Reducing the Impacts of Extreme Precipitation Using Green Infrastructure: What's the Cost? An Economic Assessment

Hilarie Sorensen
University of Minnesota Sea Grant

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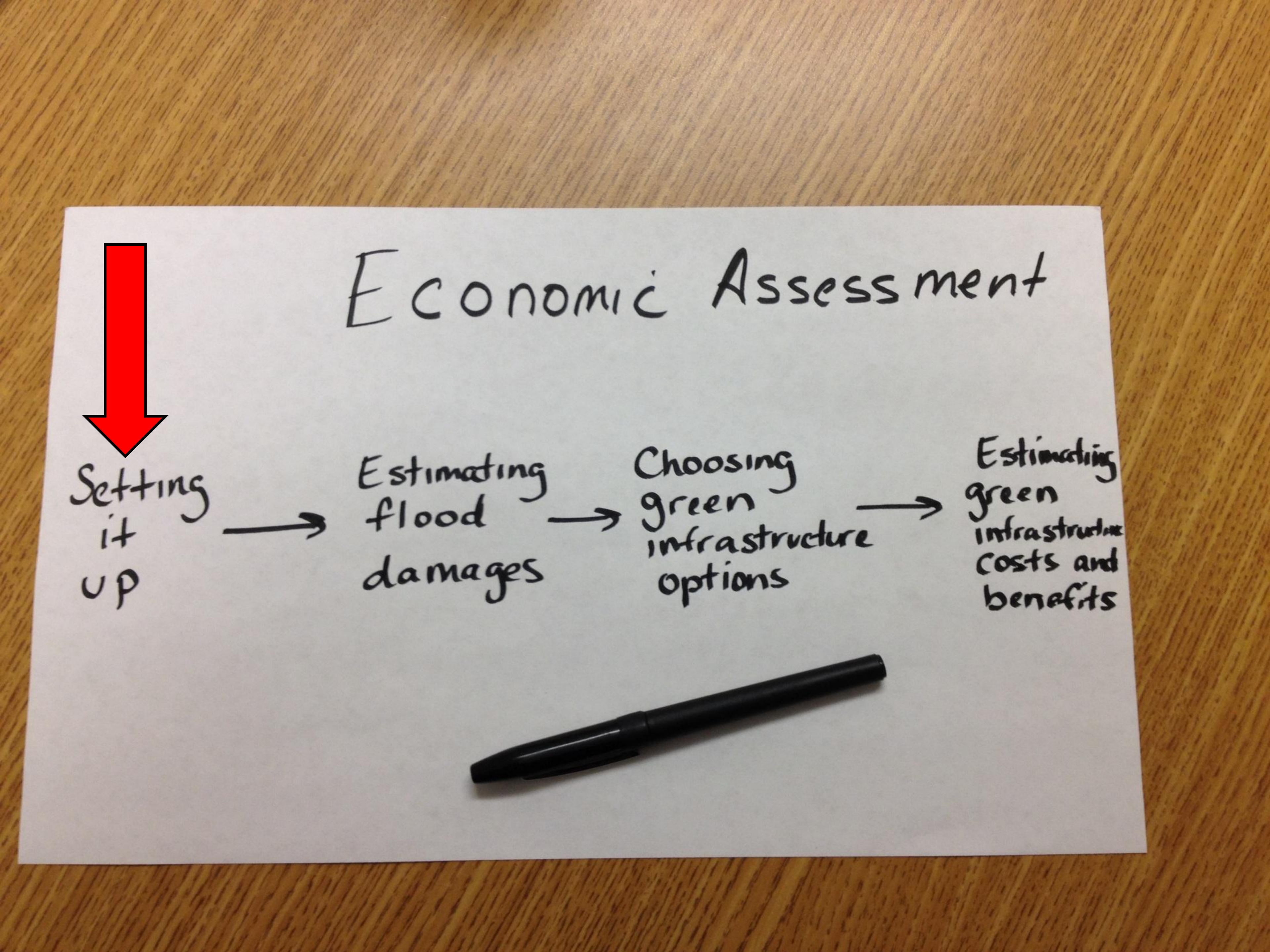

Economic Assessment
Setting it up
Estimating flood damages
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Minnesota: 7 Floods in 7 Years

Slide Courtesy: James Fallon,
USGS MN Water Science Center

2007 Late Summer SE MN record 15-inch rain

2008 June MN+IA Cedar River

2009 Spring Snowmelt Red River Basin

2010 Spring Snowmelt Red and MN Rivers

2010 Fall Southern MN 6-10 inches rain

2011 Spring Statewide

2012 June NE MN 6-10 inches rain

June 2012 Flood Event

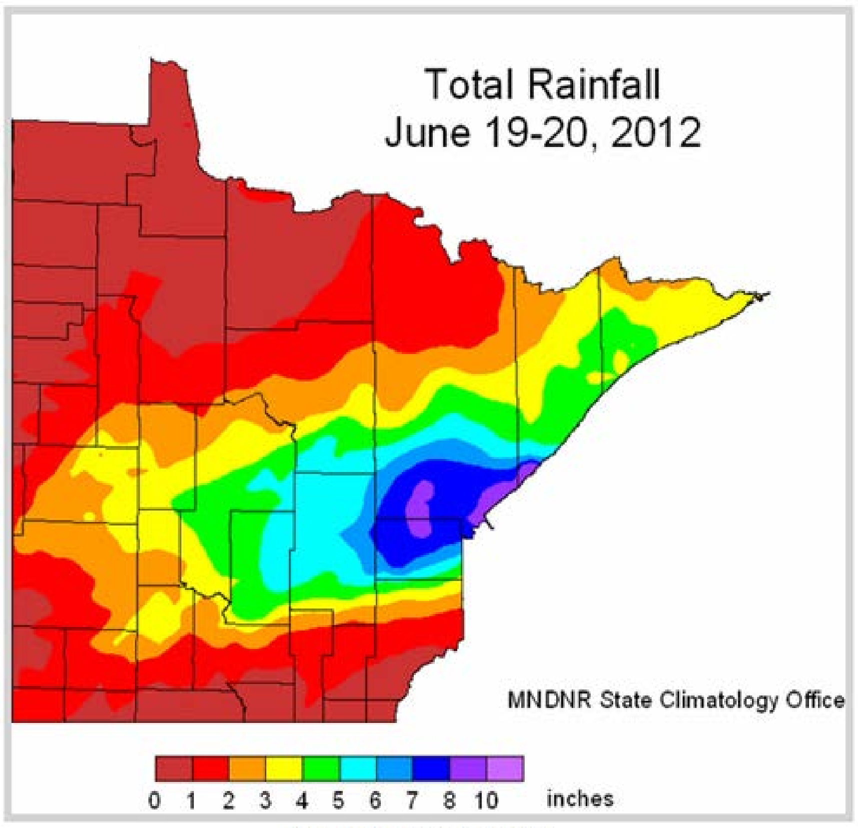
Preceded by very wet May (one of wettest on record)

