Resilience, Regulation and Reprioritization

Stormwater and Floodplain Management Updates from MSD

Charles Pugh, PE, CFM – Metropolitan St. Louis Sewer District

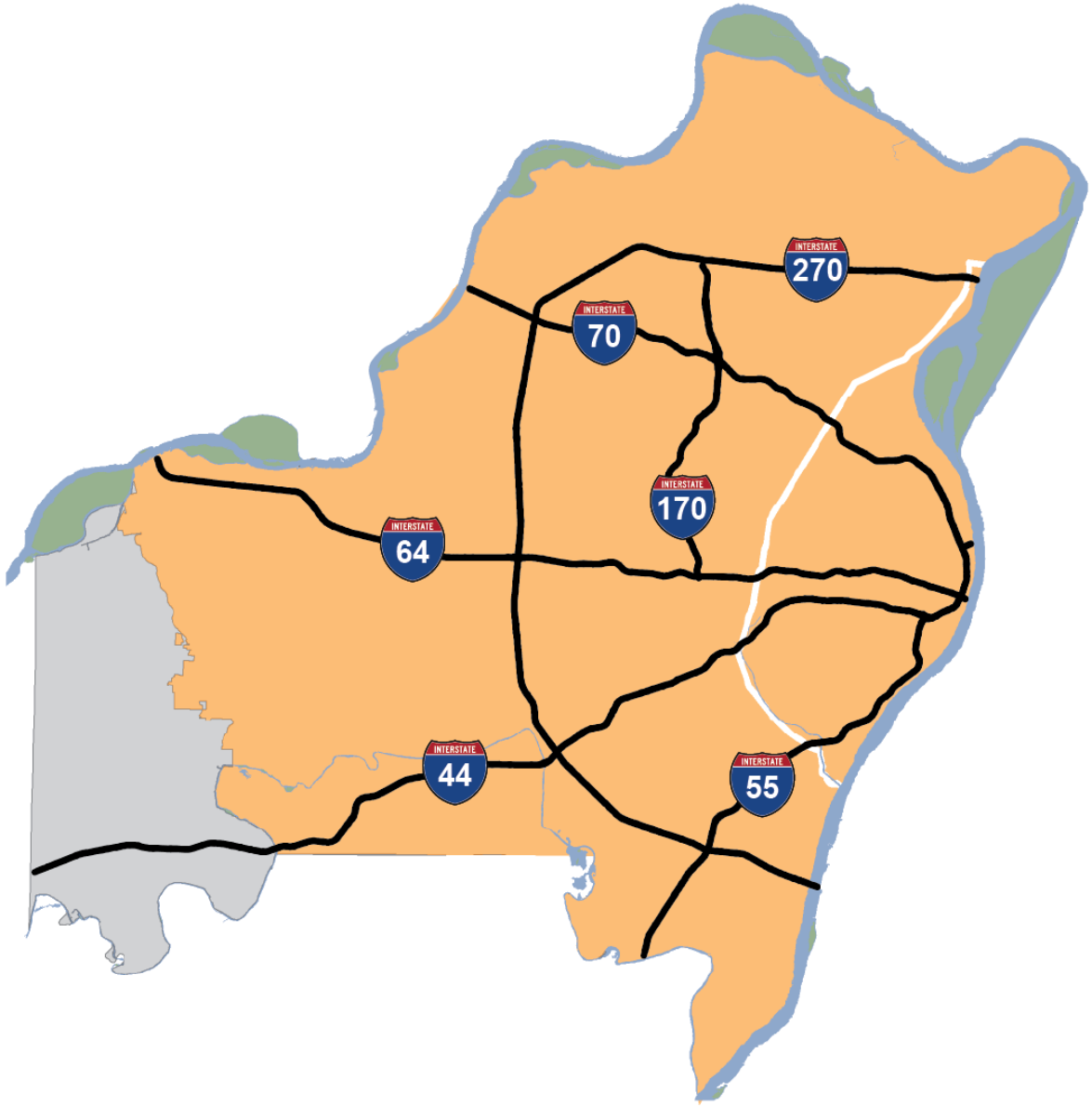
Tim Dean, PE, CFM, LEED® AP – Intuition & Logic Engineering, Inc.

Overview

- MSD Stormwater Background
- Capital Project Prioritization
- Stormwater Resilience Plan
- MSD Rules & Regulations Update

Background

project clear
wastewater + stormwater



520
SQUARE MILE SERVICE AREA

1.3 MILLION
CUSTOMERS

87
MUNICIPALITIES

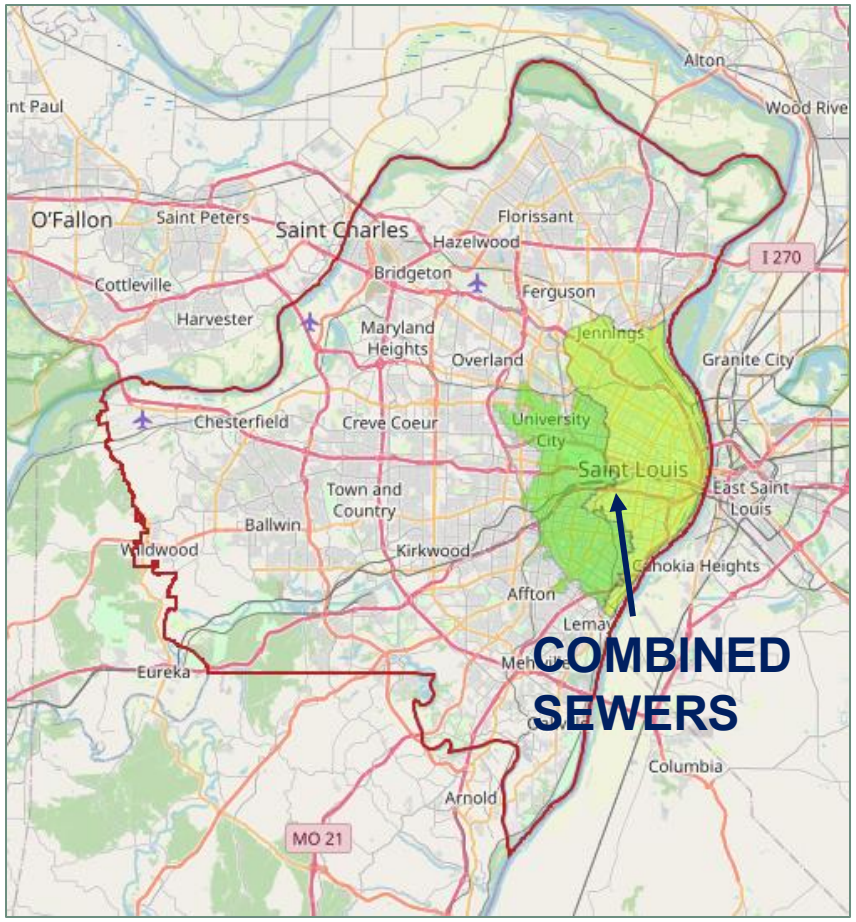
4TH
LARGEST SEWER SYSTEM IN U.S.

