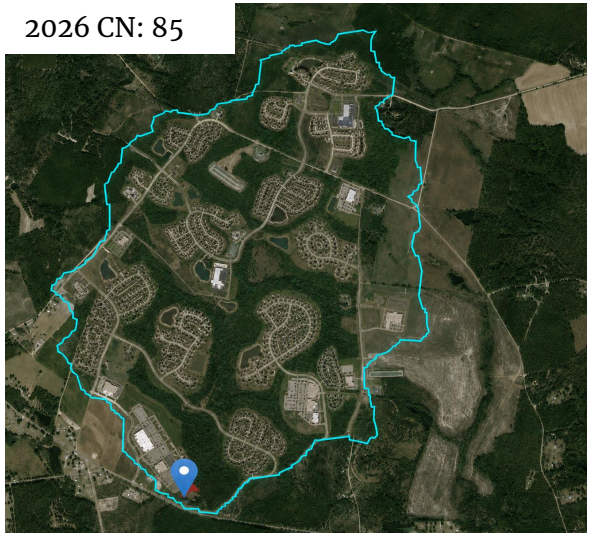
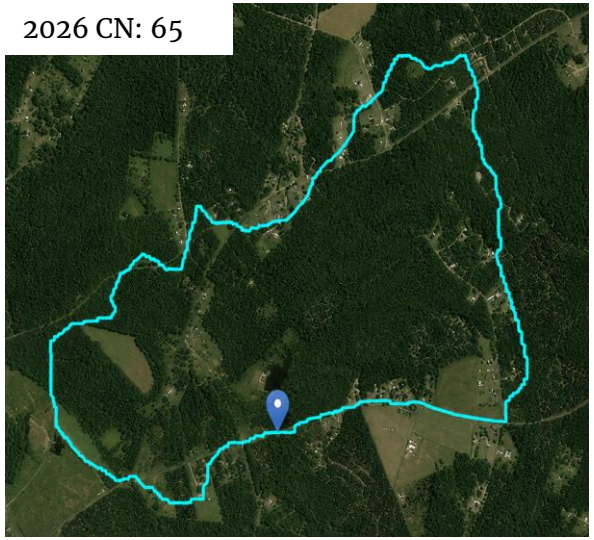