6-10 inches of rainfall June 19-20

Severe flash flooding region-wide

Record river flooding for ~2 Weeks

Estimated $80-100 million damages



Precipitation for June 19-20
Blend of radar-based and ground-based data

Hydrographs show differing stream responses

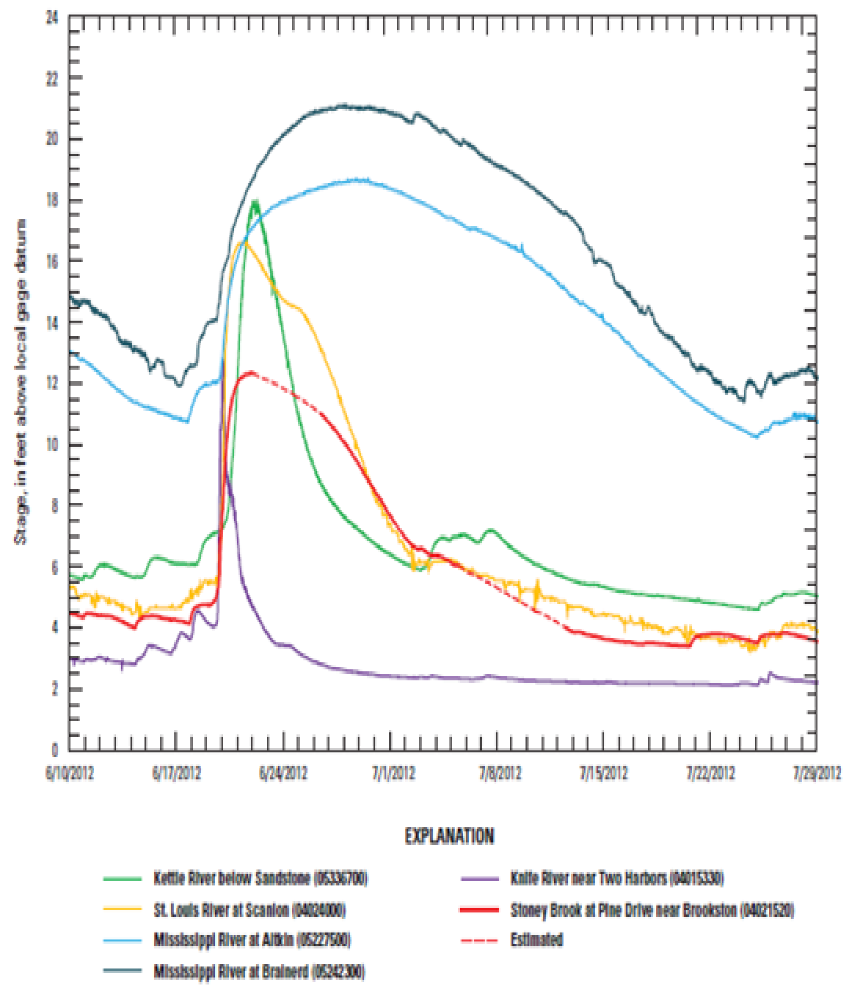


Figure 5. Provisional stage hydrographs at selected U.S. Geological Survey streamgages in northeastern Minnesota for June 10 through July 29, 2012.

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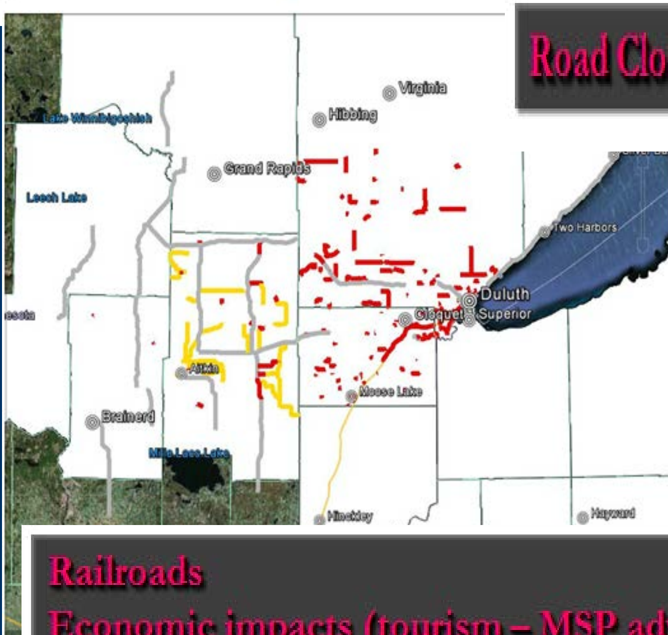
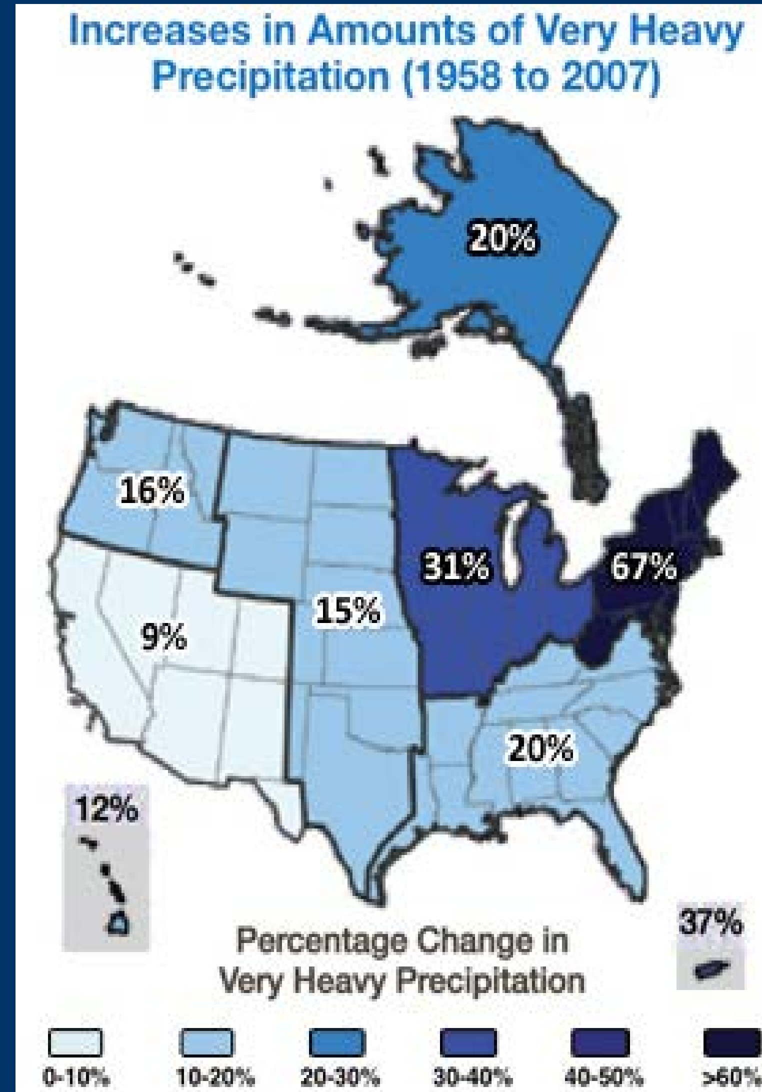
Counties Declared Presidential Disaster Areas by FEMA



Road Closures Due to Flooding



Railroads
Economic impacts (tourism – MSP advertising, etc)
Recovery time/cost – debris removal

Percent increases in the amount falling in the heaviest 1 percent of all daily events, 1958 to 2007. Credit: Updated from Groisman et al. 2005. J. Climate.