project clear
wastewater + stormwater

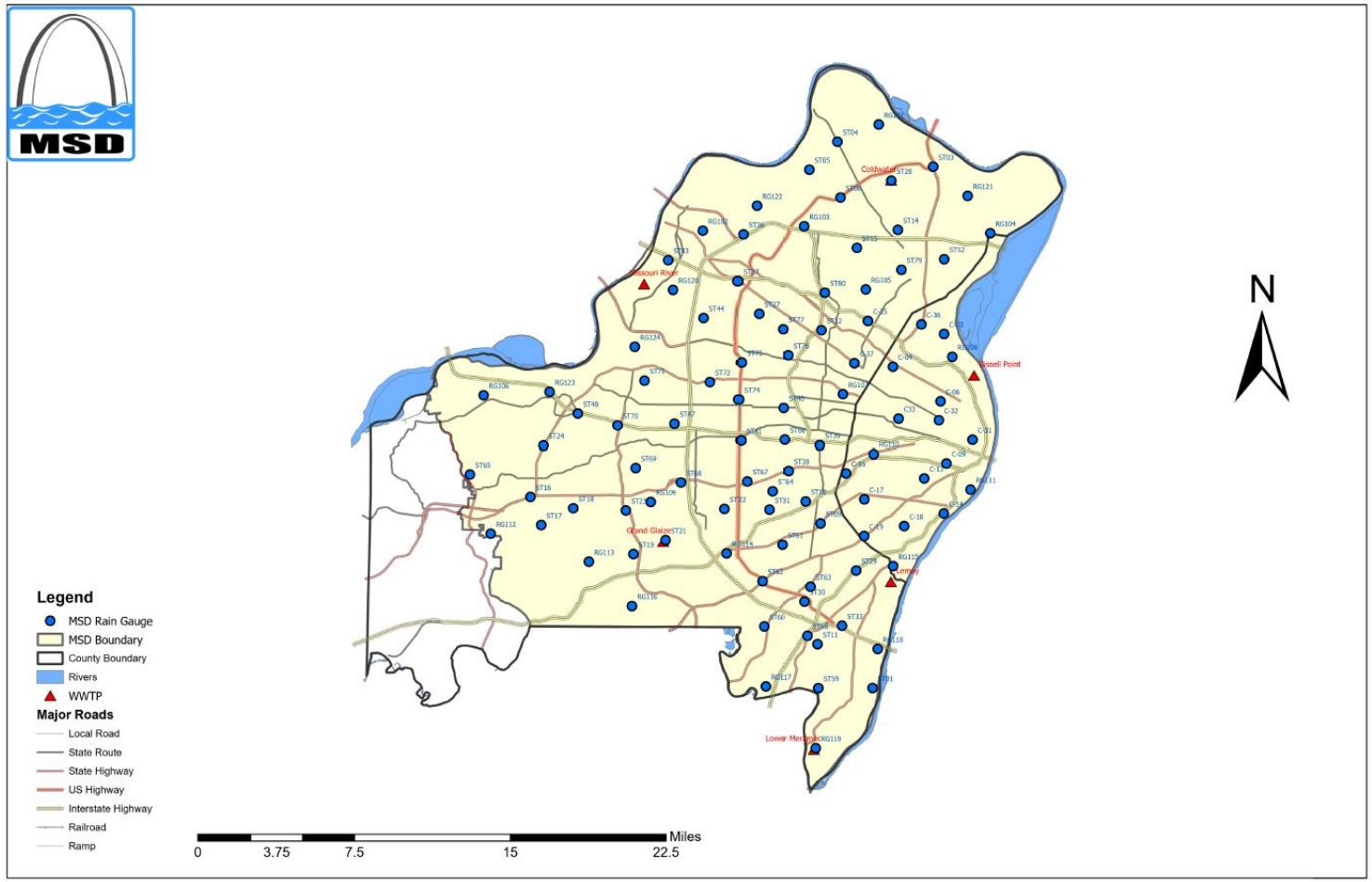
MSD Watersheds

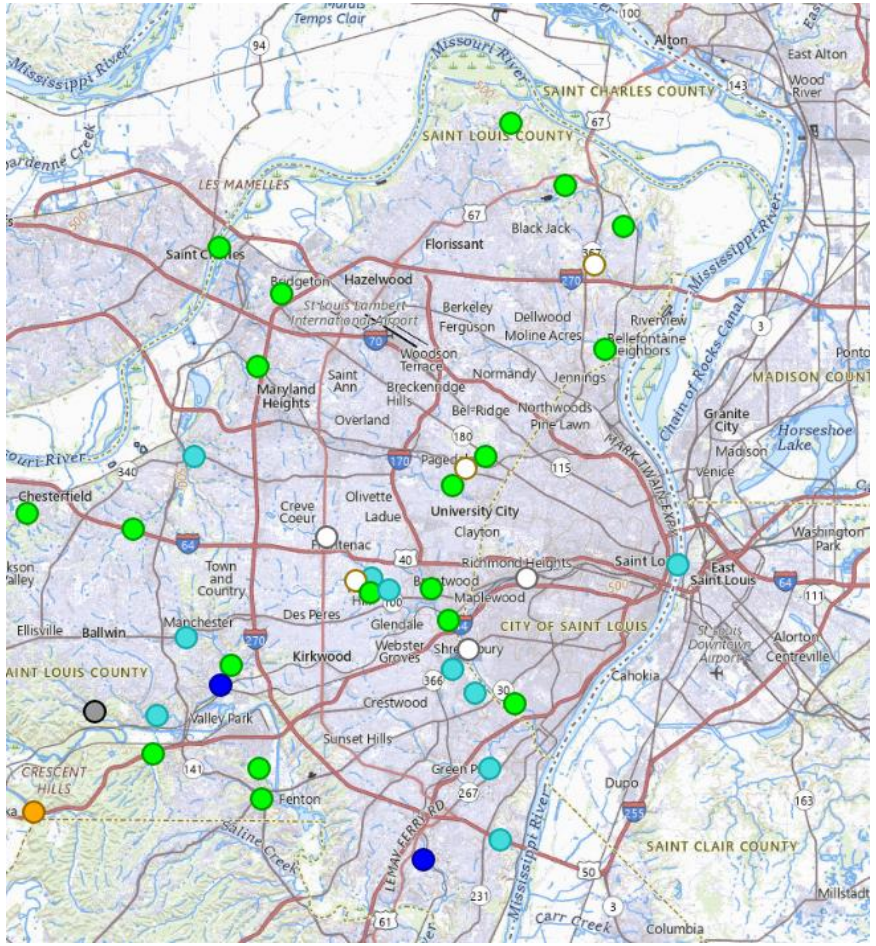


MSD Boundary



Rain Gauge / Stream Gauge Network





Precipitation Patterns for the St. Louis Metro Area

In the last 10 years, we have experienced twenty-eight extreme rainfall events.



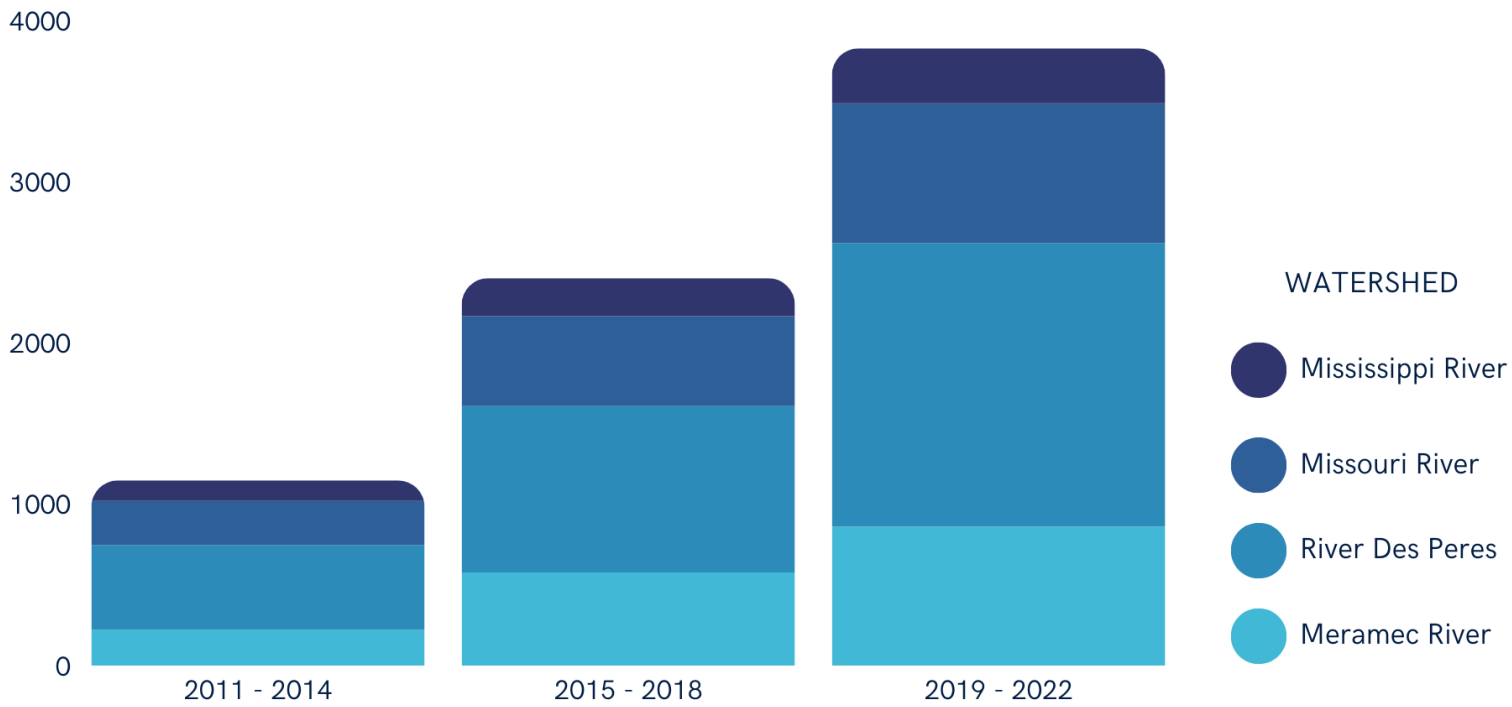
Date	Max Total Rain (in)	Max Recurrence (yr)	Duration (hr)
2022-07-26	10.58	500	6
2022-07-28	3.66	100	2
2022-08-04	7.11	500	6
2023-05-14	6.76	500	2
2023-06-18	4.30	100	2
2023-07-14	3.57	100	0.75
2023-07-29	3.00	100	0.75
2024-05-14	4.46	100	2
2024-07-04	5.22	100	6
2024-07-16	5.19	100	2
2024-11-05	9.74	100	48
2025-05-19	4.01	100	2
2025-07-08	4.89	500	2
2025-08-10	3.85	500	2
2025-08-12	3.35	100	2
2026-07-04	3.07	100	1
2026-07-16	3.14	100	0.75



A Growing Problem

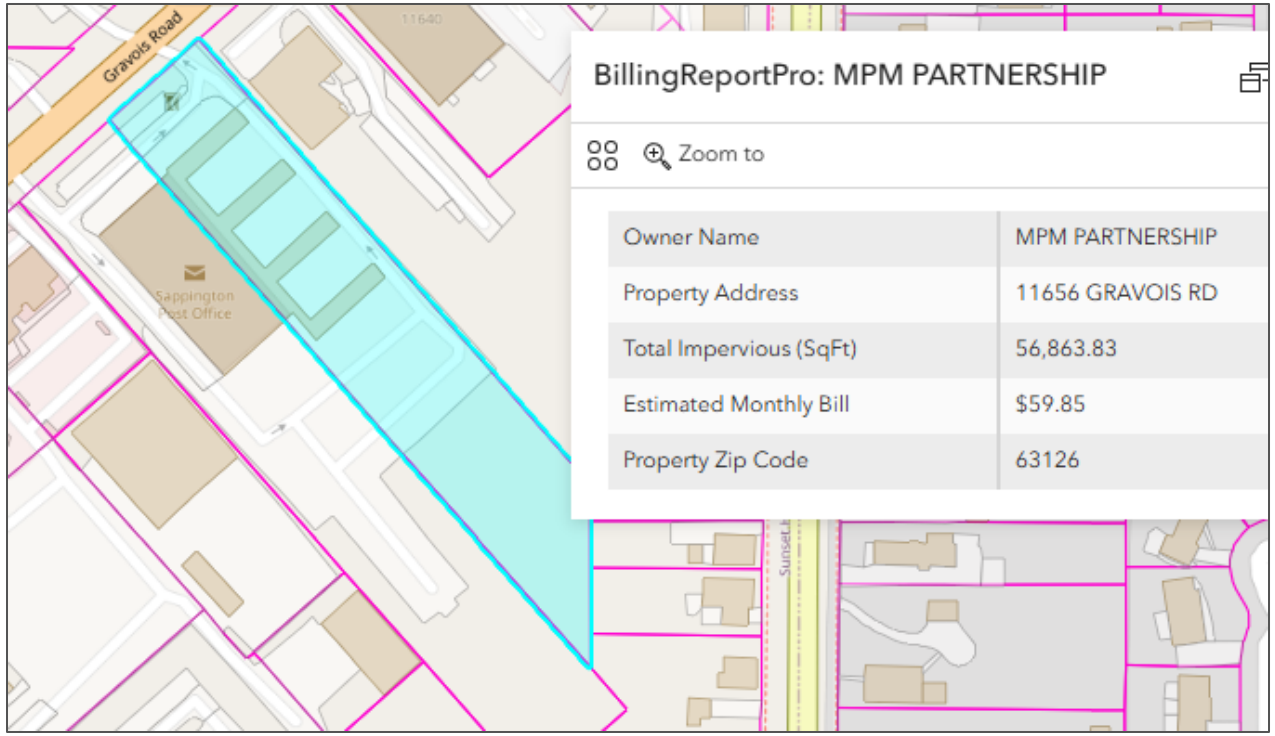
7,377 stormwater problems reported by MSD customers from 2011 - 2022