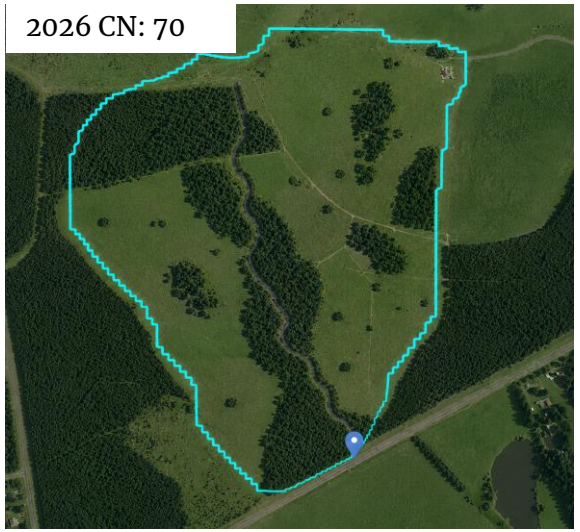
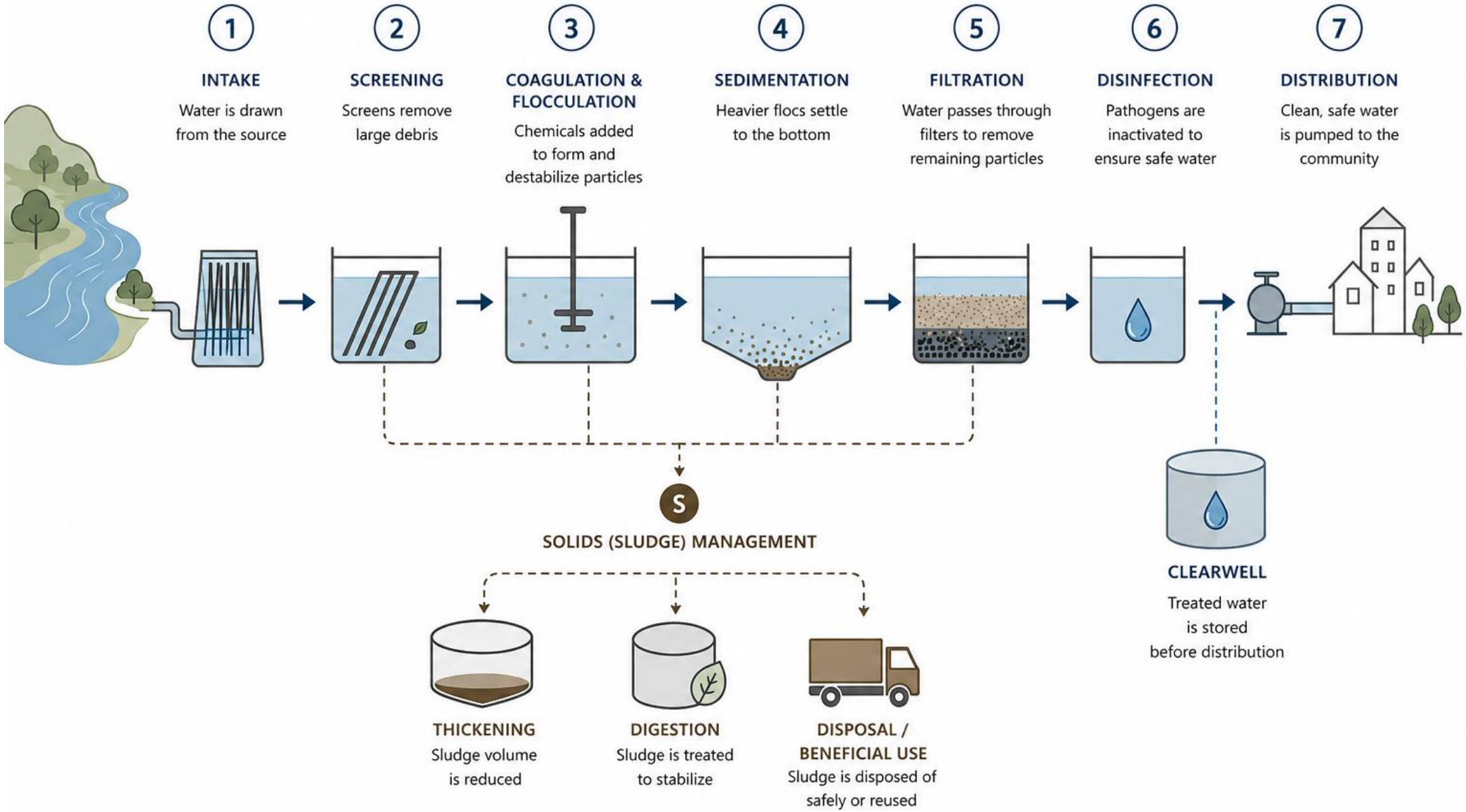