Stormwater Challenges

- Large
- Old

- Grade
- Soils C & D
- Bedrock

Slide Courtesy: Chris Kleist, City of Duluth

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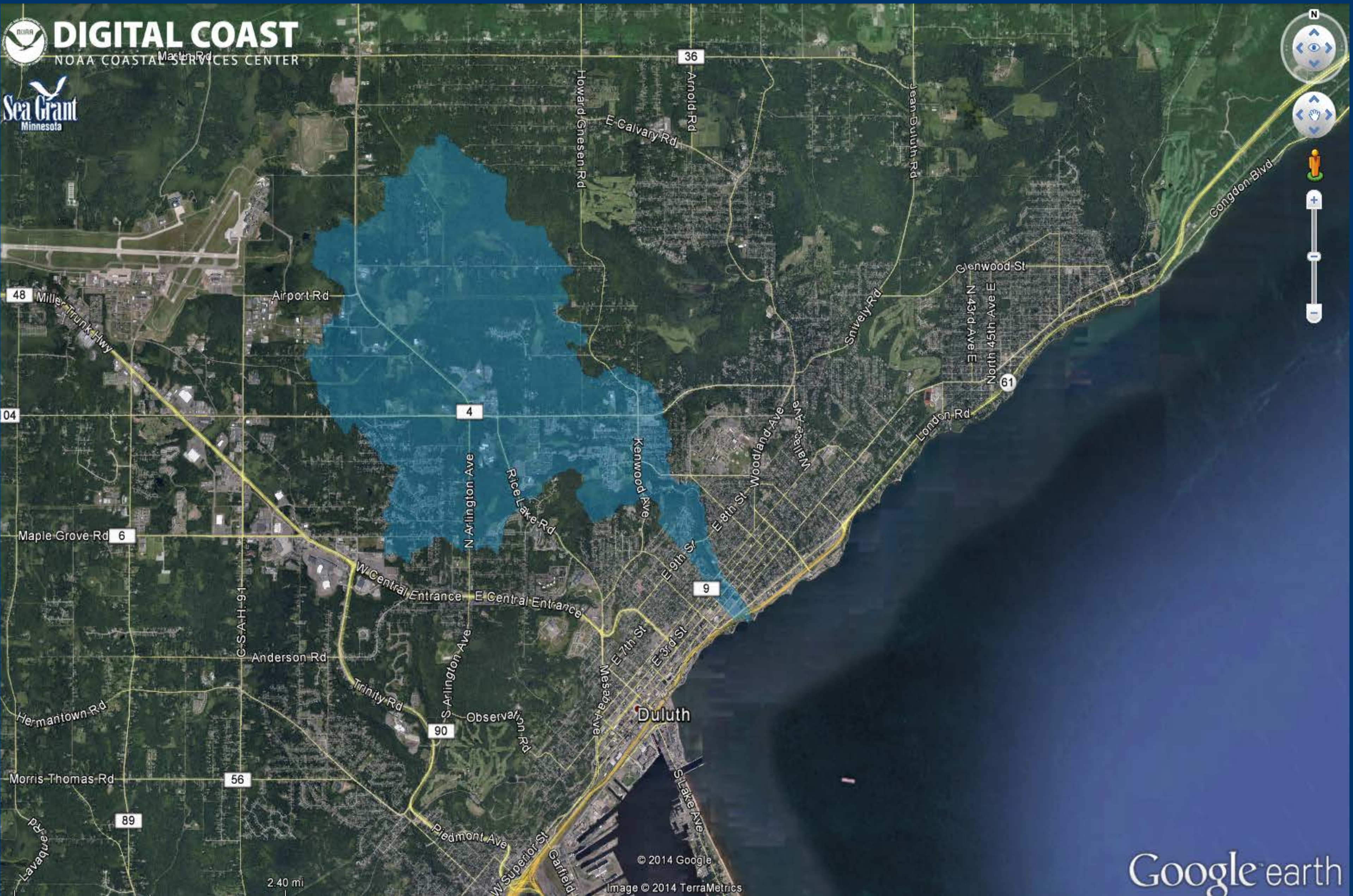
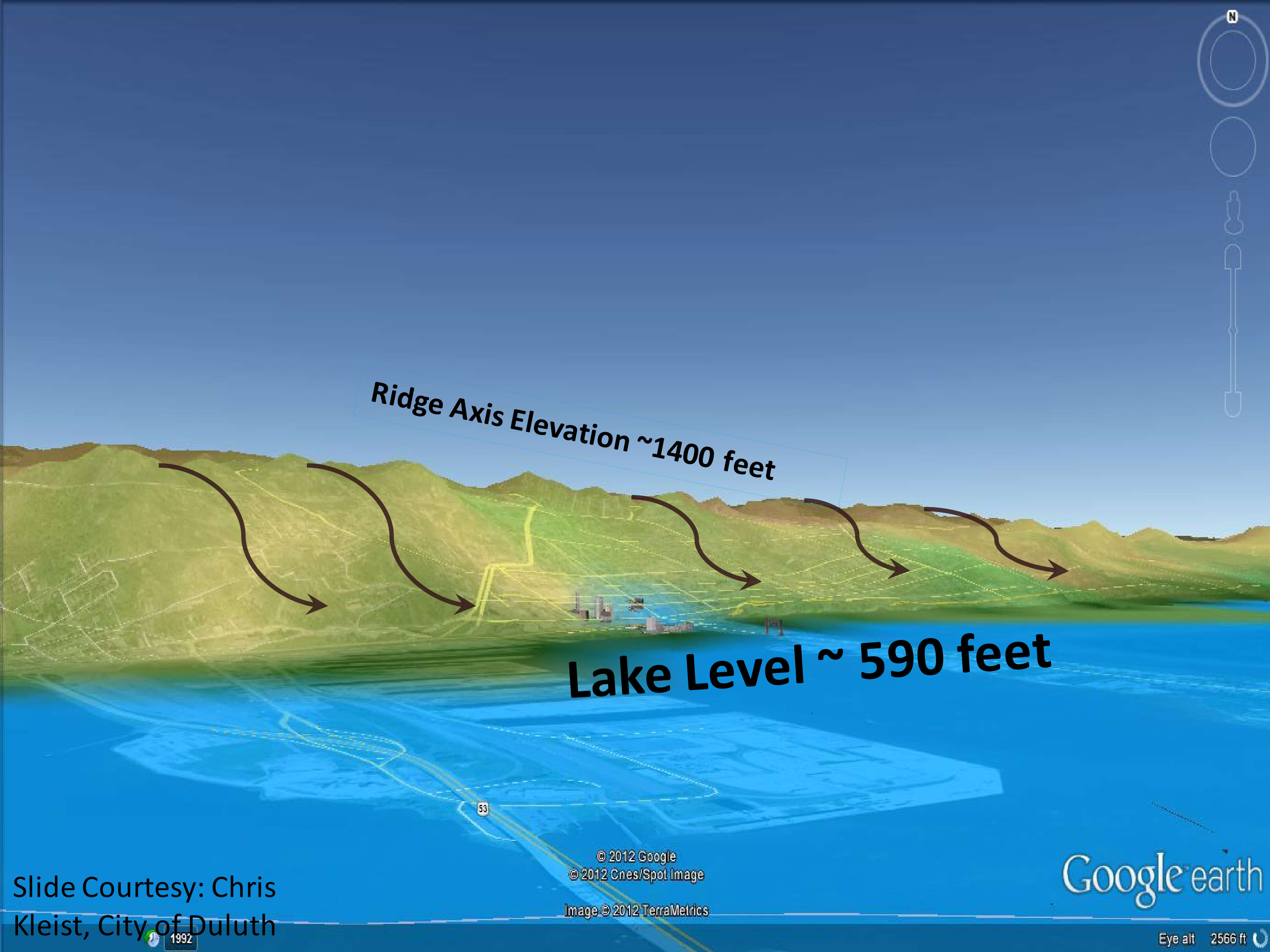
Reducing Future Damage