Stormwater Problems by Major Watershed



Proposition S – Stormwater Improvement Program

- Non-residential customers → Impervious Area
- Residential customers → Property Tax
- Hundreds of flooding/erosion project concepts created over decades from customer complaints, engineering analysis, municipal master plans



Capital Project Prioritization

Scoring Worksheet

MSD Stormwater Projects Prioritization System

ORACLE NO.:

DATE: 10/12/2026

PROJECT NAME:

BY:

PROBLEM STORM EVENT DATES:

PROBLEM STORM EVENT FREQUENCY:

PROBLEM STORM EVENT CALCULATION METHOD:

1.0 STORM SEWER / OVERLAND FLOW

1.1 FLOODING

PROBLEM SOLVED CATEGORY			Chronic (>=50% AEP) Flooding		Frequent (<50%->=6.67% AEP) Flooding		Infrequent (<6.67% AEP) Flooding		Total Points
			Points per Category	No. Lots Affected	Points per Category	No. Lots Affected	Points per Category	No. Lots Affected	
1.1.1	Structure Flooding								
	Habitable 1st floor, residential; (1 lot per structure)								
Address:	**123 Main Street (frequent)**		675		450	1	125	1	575
Address:	**124 Main Street (infrequent)**								
Address:									
	Basement (1 lot per structure)								
Address:	**125 Main Street**		250		200	1	50		200
Address:									
	Industrial, office, commercial and warehouse (1 lot per 2,500 sf of floor space flooded)		500		350		75		
Address:									
Address:									
	Attached Garage (1 lot per structure)								
Address:			120		65		20		
Address:									
	Misc. structures including porches/decks, pools, detached garages, etc. Eligible misc. structures are those that would typically require a building permit to be issued. (1 lot per structure)		80		50		15		
Address:									
Address:									
	Yard Flooding/Ponding (1 per lot)								
Address:			15		8		0		
Address:									
1.1.2	Roadway Flooding (allocate 1 lot per 250' of roadway impacted & 2 lots per intersection impacted)								
	Emergency Access restricted (>12" water over only access route to habitable structure), pts per structure		375		300		50		
Address:									
	Traffic obstruction (> 6" of water) on arterial street		100		75		12		
Location									
	Traffic obstruction (> 6" of water) on collector street		50		30		4		
Location									
	Traffic obstruction (> 6" of water) on residential street		20		12		2		
Location									
1.2	Yard Erosion (1 per lot)		No. Lots:			Points/lot:		5	
Address:									
1.3	Condition of Existing System to be replaced (if condition unknown, assign points based on age: see Pipe Material Design Life table)		Poor >125% of Design Life (30 pts)		Fair 75-125% of Design Life (15 pts)		Good <75% of Design Life (0 pts)		
	Condition:	**Poor**	30						30

2.0 STREAM

2.1 FLOODING

PROBLEM SOLVED CATEGORY		Chronic (>=50% AEP) Flooding		Frequent (<50%->=6.67% AEP) Flooding		Infrequent (<6.67% AEP) Flooding		Total Points
		Points per Category	No. Lots Affected	Points per Category	No. Lots Affected	Points per Category	No. Lots Affected	
2.1.1	Structure Flooding							
	Habitable 1st floor, residential; (1 lot per structure)							
Address:		600		300		50		
Address:								
	Basement (1 lot per structure)							
Address:		200		100		15		
Address:								
	Industrial, office, commercial and warehouse (1 lot per 2,500 sf of floor space flooded)	450		200		50		
Address:								
Address:								
	Attached Garage (1 lot per structure)							
Address:		100		50		8		
Address:								
	Misc. structures including porches/decks, pools, detached garages, etc. Eligible misc. structures are those that would typically require a building permit to be issued. (1 lot per structure)	60		30		6		
Address:								
Address:								

2.2 EROSION

2.2.1	Threatening Structure (Ratio=horizontal distance from top of bank to structure / height of bank)	Pts. for Ratio <1.5	No. Lots	Pts. for Ratio 1.51-3	No. Lots	Pts. for Ratio 3.01-5	No. Lots	
	Habitable structures, residential (1 lot per structure)							
Address:	*123 Main St*	600	0	400	0	100	0	
Address:		600	0	400	0	100	0	
Address:		600	0	400	0	100	0	
Address:		600	0	400	0	100	0	
Address:		600	0	400	0	100	0	
	Misc. structures including porches/decks, pools, detached garages, etc. Eligible misc. structures are those that would typically require a building permit to be issued. (1 lot per structure)							
Address:		100	0	75	0	25	0	
Address:		100	0	75	0	25	0	
Address:		100	0	75	0	25	0	
Address:		100	0	75	0	25	0	
Address:		100	0	75	0	25	0	
	MSD structures including headwalls, pipe outfalls, Sanitary and Storm Manholes, Sanitary Crossings, treatment plants, pump stations, etc. Typically appear on MSD GIS mapping. (1 lot per structure)							
MSD Structure Number		75	0	50	0	15	0	
MSD Structure Number		75	0	50	0	15	0	
MSD Structure Number		75	0	50	0	15	0	
MSD Structure Number		75	0	50	0	15	0	
MSD Structure Number		75	0	50	0	15	0	
	Industrial, office, commercial and warehouse (1 lot per structure)							
Address:		450	0	300	0	75	0	
Address:		450	0	300	0	75	0	
Address:		450	0	300	0	75	0	
Address:		450	0	300	0	75	0	
Address:		450	0	300	0	75	0	

2.2.2	Additional points if erosion has significantly worsened over time. The change must be substantial and obvious.		lots	10 points per lot				
2.2.3	Threatening Roadway (2 lots per intersection impacted)	Pts. for Ratio <1.5	No. Lots	Pts. for Ratio 1.51-3	No. Lots	Pts. for Ratio 3.01-5	No. Lots	
	Arterial Road: (1 lot per 50' of roadway)	150		100		25		
Address:								
	Collector Road: (1 lot per 100' of roadway)	75		50		12		
Address:								
	Residential Road: (1 lot per 250' of roadway)	35		25		6		
Address:								
						TOTAL PROBLEM POINTS =		**1405**

SOLUTION BENEFIT CATEGORY

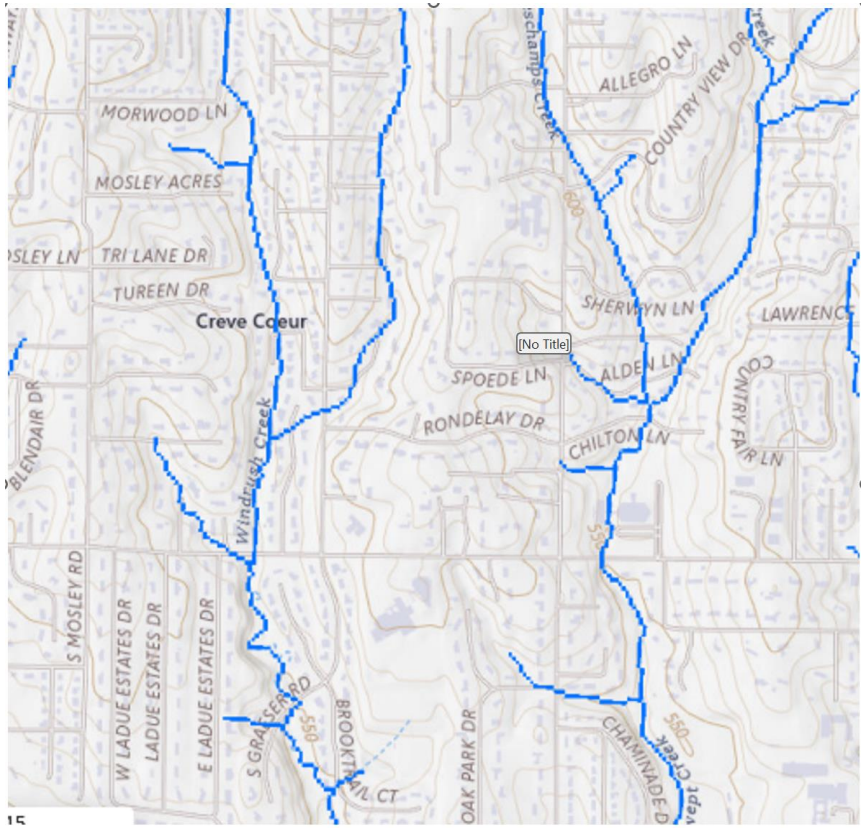
3.1	Regional Detention. If project incorporates regional detention additional points can be awarded	High level of available storage >25 acre-ft		Moderate level of available storage 10-25 acre feet		Low level of available storage 2-10 acre feet		Total points
		4000		2500		1000		
3.2	Partnership Availability - Maximum of 5, 1 per municipality or public agency	Available Partners:		Points per partner:		250		
3.3	Regional detention will reduce stormwater flow to a combined sewer system.	Yes = 200 No = 0						
4.1	Provides Water Quality Benefits or incorporates green infrastructure?	Small = 50 Medium = 125 Large = 200						
4.2	Separates Combined Sewer	> 1000LF of separated		100-1000LF separated		<100LF separated		
		500		250		100		
						TOTAL SOLUTION POINTS =		
						TOTAL BENEFIT POINTS (TOTAL PROBLEM POINTS +TOTAL SOLUTION POINTS) =		**1405**

TOTAL COST IN THOUSANDS (From Cost Worksheet) =

BENEFIT / COST RATIO = TOTAL POINTS / TOTAL COST IN THOUSANDS =

Storm Sewer / Overland Flow vs Stream

- Check National Stream Stats
- Blue Line Stream?
- Evaluate per the correct worksheet
- https://streamstats.usgs.gov/ss/



StreamStats Image of Blueline Streams

Flooding Frequency

- Chronic (≥50% AEP)
- Frequent (<50% AEP to ≤ 6.67% AEP)
- Infrequent (< 6.67% AEP)

- Drainage Area Map
  - 50% AEP (2-year) (20-min)
  - 6.67% AEP (15-year) (20-min)

