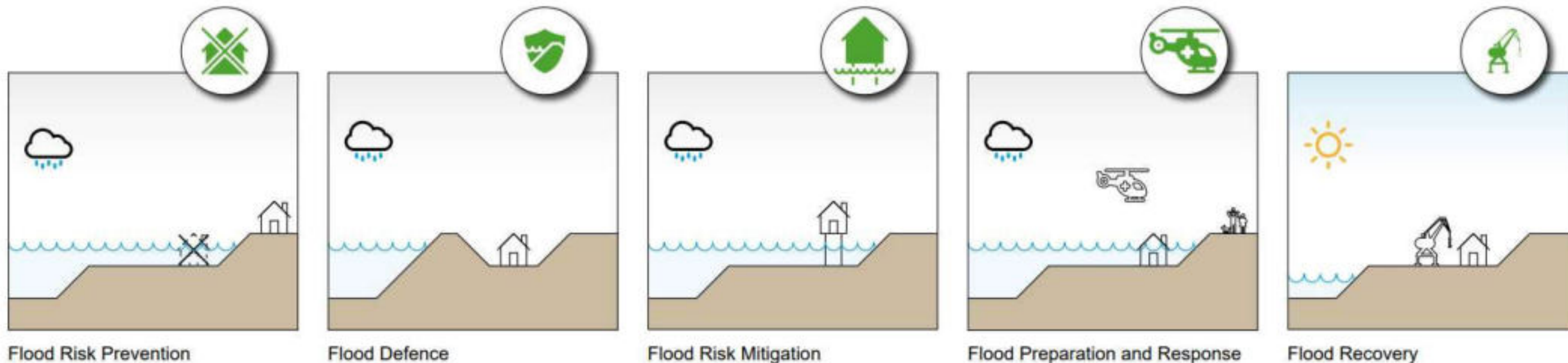


Consequence Categories

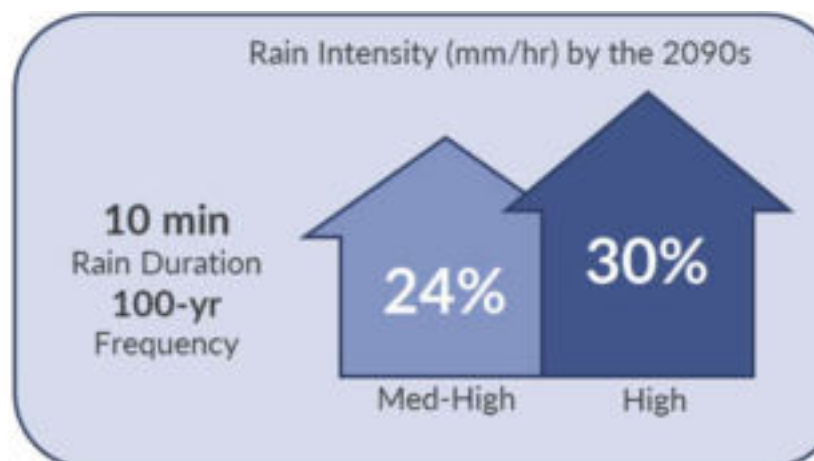
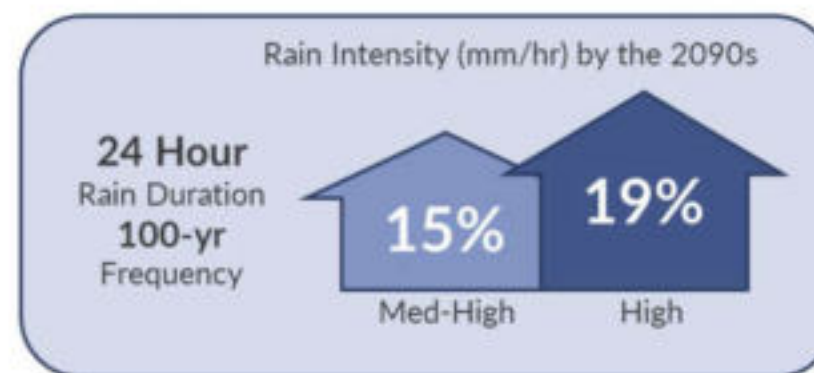
Environmental	Social	Economic	Climate
<ul style="list-style-type: none"> • Loss of natural areas or environmentally sensitive features • Groundwater flow • Surface and groundwater quality • Natural floodplain, riparian areas • Aquatic habitat • Fish passage • Wildlife passage • Regulatory approvals 	<ul style="list-style-type: none"> • Cultural resources • Reputation and inclusion • Public safety, access/egress • Community cohesion • Insurability • Displacement • Aesthetics 	<ul style="list-style-type: none"> • Capital construction costs • Annual operation & maintenance costs • Capital lifecycle replacement costs • Availability of external funding • Residual damages 	<ul style="list-style-type: none"> • Energy usage and emissions • Ability to adapt to other climate hazards (wildfire)