- Larger culverts
- Wood and vegetation
- Green Infrastructure

Slide Courtesy: Chris Kleist, City of Duluth

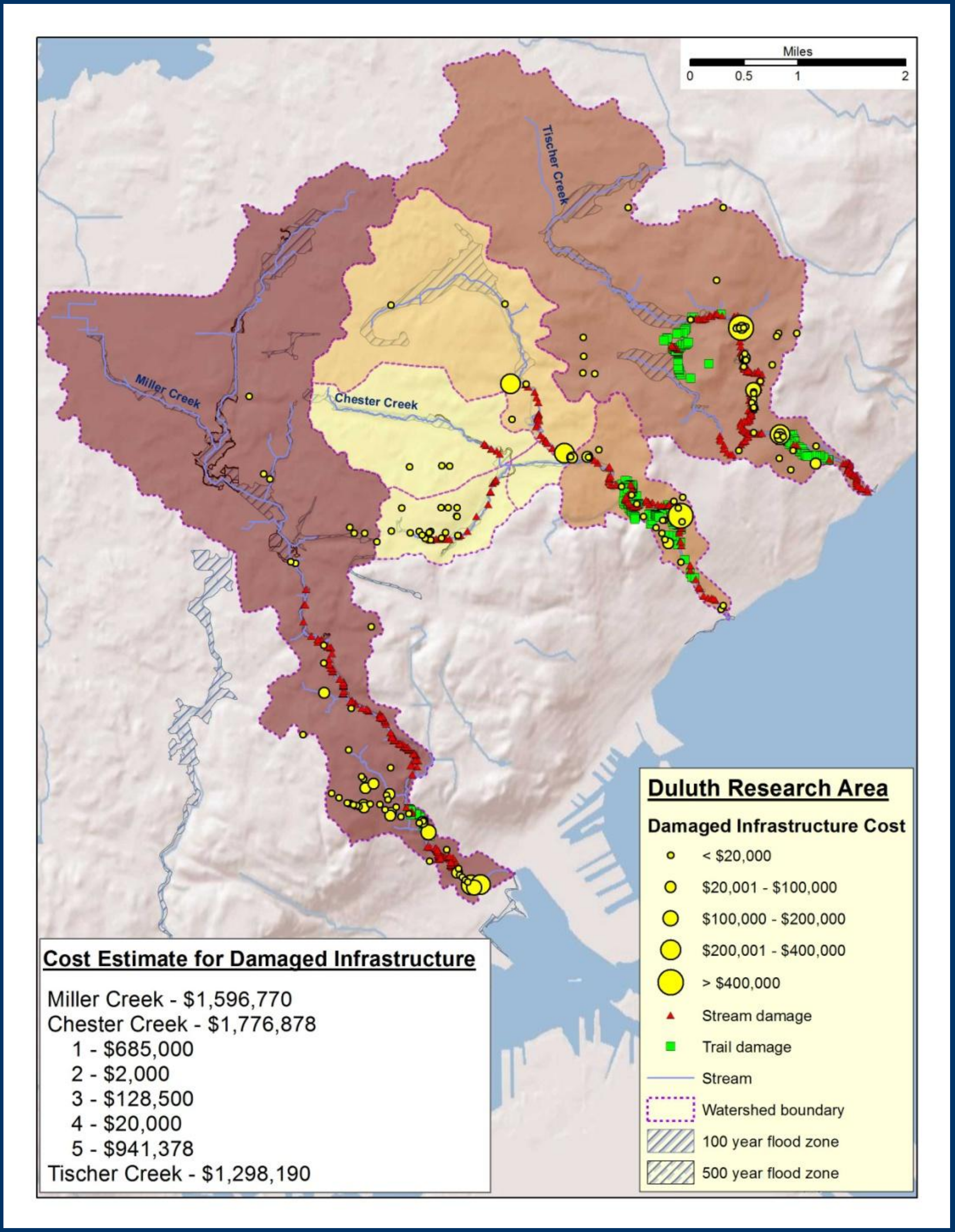
Chester Creek Watershed

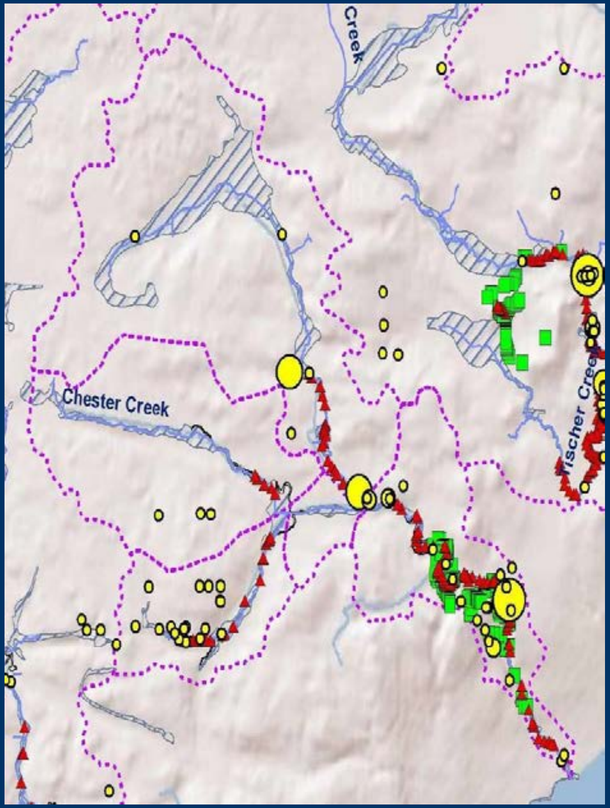




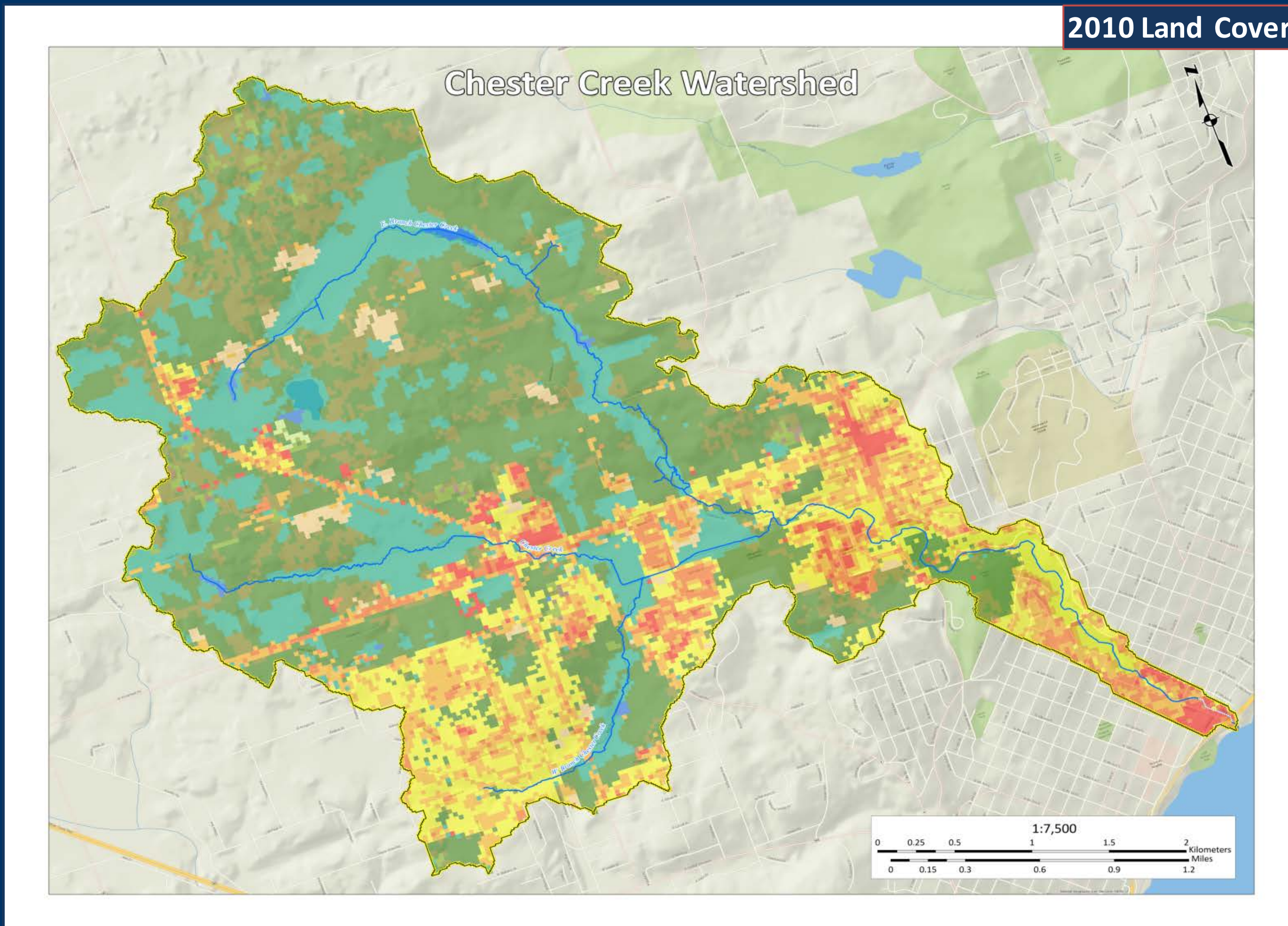
Slide Courtesy: Chris Kleist, City of Duluth

Damage in Chester Creek from June 2012 Flood





CURRENT LAND COVER



Legend

- Chester Creek Watershed
- Wetlands
- Forest