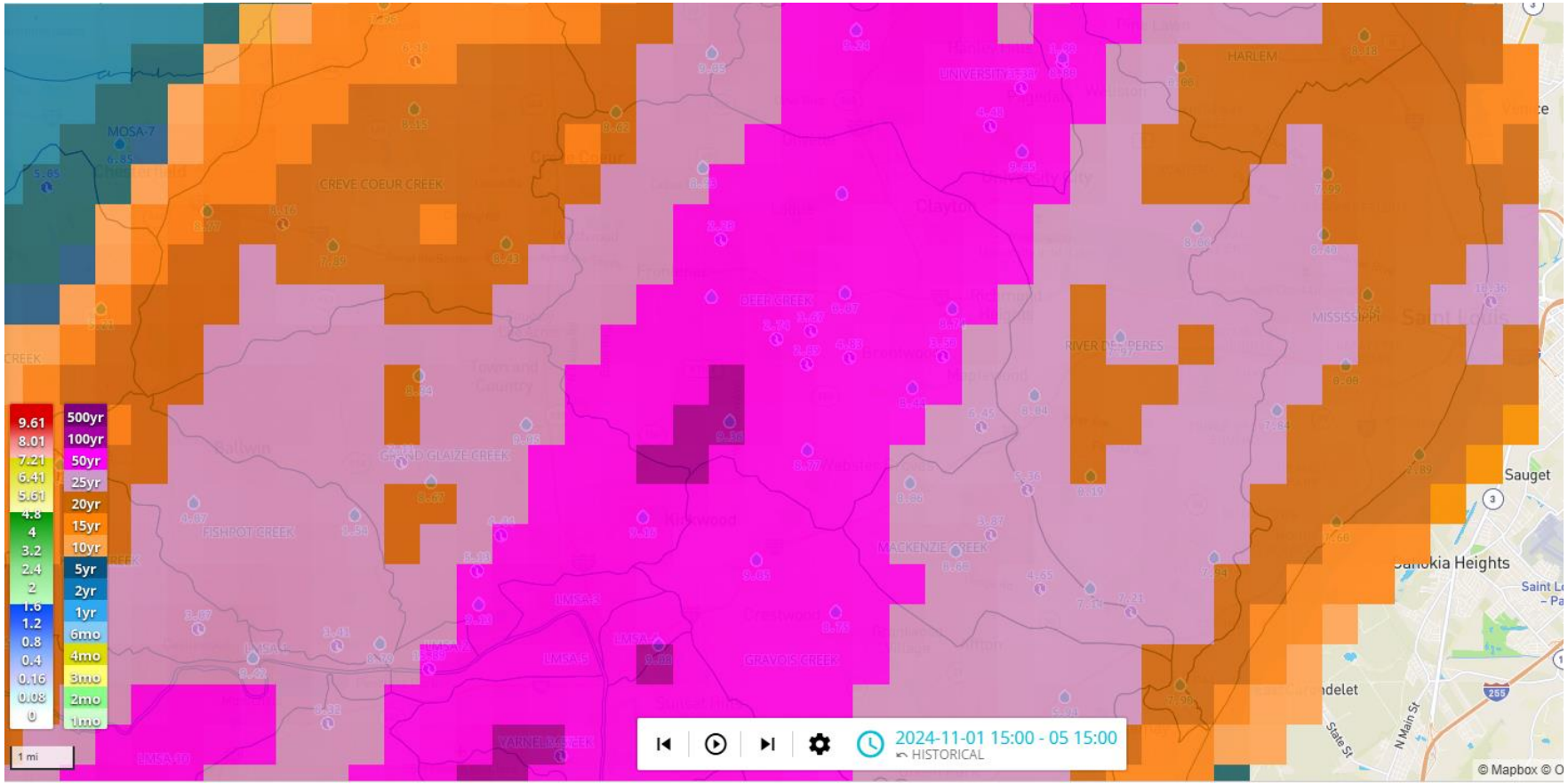






Flooding Frequency

- Gauge Adjusted Radar Rainfall (GARR)



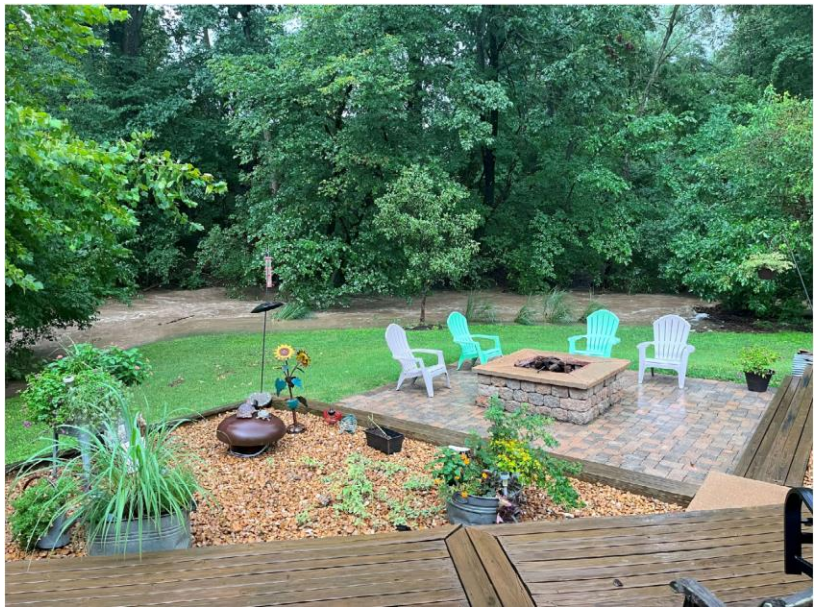
Structure Flooding

- First Floor Flooding
- Basement Flooding
  - Directly connected tuck under garage
- Attached Garage
- Misc. Structures
  - 120 sqft
  - Things that typically need a permit
- Yard Flooding
  - 1.5 acre drainage area for a new storm sewer

- Score worst case condition on a single lot







STORMWATER ISSUE SPECTRUM

LOW → HIGH

NUISANCE DRAINAGE ISSUES

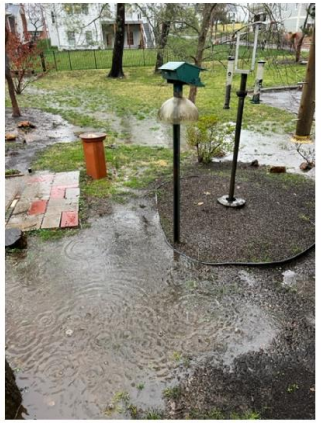






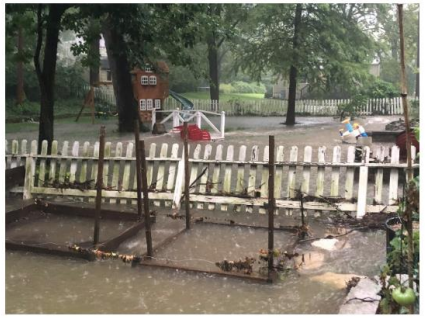
MINOR YARD FLOODING





MAJOR YARD FLOODING







STREET FLOODING







STRUCTURAL FLOODING & FAILURES







Thank you Len Madalon for the image!

Flooding

- Enclosed System/Overland Flow
  - System Improvements
  - Buyouts
- Stream
  - Regional Detention
  - Buyouts and Daylighting