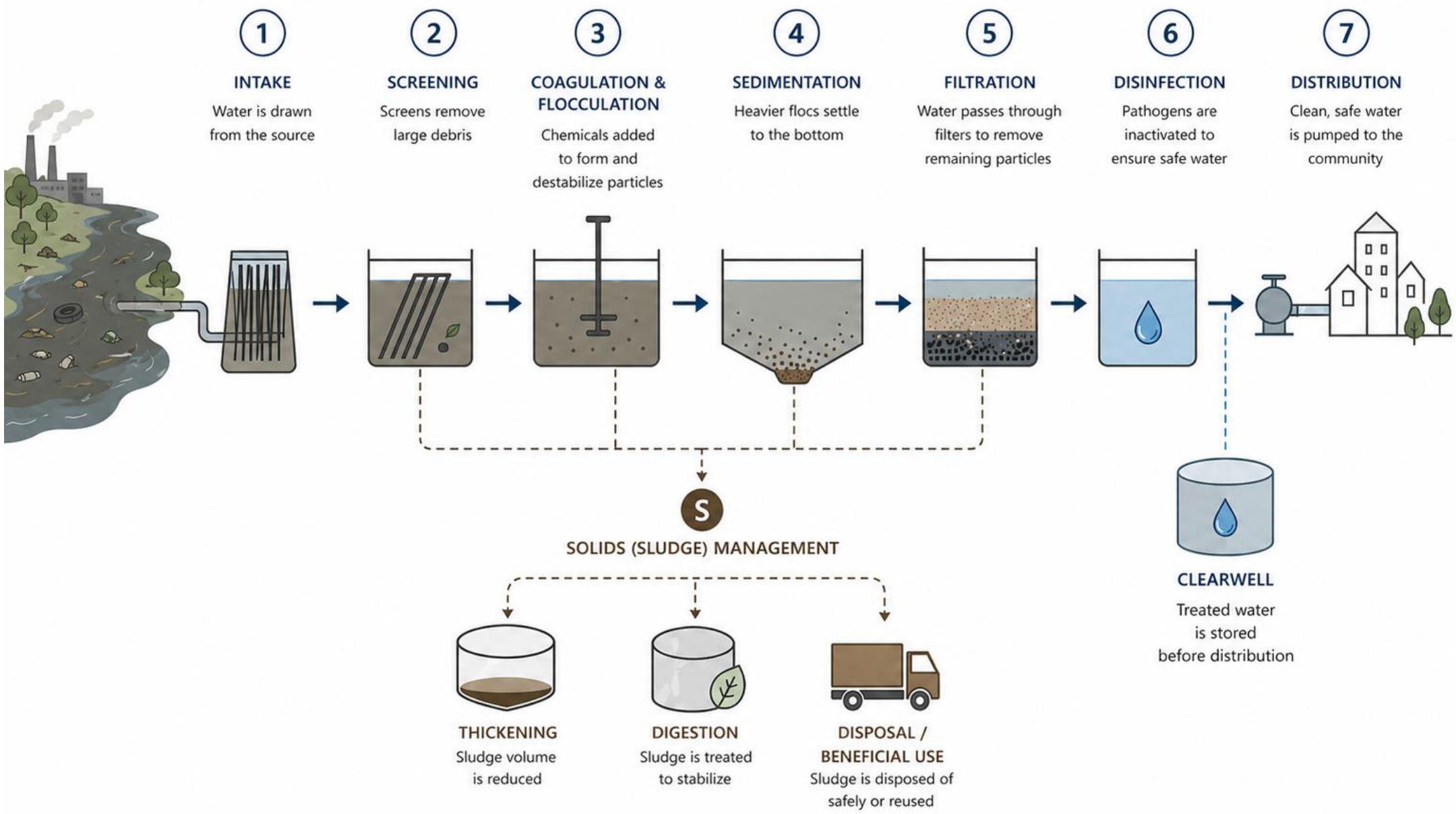
2026 CN: 65



2026 CN: 70




1
INTAKE
Water is drawn from the source
2
SCREENING
Screens remove large debris
3
COAGULATION & FLOCCULATION
Chemicals added to form and destabilize particles
4
SEDIMENTATION
Heavier flocs settle to the bottom
5
FILTRATION
Water passes through filters to remove remaining particles
6
DISINFECTION
Pathogens are inactivated to ensure safe water
7
DISTRIBUTION
Clean, safe water is pumped to the community
S
SOLIDS (SLUDGE) MANAGEMENT
CLEARWELL
Treated water is stored before distribution
THICKENING
Sludge volume is reduced
DIGESTION
Sludge is treated to stabilize
DISPOSAL / BENEFICIAL USE
Sludge is disposed of safely or reused


1
INTAKE
Water is drawn from the source
2
SCREENING
Screens remove large debris
3
COAGULATION & FLOCCULATION
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Catskill/Delaware Watersheds
Schoharie Reservoir
Pepacton Reservoir
Cannonsville Reservoir
Ashokan Reservoir
Neversink Reservoir
Rondout Reservoir
Catskill Aqueduct
Delaware Aqueduct
Croton Watershed
West Branch Reservoir
New Croton Reservoir
Kensico Reservoir
NYC Environmental Protection
New York City's Water Supply System
Catskill / Delaware Watershed Area
Croton Watershed Area
Rivers and Reservoirs
Catskill Aqueduct and Tunnels
Croton Aqueduct
Delaware Aqueduct and Tunnels
County Borders
State Borders
www.nyc.gov/dep