- Developed, High Intensity
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, Open Space
- Bare Land
- Cultivated Crops
- Grassland/Herbaceous
- Open Water
- Pasture/Hay
- Scrub/Shrub

Land Cover Source: Coastal Change Analysis Program (C-CAP) 2010

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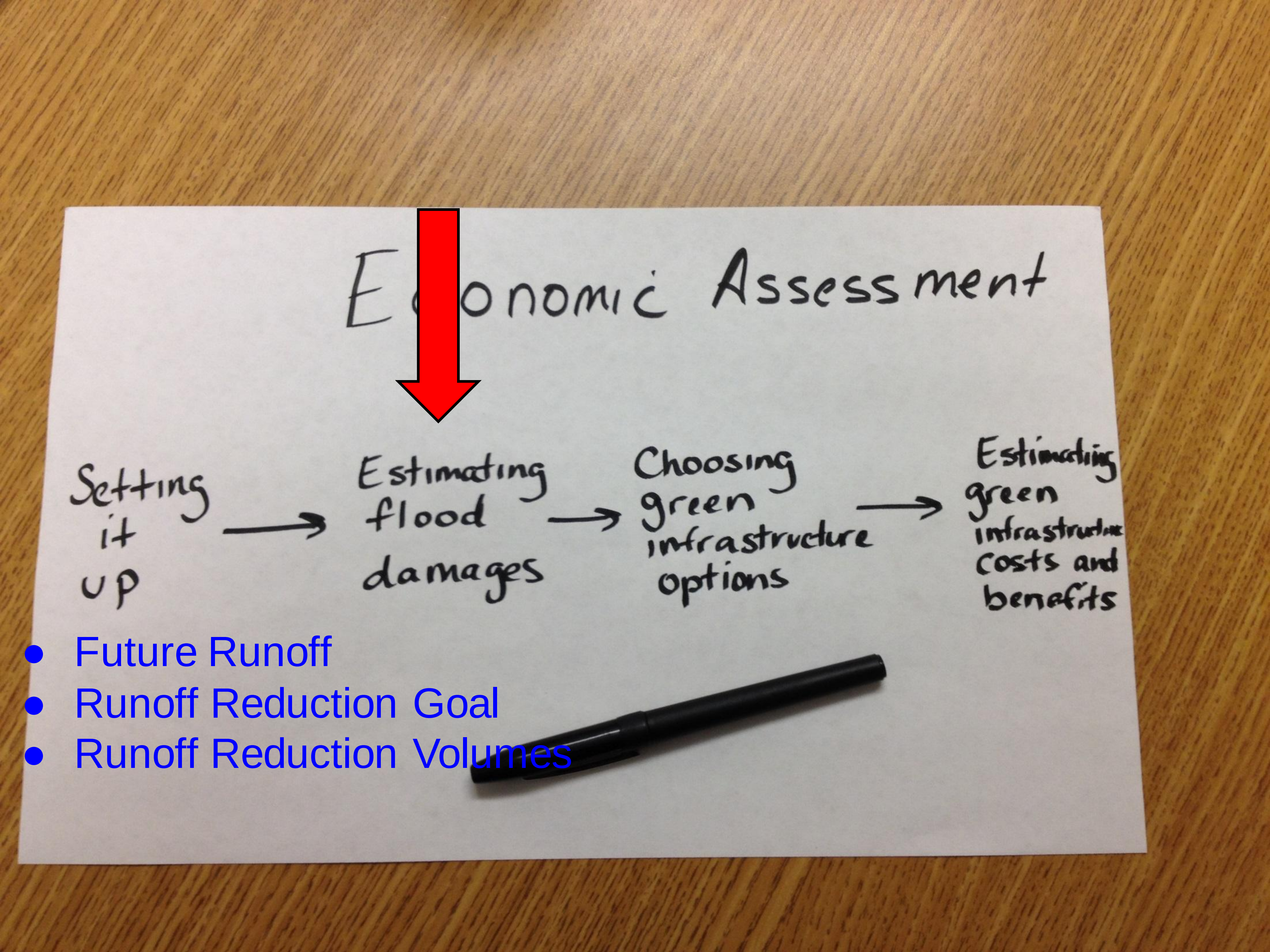
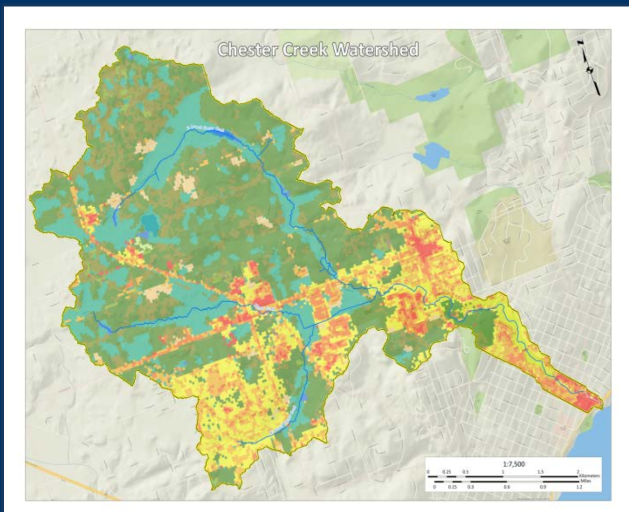
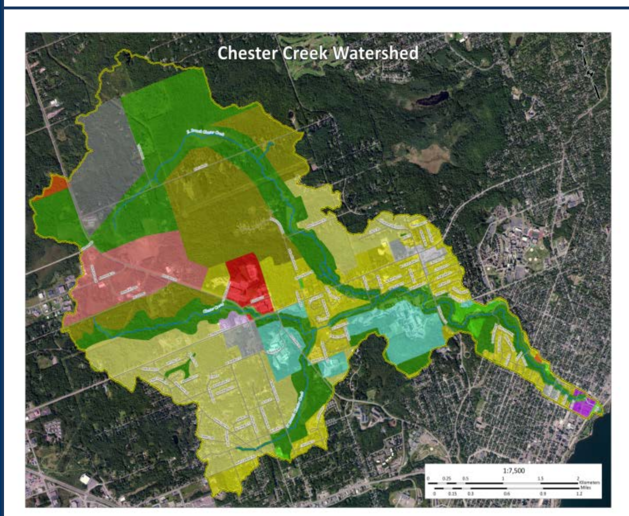