Likelihood Factors



Climate Risk

Intensity-Duration-Frequency (IDF) Curves



Climate change is a risk multiplier



Weather on "steroids"

Risk Treatment Option Analysis (RTOA) Results

Used a risk-informed process to support decision-making.

All options have a remaining residual risk (ALARP). *“Is the squeeze worth the juice”*

6 options were approved to proceed to the detailed cost-benefit analysis (CBA) phase.




Assumptions and Scope

- Informed by prior studies and analyses.
- Opinion of Probable Costs. Class D ($\pm 50\%$) estimate based on conceptual design.
- Further optimization based on preliminary and detailed design to follow for selected option.
- Costs, dike heights and number of impacted dwellings may change with further design.

		Likelihood				
		Very Low [1]	Low [2]	Moderate [3]	High [4]	Very High [5]
Consequence	Catastrophic [5]					
	Major [4]		12 Diversion to Oilman Creek 7 Constrained N/S 4 Diversion to Oxbow			
	Moderate [3]		2 North Barrier 3 N/S Barrier 5 Room for the River		11 Dredge	1 Base Case 8 Land Use Restrictions 10 Levy/Tax
	Minor [2]		6 Managed Retreat			9 Lift Residences
	Rare [1]					

Legend

Option 2

-  100-year Flood Extent
-  Division Points
-  Constructibility Offset

Average Sheetpile Height (m)

-  0 < 0.6
-  0.6 < 1.2
-  1.2 < 1.8
-  1.8 < 2.4
-  2.4 < 3.0



Option 2 North Only

Overview:

Baseline scenario; no flood mitigation activities. Scenarios to which all other options are compared.

Impacted:

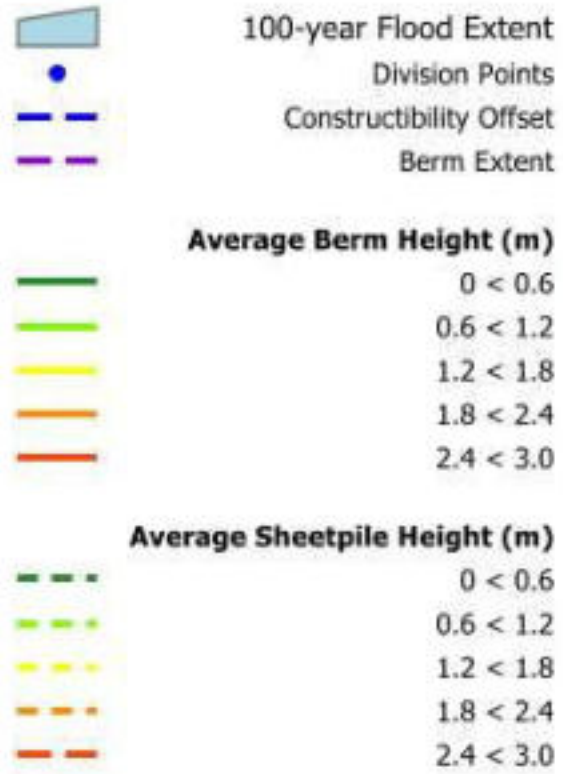
3 Permanent Resident Properties
1 Seasonal Resident Property
8 Vacant/Campground Properties

Class D ($\pm 50\%$) Cost Estimate:
\$13.8 Million

Residual Risk:
7.8 out of 25

NPV (@ 3% Discount Rate):
\$4.1 Million

**Legend
Option 3**



Option 3 North and South Overview:
Overview:
 Sheetpile on north side, earth berms on south side.