Drink it in.
The beauty of New York City water is that it tastes great, too.
Read the 2022 Drinking Water Supply & Quality Report and about how New York City gets its water.
NYC Environmental Protection
Eric Adams Mayor
Rohit T. Aggarwala Commissioner

Case Study: Garnsey Range Troop Crossing

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Case Study: Garnsey Range Troop Crossing

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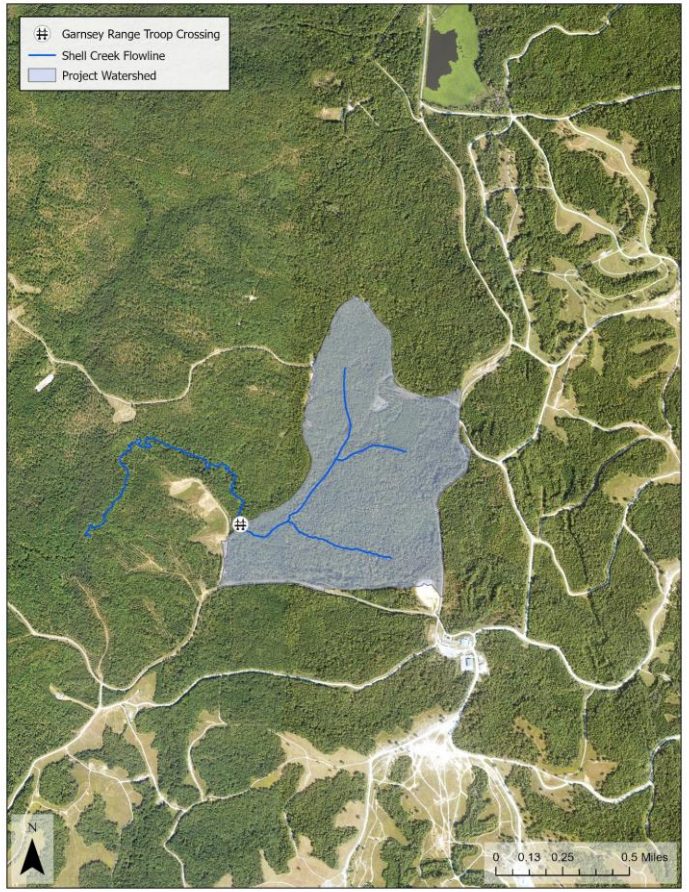