- Future Runoff
- Runoff Reduction Goal
- Runoff Reduction Volumes

What Flooding Should We Expect?





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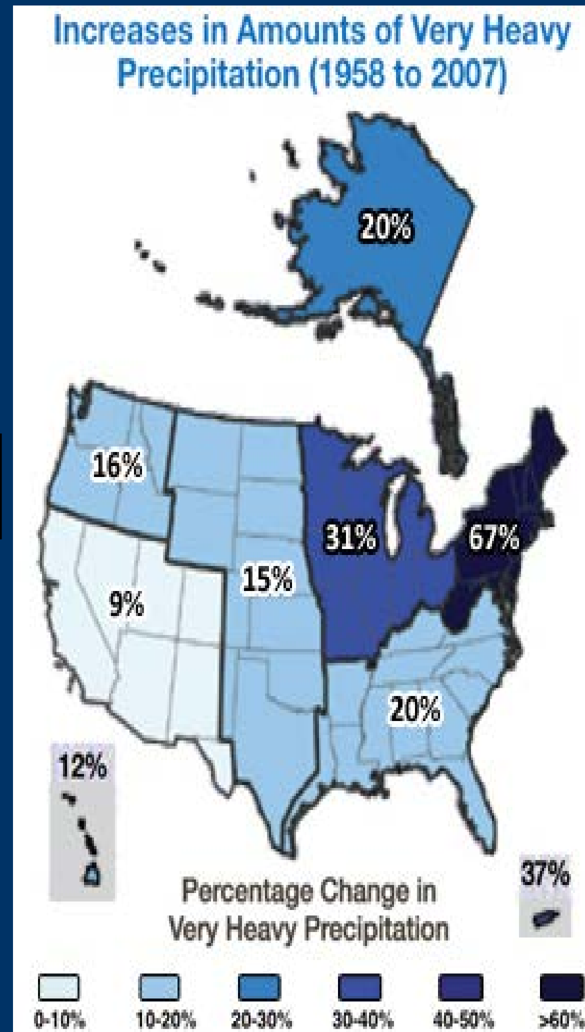

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Future Flood Events

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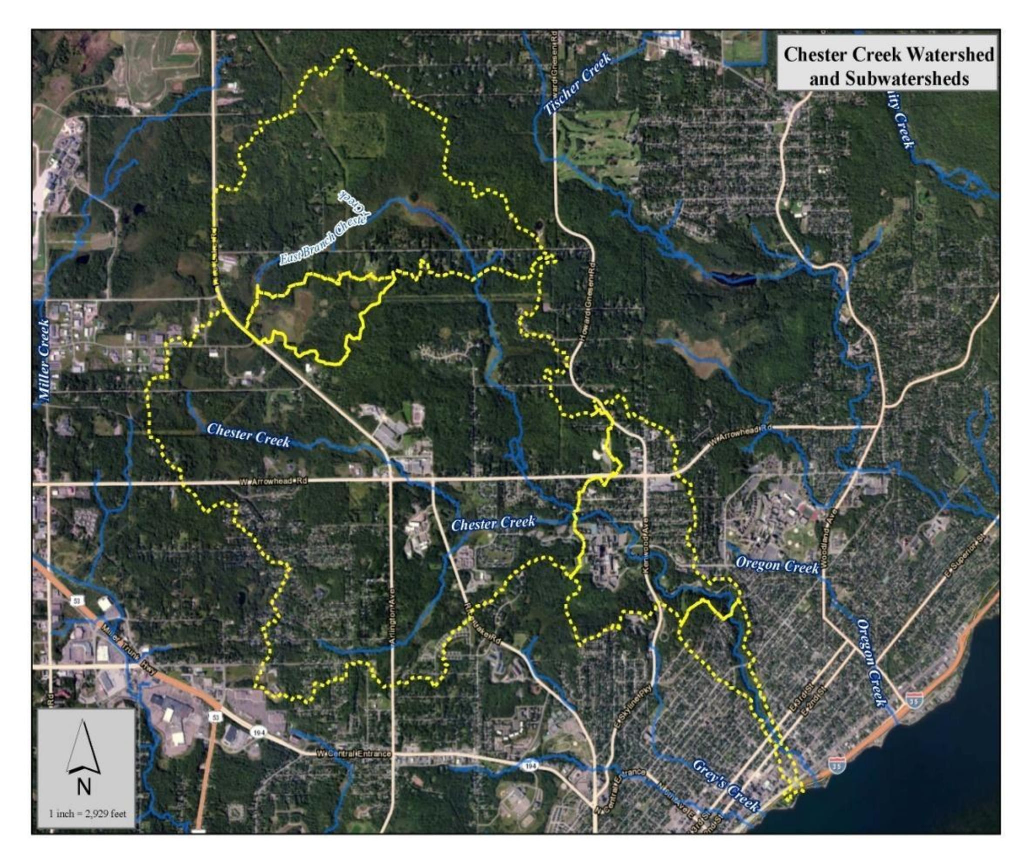
Future Precipitation

Scenario	Model	Year	2-yr storm*	10-yr storm	100-yr storm
Warm and wet	MRI	2035	8.49%	8.54 %	8.77 %

* This value is not generated by CREAT and was extrapolated using a log regression trend

GOAL:
20% Reduction in Peak Discharge

How much storage is needed to reach this target?



Frequency Increase of Peak Discharges

Scenario:	% Chance 2 yr Peak Discharge*	% Chance 10 yr Peak Discharge	% Chance 100 yr Peak Discharge
Current Land use & Precipitation	50.00%	10.00%	1.00%
Future Land Use & Precipitation	74.87%	14.95%	1.84%
Current Land Use & Precip with Storage**	34.00%	3.95%	0.24%
Future Land Use & Precip with Storage**	52.49%	7.00%	0.51%

Final Report, Table 20

% Chance peak discharge based on current discharge
** Storage assumed to be 20% of flow from current conditions

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GOAL:
20% Reduction in Peak Discharge

How much <u>storage</u> is needed to reach this target?

76 acre-feet
(current conditions)

86 acre-feet
(future conditions)

Damages: What We Estimated

- Damage to Structures (Hazus)
- Loss of Recreational Use
- Post Storm Land Restoration Costs
- Storm Sewer Infrastructure Costs



Change in Flooding

How does flooding change if the desired GI storage is implemented?