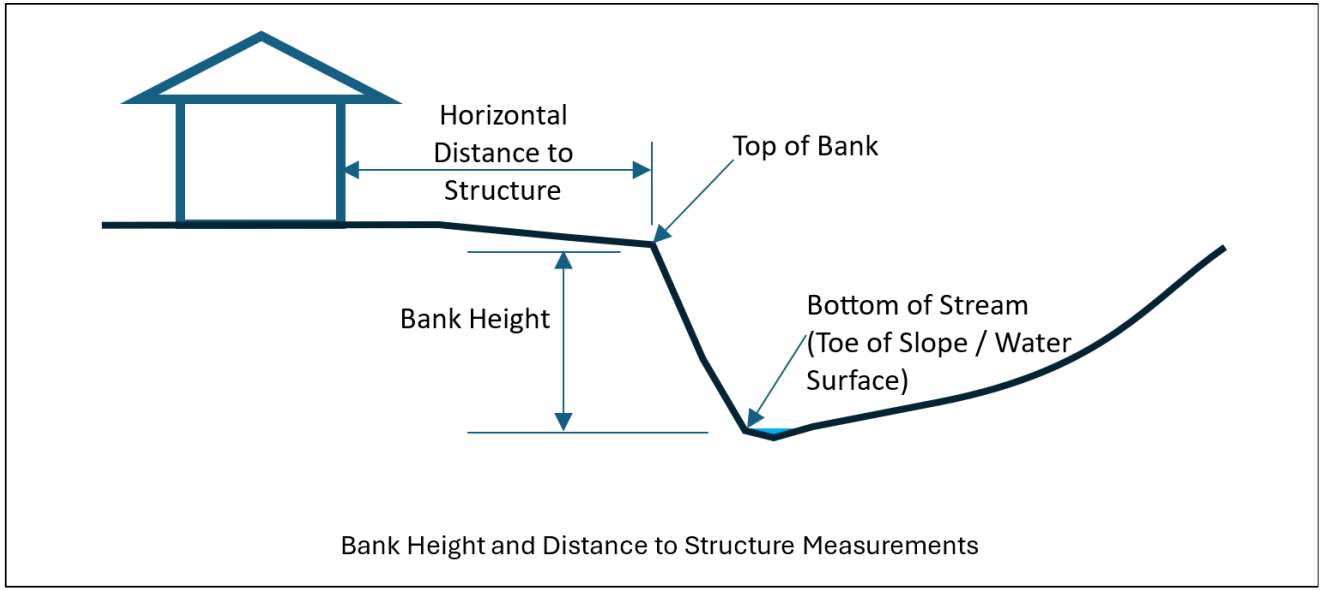
Stream Erosion

- Erosion projects are focused on threatened structures

- Severity Ratio

$$\frac{\text{Horizontal Distance}}{\text{Bank Height}}$$

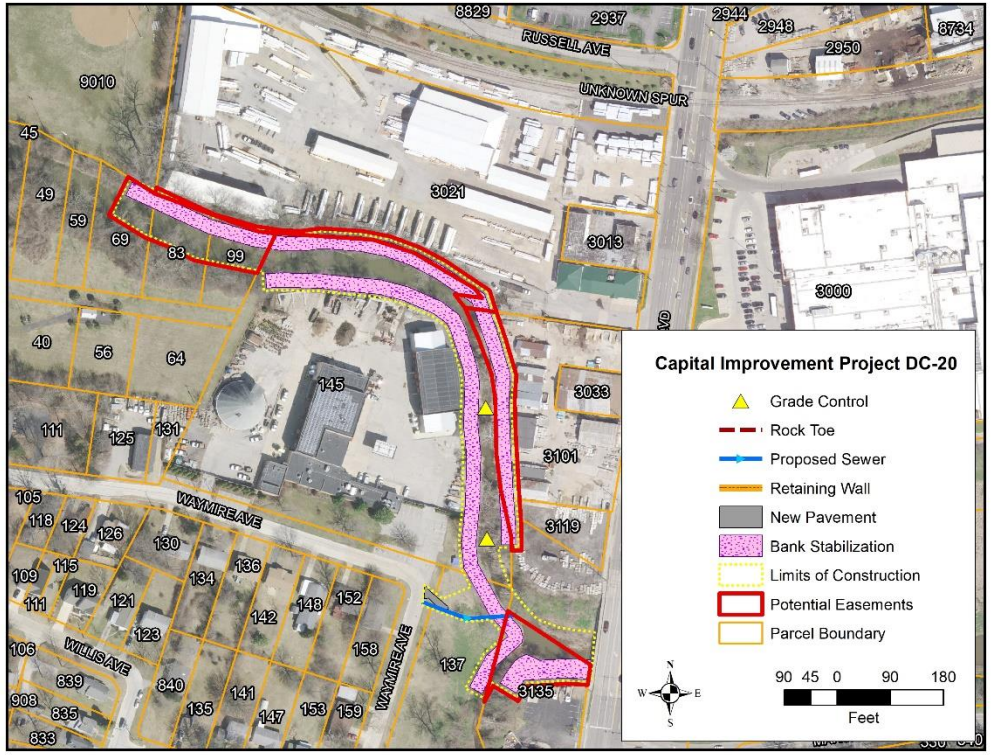
- Severity Ranges
  - <1.5
  - 1.5 to 3
  - >3



Bank Height and Distance to Structure Measurements

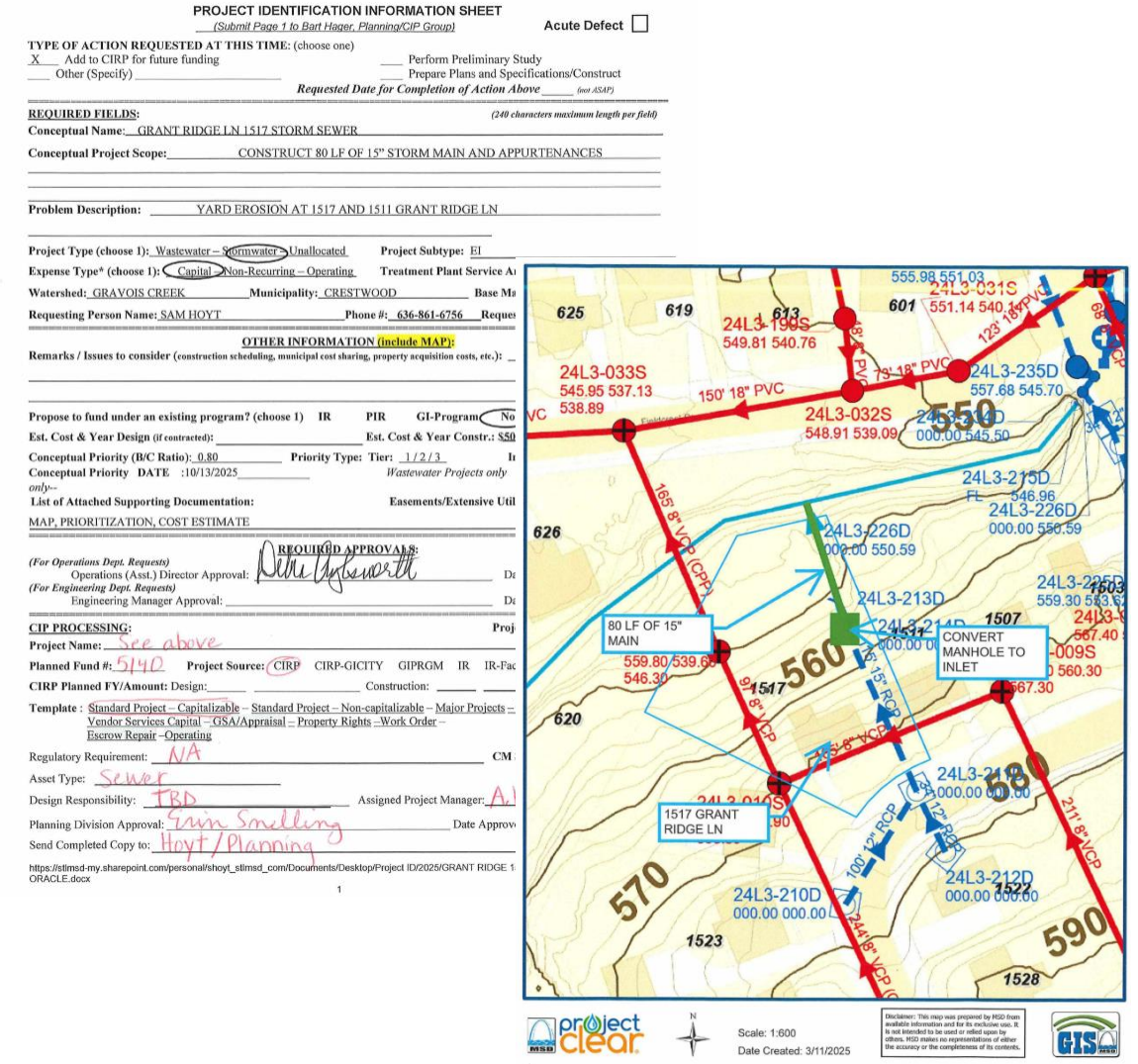
Stream Projects

- Bio-engineered solutions preferred
- Minimize retaining walls and concrete lined channels
- Evaluate both banks as part of site assessment.
- Extend to a stable tie-in



Reevaluation / Rescoring

- 62 Preliminary Studies updated
- 586 conceptual level projects to re-score and prioritize
  - To be completed in 2027
  - Update Prioritization
  - Update Budget Cost



PROJECT IDENTIFICATION INFORMATION SHEET

(Submit Page 1 to Bart Hager, Planning/CIP Group)

Acute Defect ☐

TYPE OF ACTION REQUESTED AT THIS TIME: (choose one)

X Add to CIRP for future funding
___ Other (Specify) _____
___ Perform Preliminary Study
___ Prepare Plans and Specifications/Construct

Requested Date for Completion of Action Above _____ (not ASAP)

REQUIRED FIELDS: *(240 characters maximum length per field)*

Conceptual Name: GRANT RIDGE LN 1517 STORM SEWER

Conceptual Project Scope: CONSTRUCT 80 LF OF 15" STORM MAIN AND APPURTENANCES

Problem Description: YARD EROSION AT 1517 AND 1511 GRANT RIDGE LN

Project Type (choose 1): Wastewater – Stormwater – Unallocated **Project Subtype:** FI

Expense Type* (choose 1): Capital Non-Recurring – Operating **Treatment Plant Service Ar**

Watershed: GRAVOIS CREEK **Municipality:** CRESTWOOD **Base Ma**

Requesting Person Name: SAM HOYT **Phone #:** 636-861-6756 **Reques**

OTHER INFORMATION (include MAP):

Remarks / Issues to consider (construction scheduling, municipal cost sharing, property acquisition costs, etc.):

Propose to fund under an existing program? (choose 1) IR PIR GI-Program No

Est. Cost & Year Design (if contracted): **Est. Cost & Year Constr.:** $50

Conceptual Priority (B/C Ratio): 0.80 **Priority Type:** **Tier:** 1/2/3 **I**

Conceptual Priority DATE :10/13/2025 *Wastewater Projects only*

only--

List of Attached Supporting Documentation: **Easements/Extensive Util**

MAP, PRIORITIZATION, COST ESTIMATE

REQUIRED APPROVALS:

(For Operations Dept. Requests)
Operations (Asst.) Director Approval: Debbie Lykins-Wortell **D**

(For Engineering Dept. Requests)
Engineering Manager Approval: _____ **D**

CIP PROCESSING: **Proj**

Project Name: See above

Planned Fund #: 5140 **Project Source:** CIRP CIRP-GICITY GIPRGM IR IR-Fac

CIRP Planned FY/Amount: Design: _____ Construction: _____

Template : Standard Project – Capitalizable – Standard Project – Non-capitalizable – Major Projects – Vendor Services Capital – GSA/Appraisal – Property Rights –Work Order – Escrow Repair –Operating