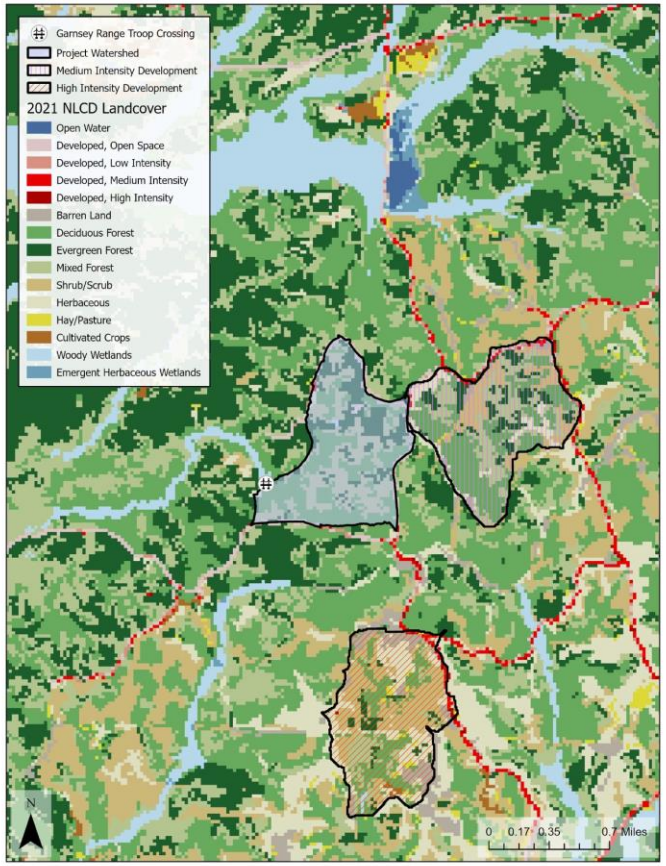

Case Study: Garnsey Range Troop Crossing

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Existing Level of Service	Discharge (cfs)	Medium Intensity Development Level of Service	Discharge (cfs)	High Intensity Development Level of Service	Discharge (cfs)
100-yr	1044	50-yr	1027	25-yr	1023

Case Study: Garnsey Range Troop Crossing

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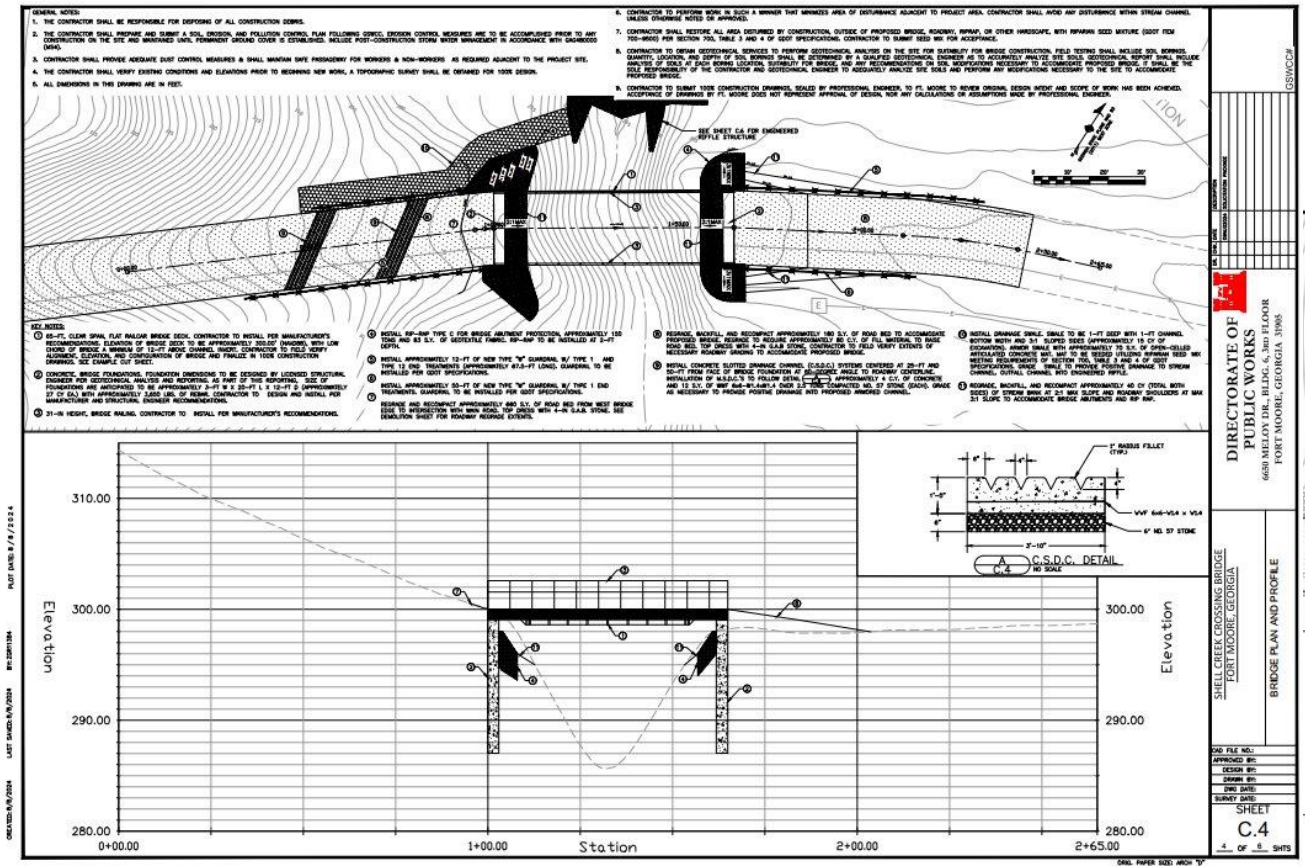