How We Did It

- Reduce previously calculated peak discharges by 20 % (USGS Regression equations)
- Input the new peak discharges into HEC-RAS to obtain flood depth grids
- Re-run Hazus with the new flood depth grids to see how damage changes

The Results

Current Precipitation, Current Land Use, 20% Flood Storage

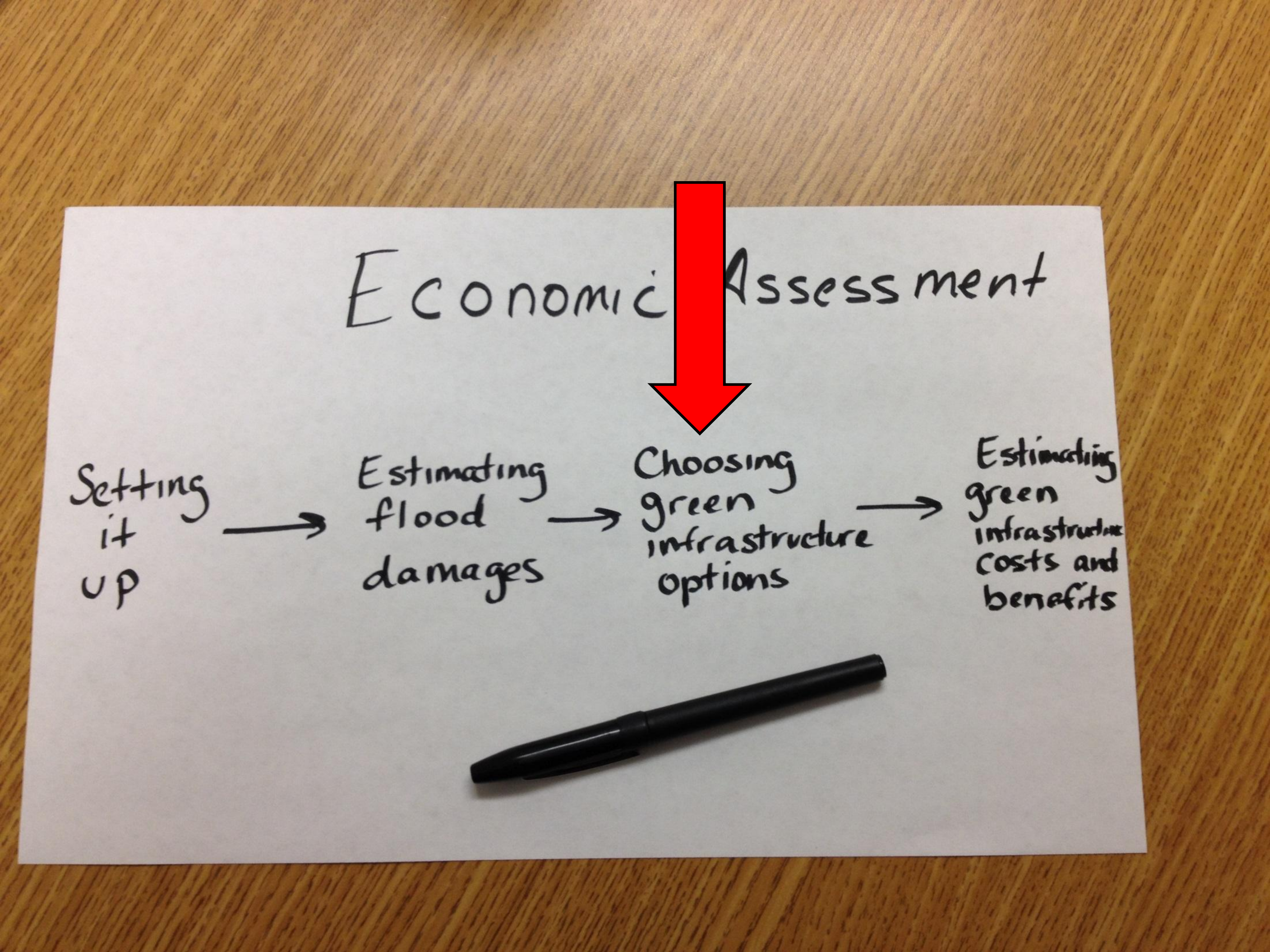
- 38% fewer buildings damaged
- 27% monetary reduction in building damages

Future Precipitation, Future Land Use, 20% Flood Storage

- 27% fewer buildings damaged
- 16% monetary reduction in building damages

Potential Impacts/ Co-Benefits

- Transportation Infrastructure: roads, bridges, dams, drainage
- Water/wastewater infrastructure: CSOs, SSOs, sewage treatment, drinking water
- Water quality
  - Boating, swimming, fishing
- Recreation - Are there use data?
  - Camping, hiking, birding, xc skiing?
- Increased property values
- Non-Market Values: ecosystem services, wildlife habitat, open space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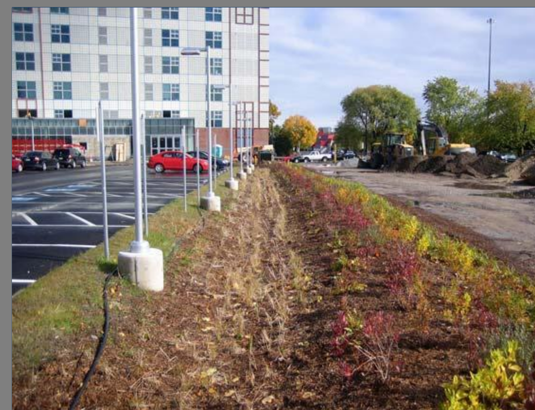
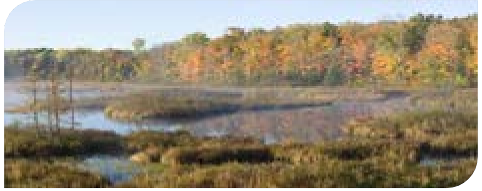
Green Infrastructure/LID



PROTECT EXISTING FORESTS AND WETLANDS

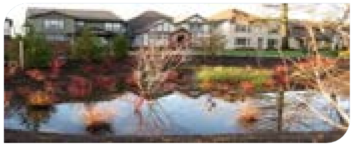


Chester Creek Watershed is **19.2% wetland** and **35.1% forest**!