Impacted:
 0 Permanent Resident Properties
 1 Seasonal Resident Property
 5 Vacant/Campground Properties

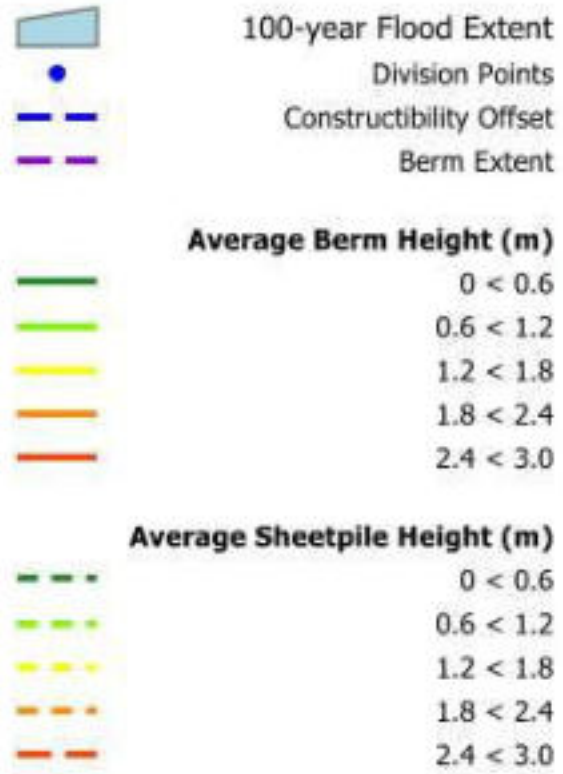
Class D (±50%) Cost Estimate:
 \$19.0 Million

Residual Risk:
 6.8 out of 25

NPV (@ 3% Discount Rate):
 -\$2.6 Million

Note: Berm extent based on the average height of the berm using 0.5 m freeboard

**Legend
Option 4**



Option 4 Divert to Oxbow Overview:
 Reactivate old oxbow channel, earth berms and Sheetpile on north side, earth berms on south side.

Impacted:
 0 Permanent Resident Properties
 0 Seasonal Resident Property
 1 Vacant/Campground Properties




Class D (±50%) Cost Estimate:
 \$18.2 Million

Residual Risk:
 8.0 out of 25

NPV (@ 3% Discount Rate):
 -\$1.3 Million

Note: Berm extent based on the average height of the berm using 0.5 m freeboard

**Legend
Option 5**

-  100-year Flood Extent
-  Division Points
-  Berm Extent

Average Berm Height (m)

-  0 < 0.6
-  0.6 < 1.2
-  1.2 < 1.8
-  1.8 < 2.4
-  2.4 < 3.0



Option 5 Room for the River Overview:
Widen and re-establish the floodplain, remove downstream residents, earth berms on north and south sides.

Impacted:
5 Permanent Resident Properties
13 Seasonal Resident Property
10 Vacant/Campground Properties

Class D ($\pm 50\%$) Cost Estimate:
\$11.5 Million

Residual Risk:
6.4 out of 25

NPV (@ 3% Discount Rate):
\$6.5 Million

Legend

Option 1 Base Case and Option 6 Managed Retreat



100-year Flood Extent



Option 6 Managed Retreat

Overview:

Remove all properties within the 100-year return period floodplain. Re-naturalize that area.