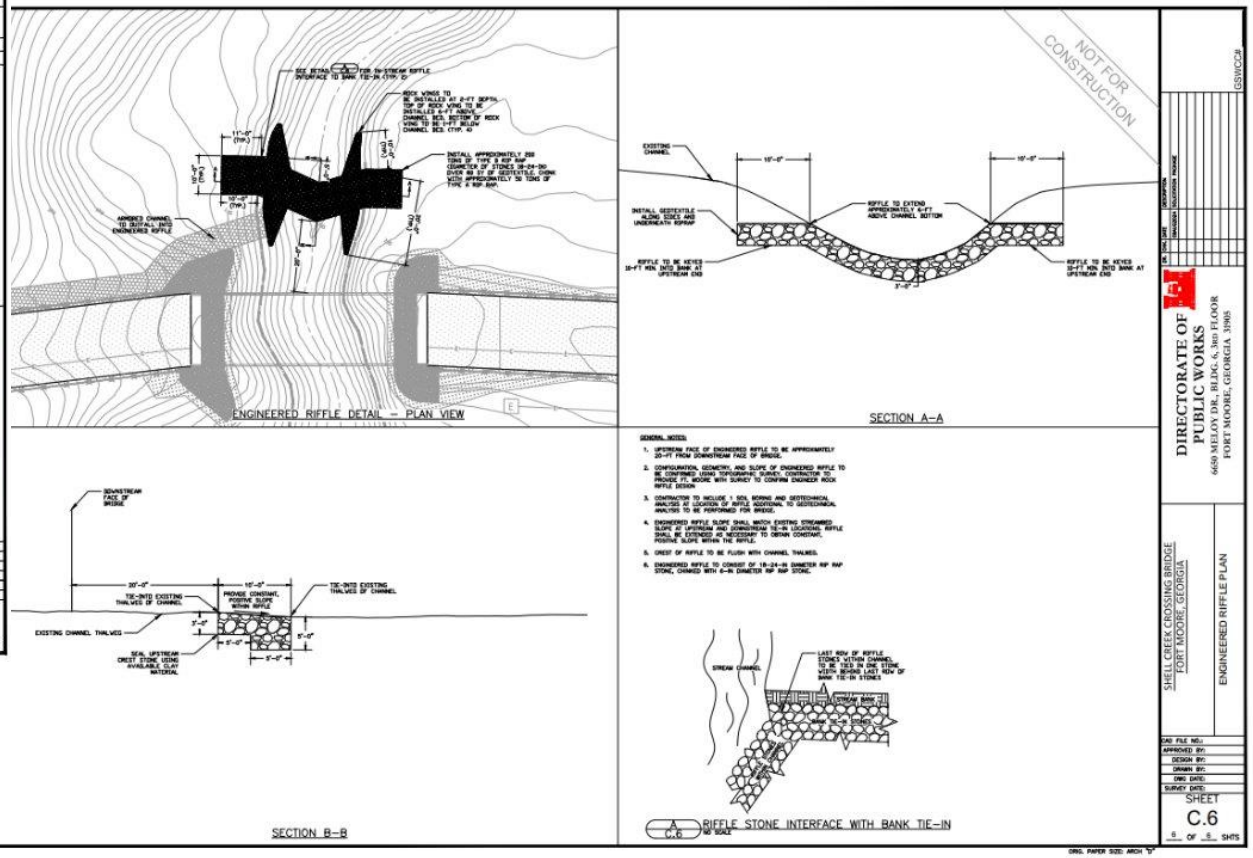

Closing Thoughts

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- Asset management is vital to helping infrastructure owners make informed, data-driven decisions to ensure infrastructure provides expected level of service throughout its lifecycle
- Natural and built assets should be considered in effective asset management plans
- Management of natural assets requires a different, but similar, approach compared to built assets
- Comprehensive asset management plans should evaluate infrastructure as part of the system it is in, not just the asset itself

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Questions?