Regulatory Requirement: NA **CM**

Asset Type: Sewer

Design Responsibility: TBD Assigned Project Manager: A

Planning Division Approval: Erin Smelling Date Approv

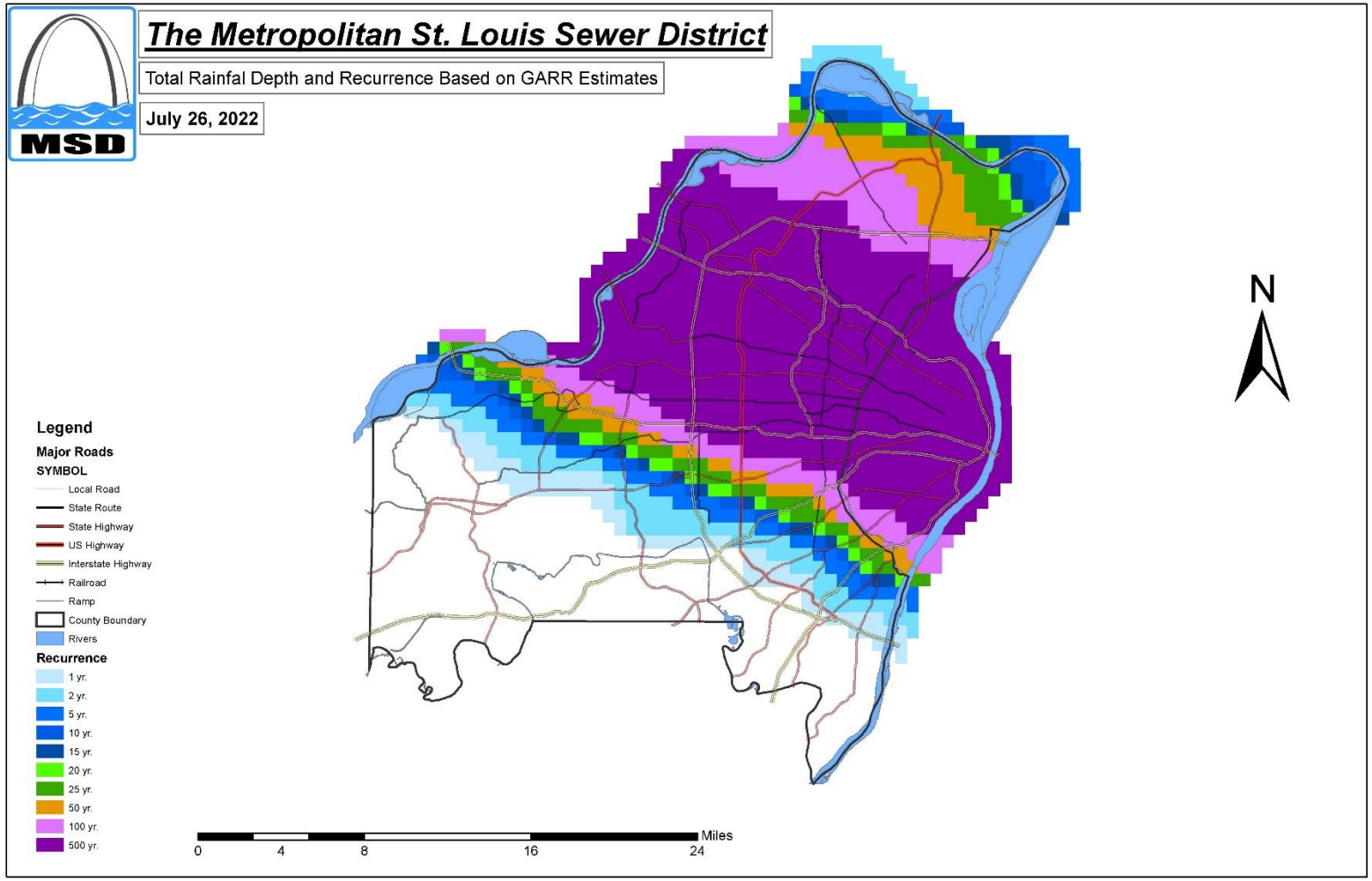
Send Completed Copy to: Hoyt/Planning

https://stlmsd-my.sharepoint.com/personal/shoyt_stlmsd_com/Documents/Desktop/Project ID/2025/GRANT RIDGE 1 ORACLE.docx

1

Stormwater Resilience Plan

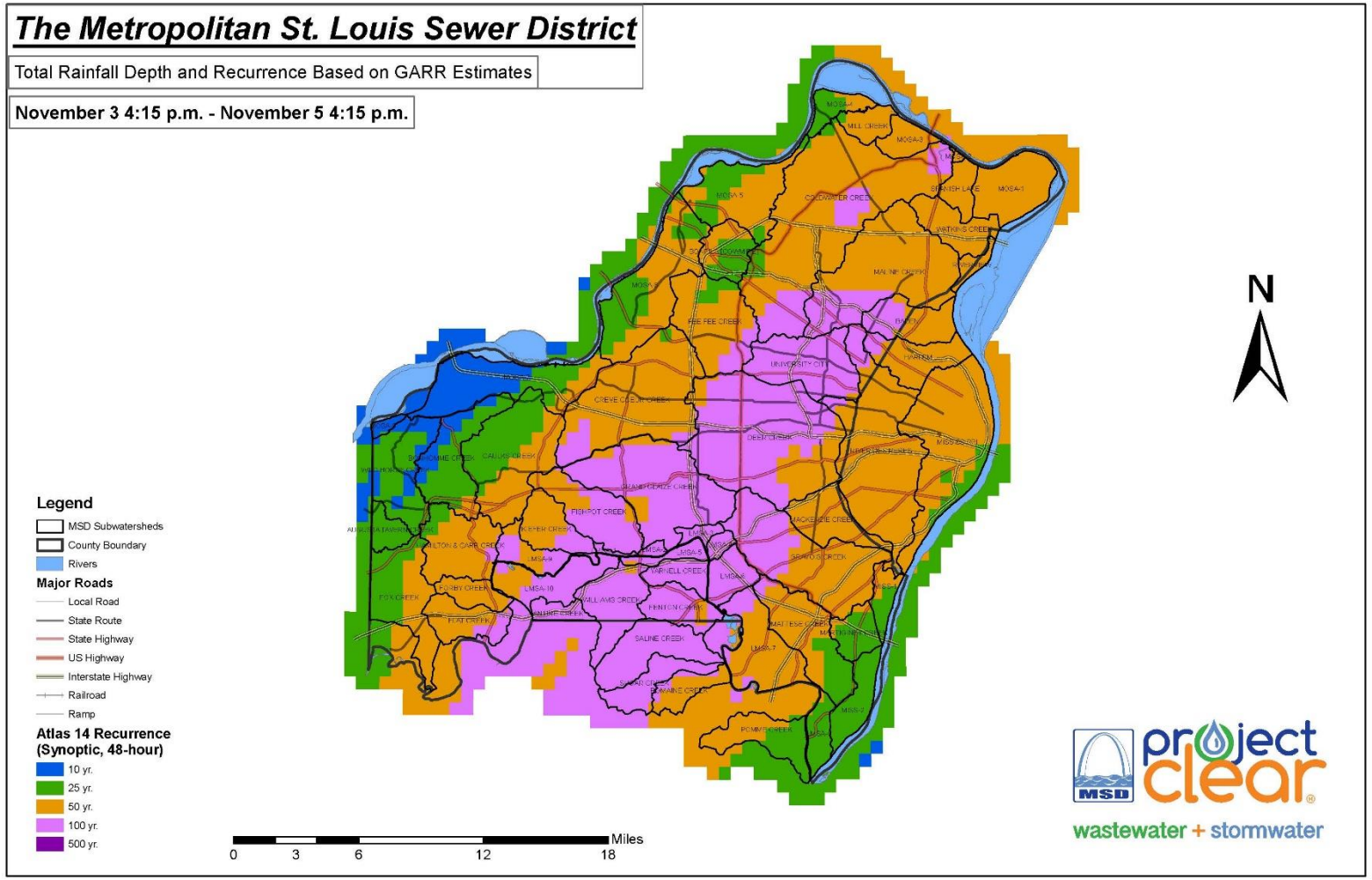
Intense Flash Flooding

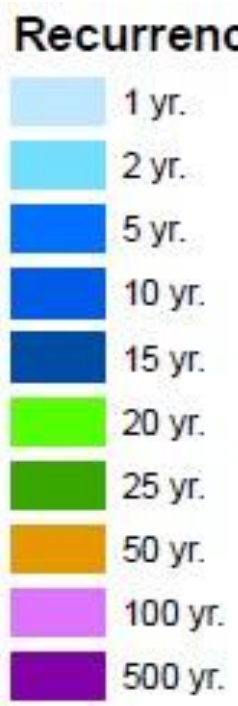


Recurrence

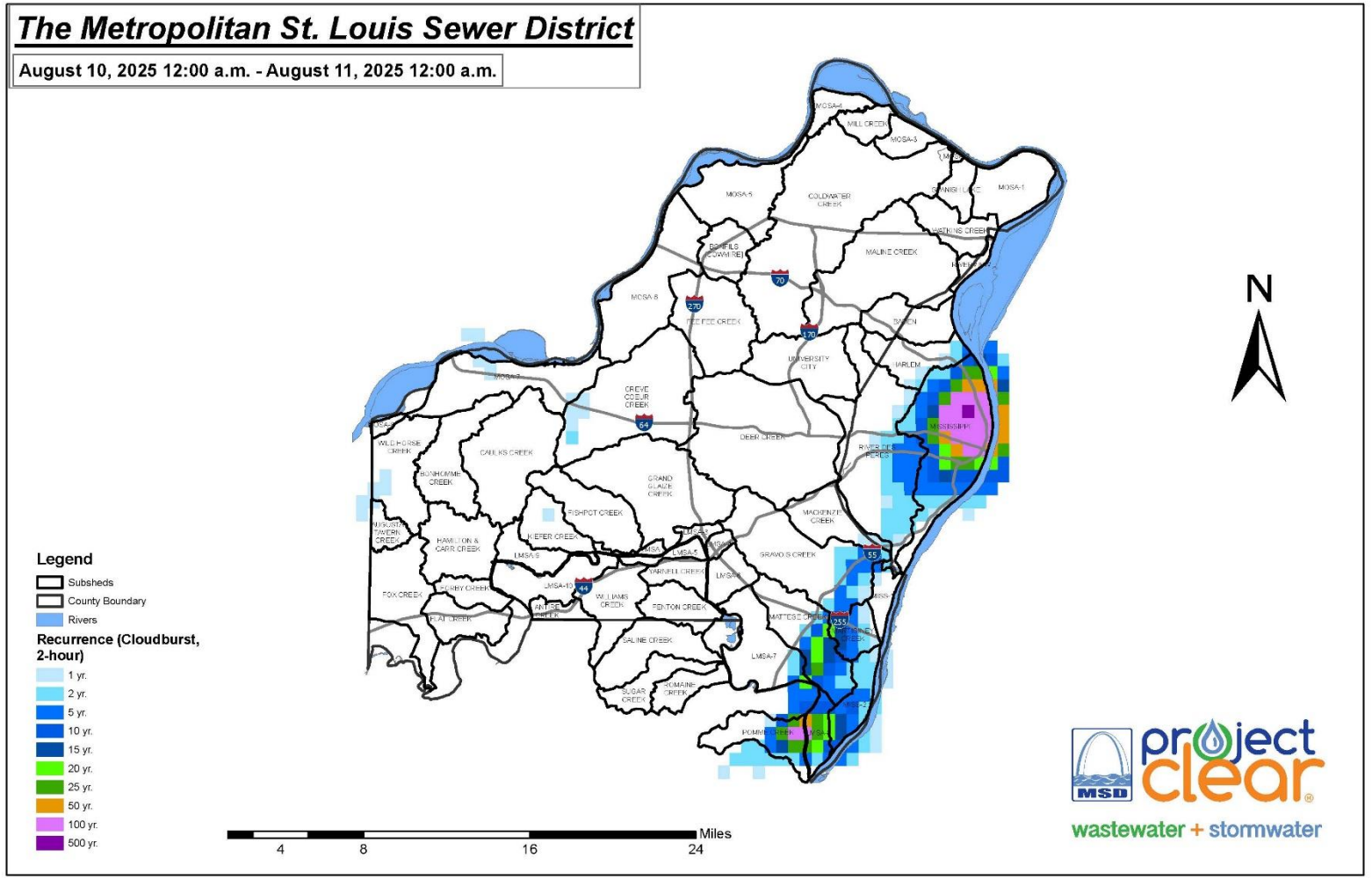
- 1 yr.
- 2 yr.
- 5 yr.
- 10 yr.
- 15 yr.
- 20 yr.
- 25 yr.
- 50 yr.
- 100 yr.
- 500 yr.