CREATE NEW NATURAL AREAS TO ABSORB FLOOD WATERS

Rain Barrels and Cisterns

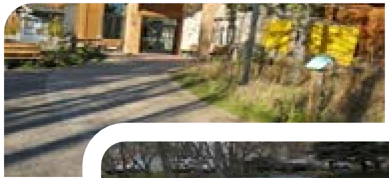
Retention Ponds

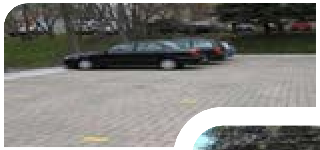


Green and Blue Roofs

Extended Detention Wetlands

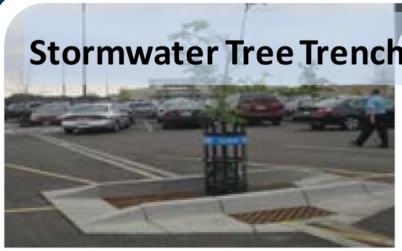
Permeable Pavement



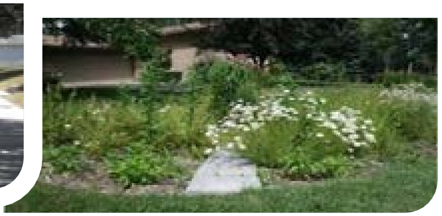


Underground Storage

Stormwater Tree Trenches



Bioswales and Rain Gardens



Committed communities

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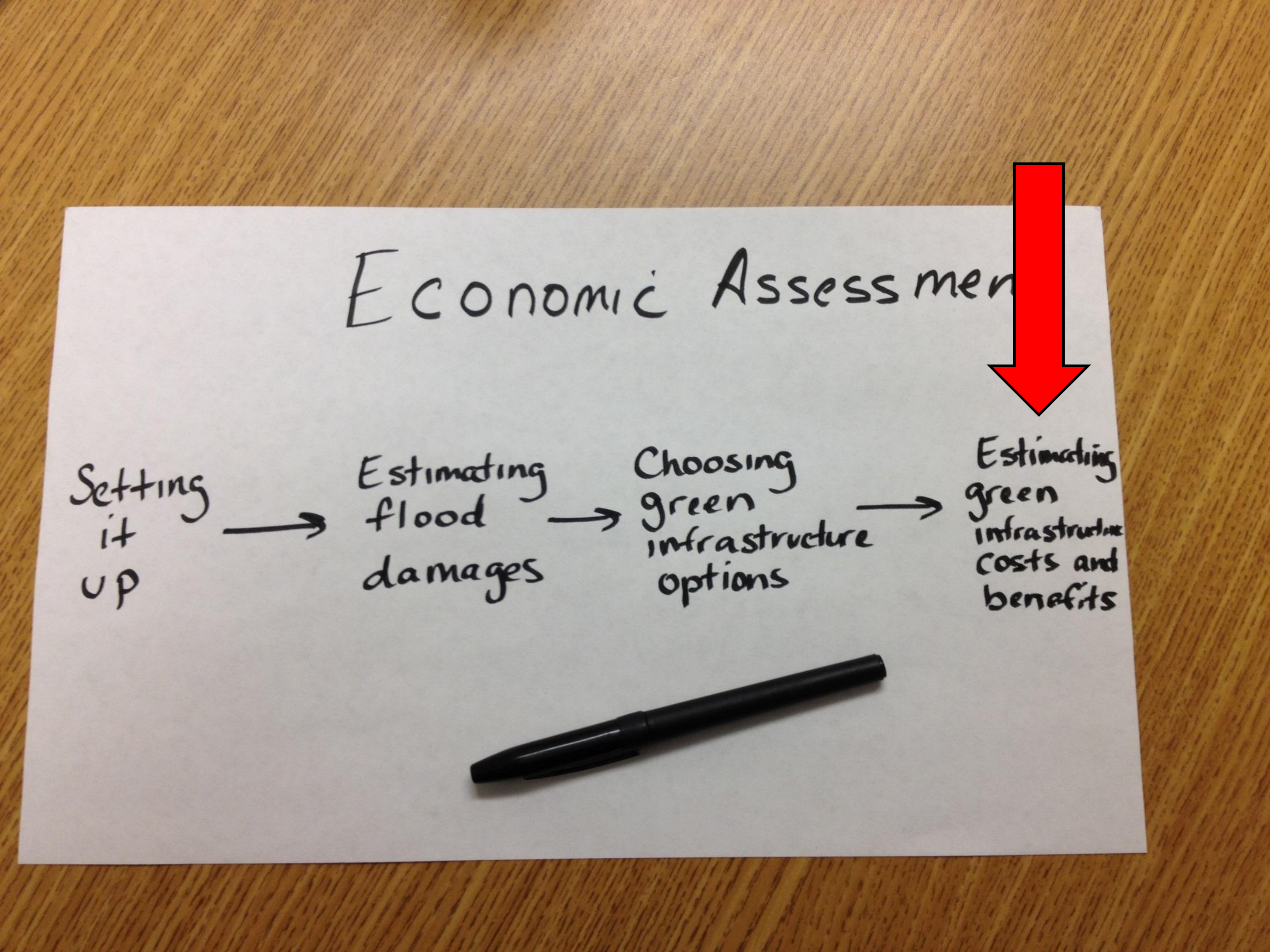
Chester Creek GI/LID Options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What would it cost to get 76 Acre-feet using GI?

Factors influencing cost:

- Site Hydrology
- Available open space
- Community preference
- Presence of underground obstructions
- Presence of natural features

GI Practice	Capital Cost / CubiC foot storage	Annual O&M / cubiC foot storage
Bioswale	21.2	1.3
Blue Roof	6.0	0.2
Permeable Pavement	16.8	N/A
Underground Storage	41.3	1.3
Retention Pond	2.9	0.0
Detention Wetland	1.3	N/A

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How Much Will it Cost?

If you implemented 76 acre-feet of extended detention wetlands at $1.30/CF your total cost would be $4,303,728

If you implemented 76 acre-feet of underground storage at $41.30/CF your total cost would be $136,726,128

What's the answer?

	Capital Cost per Cubic Foot of Flood Storage Provided ($/CF)
Most Expensive $$$$	Underground Storage
	Bioretention
	Permeable Pavement
	Blue Roof
	Retention Pond
Least Expensive $	Extended Detention Wetland

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Co-Benefits of Green Infrastructure

- Recreational, educational, and other use
- Increased property values
- Ecological Benefits
- Improved water and air quality
- Improved neighborhood aesthetics

- Reduced damages to public infrastructure
  - Roads, bridges, sidewalks
  - Water and sewage treatment facilities

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What can this mean for Duluth?

Duluth has science-based information to support planning, decisions, and future funding opportunities

Increased property values

Pilot projects

Increased water quality

Reduced risk

Able to use park

Reduced O&M costs

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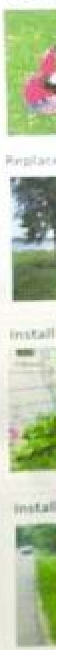

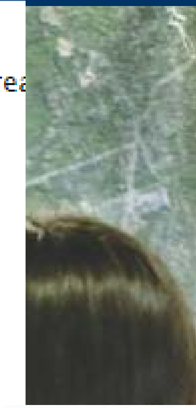

Duluth receives U.S. EPA's first Great Lakes Shoreline Cities Green Infrastructure Grant

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Table 50.18.1.E-4: Discharge Rate Limits

Location ▶ / Type of Activity ▼	Post-Development Peak Flow Rates at Each Discharge Point Shall Not Exceed: Zone A -- Above Bluff Line	Post-Development Peak Flow Rates at Each Discharge Point Shall Not Exceed: Zone B -- Below Bluff Line
New Development	75% of predevelopment peak flow rates for 10 and 100 year events; and 90% of predevelopment peak flow rate for 2 year event	Predevelopment peak flow rates for all storm events
Redevelopment	Predevelopment peak flow rates for all storm events	Predevelopment peak flow rates for all storm events

Major Project Components

- <u>Climate Prediction</u>: How much precipitation in 2035 and 2060? ERG/HW (EPA's CREAT Model)
- <u>Hydrology and Hydraulics</u>: What is the resulting flood elevation and associated impacts for the biggest storms? Army Corps of Engineers
- <u>Flood Damage Estimate</u>: What is the cost of the damage caused? ASFPM (HAZUS)
- <u>Planning Options</u>: What can be done to minimize damages (i.e., adapt)? ERG/HW (Land Use Planning and Gray/Green Infrastructure)
- <u>Economic Analysis</u>: What are the costs and benefits of such adaptations? ERG/HW

Questions?

Hilarie Sorensen
soren360@d.umn.edu
218-726-7677

http://coast.noaa.gov/digitalcoast/publications/climate-change-adaptation-pilot