Impacted:

30 Permanent Resident Properties
26 Seasonal Resident Property
26 Vacant/Campground Properties

Class D ($\pm 50\%$) Cost Estimate:
\$20.8 Million

Residual Risk:
4.1 out of 25

NPV (@ 3% Discount Rate):
-\$3.3 Million

Option 1 Base Case

Overview:

Baseline scenario; no flood mitigation activities. Scenarios to which all other options are compared.

Residual Risk:
15.3 out of 25

Cost-Benefit Analysis: Methods

CBA is a generally accepted approach to estimate the **net social benefit** of a project/policy.

- All costs and benefits are assigned a dollar value, where possible.
- Future costs and benefits are “discounted” back to present value using an appropriate discount rate.
- The present value of social costs are subtracted from the present value of social benefits to yield a Net Present Value (NPV).
- **If NPV >0, the project is of net benefit to society.**

Social Costs

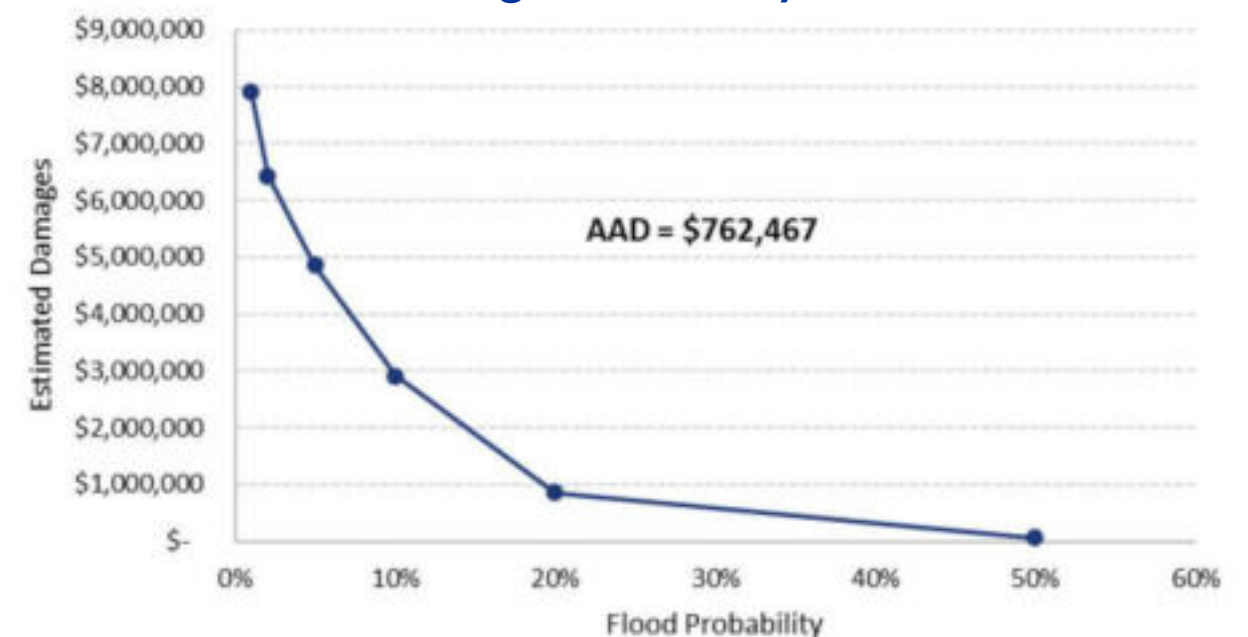
- Construction costs, operating costs, residential buyouts, reclamation/demolition costs, and environmental damages.
- Differ by mitigation option.

Social Benefits

Primary social benefit of flood mitigation is the value of avoided flood damages, including:

- Damages to properties/dwellings, displacement of residents, disruption to the MDLSR, damages to environment, and health impacts on affected residents.
- Average avoided annual damages=**\$762,467**.

Damage Probability Curve



Cost-Benefit Analysis: Results

All costs are shown in \$ Millions