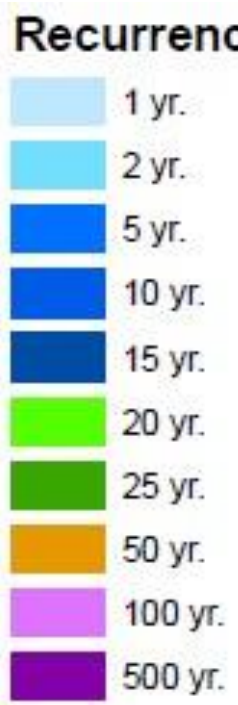
Long Duration Storms





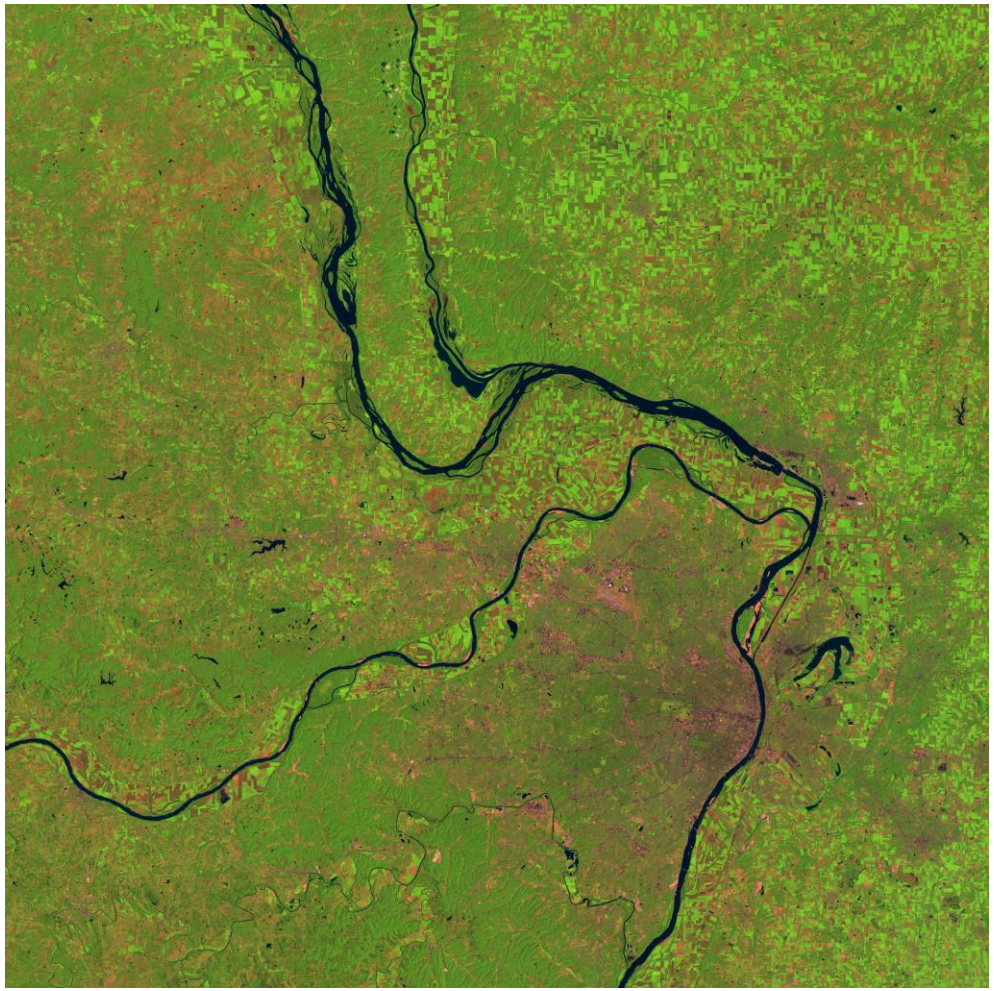
Hyper Local Storms





Riverine Flooding

Pre-Flood



1993 Peak



Scientific Visualization Studio



Why a Stormwater Resilience Strategy?

- Districtwide Stormwater Funding Approved by Voters in April 2024
- Changing Weather
- Increasing Customer Service Requests

Resilience Strategy Evaluation Process

System Components

- Collection Systems
- Facilities
- MSD Employees
- Extended Workforce
- MSD Customers

Stormwater Exclusive System Components

- Basins
- Channels and Walls

Resilience Strategy Evaluation Process

Climate and Infrastructure Shocks and Stressors

Climate Shocks and Stressors	Shock or Stressor
Channel Erosion	Climate Stressor
Convective Storms (Strong Winds and Hail)	Climate Shock
Drought	Climate Stressor
Earthquake	Climate Shock
Excessive and Sequential Rainfall Events	Climate Stressor
Extreme Cold	Climate Shock
Extreme Heat	Climate Stressor
Extreme Rainfall Events	Climate Shock
High Groundwater Levels	Climate Stressor
Local Flooding	Climate Shock
Riverine Flooding	Climate Shock
Tornados	Climate Shock
Wildfire	Climate Shock

Infrastructure Shocks and Stressors	Shock or Stressor
Aging Infrastructure	Infrastructure Stressor
Private, State, Local Stormwater Systems	Infrastructure Stressor
Staffing Challenges	Infrastructure Stressor
Supply Chain	Infrastructure Stressor
Utilities	Infrastructure Shock

Resilience Strategy Evaluation Process

Vulnerability Assessment

Vulnerability Score - Each system component is evaluated against each shock and stressor



- **Exposure – YES / NO**
- **Sensitivity – High / Moderate / Low**

Resilience Strategy Evaluation Process

Risk Assessment

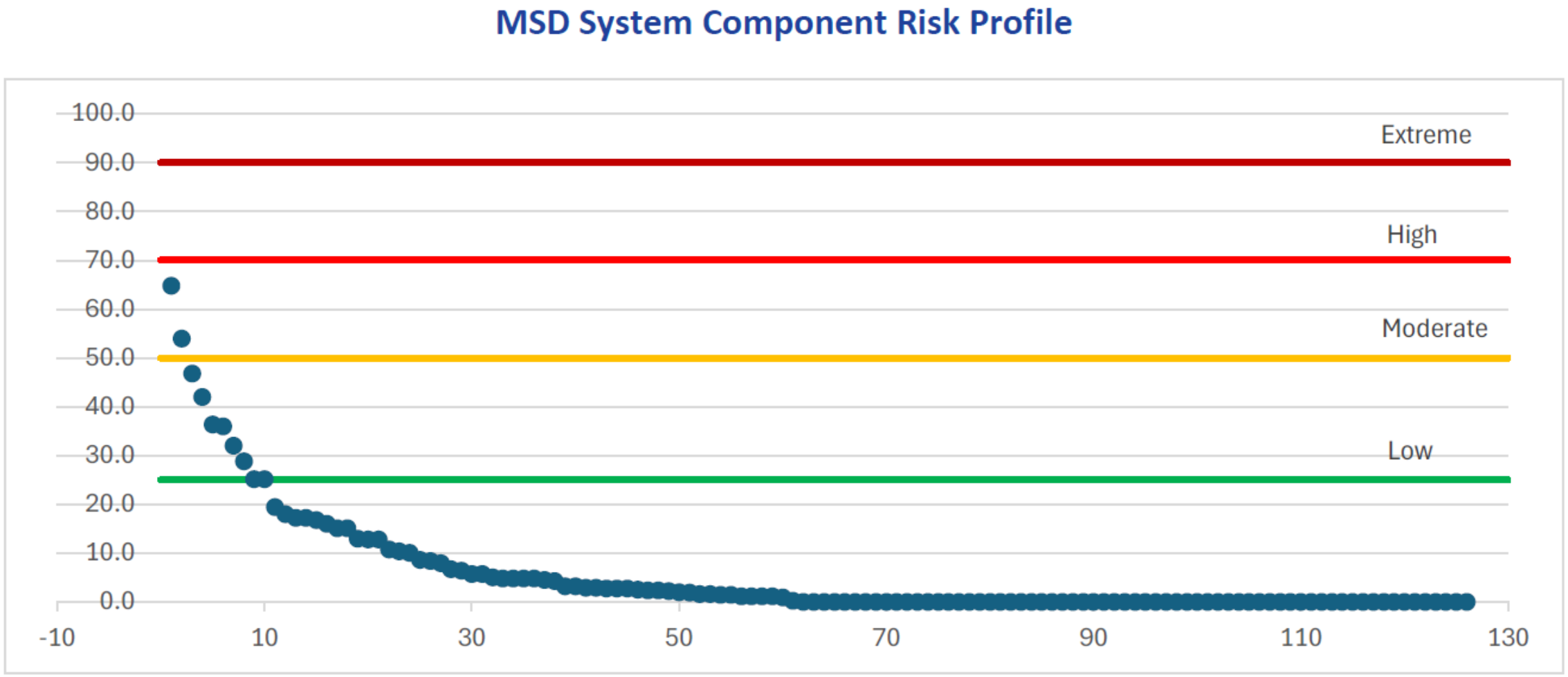
Risk Score - Builds on the vulnerability score and defines the impact and probability of each shock and stressor on each component



- **Consequence – Quantifies the Impact in 5 Categories**
- **Likelihood – High / Very / Moderate / Low / Very Low**

Resilience Strategy Evaluation Process

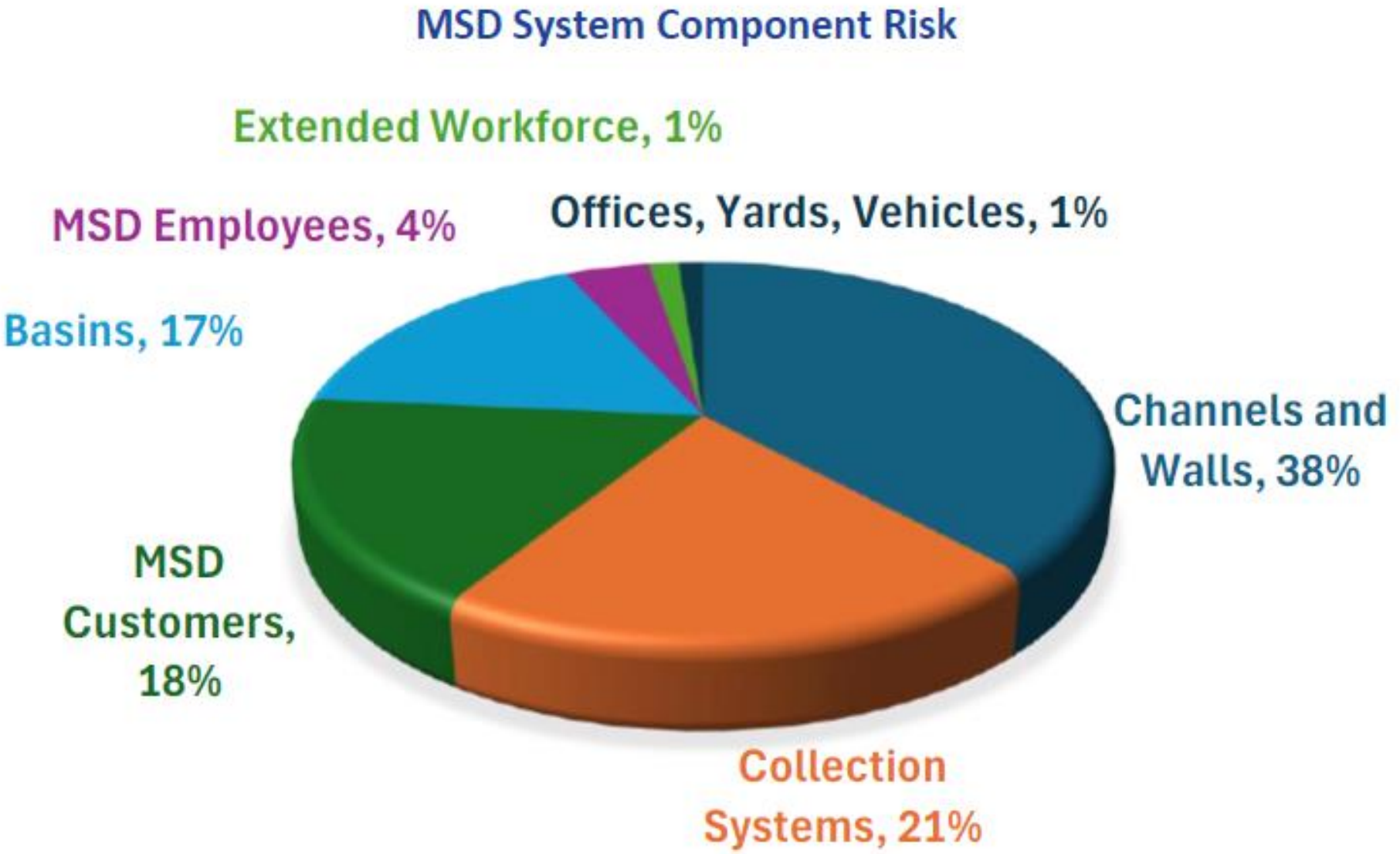
Stormwater Risk Assessment Results



● = *component shock or stressor pair*

Resilience Strategy Evaluation Process

Stormwater Risk Assessment Results

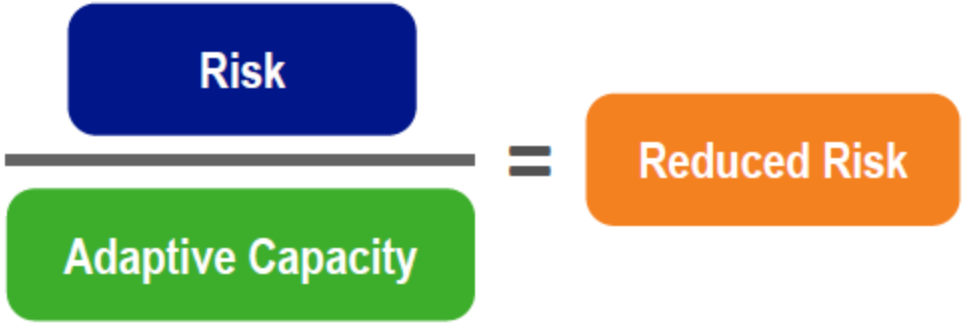


Shock / Stressors	Total Risk
Excessive & Sequential Rainfall Events	18%
Extreme Rainfall Events	17%
Local Flooding	16%
Channel Erosion	15%
Riverine Flooding	10%
Top 5 Total	76%

Resilience Strategy Evaluation Process

Adaptive Capacity

Reduced Risk – When system components become more resilient through adaption



Adaptive Capacity – Fully / Partially / Not

Potential Risk Reduction Through Adaptive Capacity

Component	Potential Risk Reduction
Channels and Walls	-79%
Collection Systems	-78%
MSD Customers	-75%
Basins	-78%
MSD Employees	-77%
Extended Workforce	-78%
Offices, Yards, Vehicles	-70%

Strategy Implementation and Next Steps

Stormwater Resilience Strategy

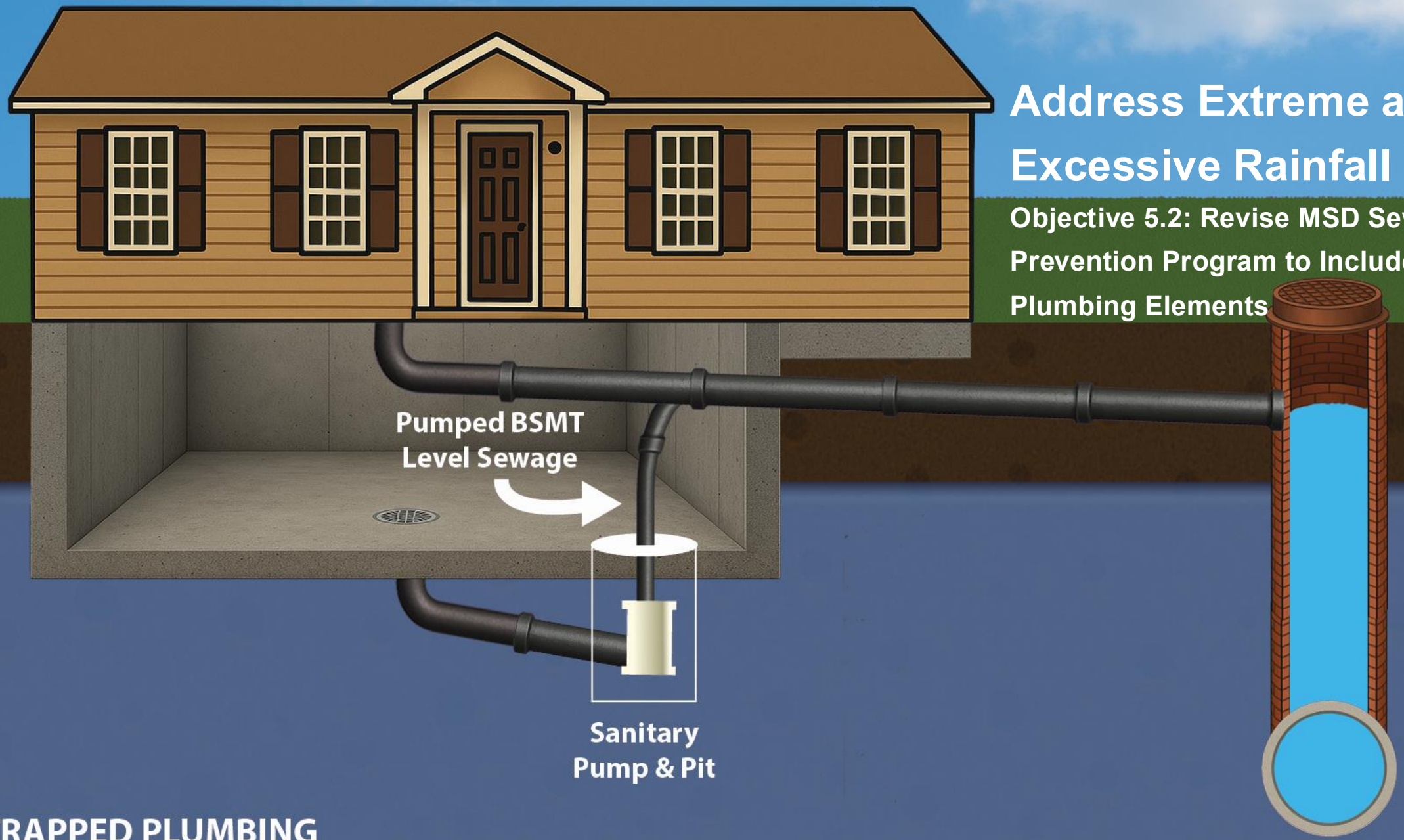
MSD Strategic Business and Operating Plan

- **Objective 5.3: Revise MSD Rules and Regulations for Climate Adaptation Strategies, including Strapped Plumbing**
- **Objective 5.4: Develop Flood-prone Property Buyout Program**

Rules & Regulations Update

Address Extreme and Excessive Rainfall

Objective 5.2: Revise MSD Sewer Backup Prevention Program to Include Strapped Plumbing Elements



Rules & Regulations Updates

- Stormwater Quantity Management BMPs for ANY Development in combined sewer area which increases runoff
- Design rainfall depths increased
- Encouraging prairie planting as preferred basin vegetation



project clear
wastewater + stormwater

Original Turf



Year 0: turf killed, prairie planted



MSD project clear
wastewater + stormwater

Year 1: prairie emerging



Year 2: prairie developing



Year 3: prairie established



MSD project clear
wastewater + stormwater
INTUITION & LOGIC

Thank you!

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