
VDOT
Virginia Department of Transportation

VDOT RESILIENCE

Estimating Cost of Resilience for the Construction Program

10/13/2026

Why are we here?

- Follow up from September resilience overview – Cost implications of resilience
- Present findings of study estimating cost to incorporate resilience practices on highly vulnerable construction projects
- Return in December to discuss incorporation of resilience practices for operation and maintenance activities
- January discussion on elements of resilience policy

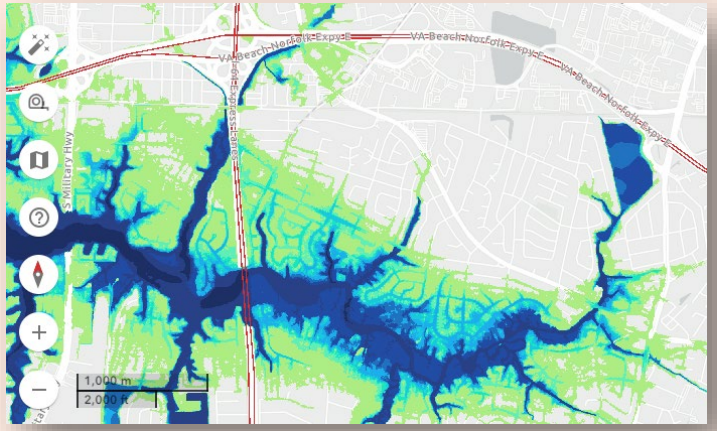
VDOT Resilience Plan Layout: Objectives & Strategies

1. Data Driven Decisions	• Authoritative Datasets • Data and Research Gaps
2. Stakeholder Engagement	• Coordination with Federal, State, MPO, Local Initiatives
3. Identify Vulnerable Infrastructure	• Visualization Tool (Asset and Network Vulnerability Assessment) • Inform focus areas, projects
4. Resilience Practices	• Adaptive Design Criteria (Hydraulics, Materials, Structure and Bridge) • Other Physical Enhancement Practices • Natural and Nature-based Solutions • Operational, Maintenance, and Emergency Management Practices • Administrative and Policy Practices
5. Feasibility and Cost Effectiveness Analyses	• Benefit Cost Analysis (BCA) Tool
6. Funding Opportunities	• PROTECT • Other Funding Opportunities

Resilience Tools

1 Identify Highly Vulnerable Infrastructure

Identify if project or activity includes vulnerable assets



Visualization Tool

2 Options to Address/Mitigate Vulnerability

Identify design/construction, traffic operations, maintenance, and emergency management practices

Construction	Adaptive Design Criteria (Structures & Bridge, Hydraulics, Materials)
	Natural and Nature Based Solutions
	Other Physical Enhancement Practices
Traffic Operations	Power Redundancy
	Transportation Network Redundancy
	Equipment Resilient Design/Installation
Maintenance	Pre-Storm Best Practices
	Upsizing vs. In-Kind Replacement
OSSEM	Flood Forecasting during weather events
	Enhancement to Processes for Identifying Mitigation Opportunities

Resilience Practices Toolbox

3 Evaluate Cost Effectiveness of Resilience Options

Evaluate if benefits of reduced replacement, maintenance, closure, and traffic outweigh costs

STEP 1: What is at-risk?				
1.1	**Hazard you are looking to mitigate**	Coastal Flooding		
	Hazard Exposure Score (Visualization Tool)	2.31-2.45		
1.2	**Size of the relevant at-risk asset(s)**	*Road:*	20	MI
	e.g., 20 lane miles of road are at-risk due to the	*Bridge:*	0	SQF
	selected hazard at this site	*Culvert:*	0	LF
STEP 2: What resilience practice(s) are you proposing to mitigate this risk?				
2.1	**Primary resilience practice (RP 1)**	Raise Roadway (by 2 feet)		
2.2	**Details of RP 1**	*Design Size:*	1000	CYD
		Unit Cost:	$922.50	pe
		Cost of RP 1:	$922,500.00	

Benefit Cost Analysis Tool

**Tools are in development and have not yet been released*

2 VDOT Resilience Toolbox

Goal: Provide a suite of vetted resilience practices for potential inclusion in projects to mitigate for coastal flooding, inland flooding, and landslides

Practice	Primary Division(s)	Resilience Purpose/Developed Tools
Adaptive Design Criteria	Structures & Bridge (S&B)	Structure and Bridge Chapter 33 (2020): Enhance scour protection, increase superstructure elevation, include corrosion resistant materials
	Location & Design (L&D)	Drainage Manual Chapter 18 (Draft): Enhance hydraulic design to incorporate increase in precipitation and sea level rise
	Materials	Material Memorandum of Instruction – Geotechnical, Pavement (Draft): Enhanced pavement and geotechnical design to incorporate increase saturation due to increased precipitation and flooding
Other Physical Enhancement Practices	Environmental/ L&D	VDOT OPEP Reference Materials Report (Draft): Coastal (Breakwaters, Groins), Riverine (Riverine Vanes, Flood Diversion Berms), and Slope and Bank Stability
Natural and Nature-Based Solutions	Environmental	Living Shoreline NNBS Pilot Simonson Rd. NNBS Reference Manual (Draft) NNBS Prioritization Tool (help select among sites) NNBS BCA Tool (help select among NNBS scenarios)

2 Example Toolbox - Geotech and Landslides

- Identification of Vulnerable Infrastructure includes landslide hazards
- Resilience Toolbox includes landslide mitigation practices
  - Rockfall Protection Mesh
  - Geosynthetic Reinforcement (reinforced soil slopes)
  - Geosynthetic Reinforcement (constructing reinforced soil slope embankments)
  - Revetments (stream restoration)
  - Revetments (riprap armoring streambanks)

Estimating the Cost of Resilience – Analyze Sample Set

An illustrative analysis to estimate the cost of resilience across the construction program

- No changes to scope of existing project

SYIP was screened with the At-Risk Infrastructure Visualization Tool for:

- VDOT administered projects
- Projects in final design, awarded, or in construction
- Projects with Construction estimates over $100K
- Located in areas highly vulnerable to coastal flooding, inland flooding, and/or landslides

Initial screening resulted in **71 bridge and roadway projects** across all 9 Districts

Evaluation:

- Total incremental cost estimated for incorporating cost-beneficial resilience practices
- Internal feedback gathered on constructability and cost of recommended resilience practices
- Results synthesized to estimate cost of resilience across construction program in the current SYIP

Estimating the Cost of Resilience – Analyze Sample Set

1 Identify Highly Vulnerable Assets

Look up the asset, pull exposure / sensitivity / adaptive-capacity scores for each hazard (0-3 scale).

Verify vulnerability using project specific details including elevations, etc.

2 Applicable Adaptive Design Criteria & Candidate Practices

Match the hazard to the governing chapters:

- Ch. 33 of S&B Manual (coastal/SLR bridges)
- Draft Ch. 18 of VDM (drainage/rainfall)
- Draft MOI Sections (pavement and geotechnical)
- Shortlist of resilience practices per asset from the Resilience Practices Toolbox or a documented outside practice.

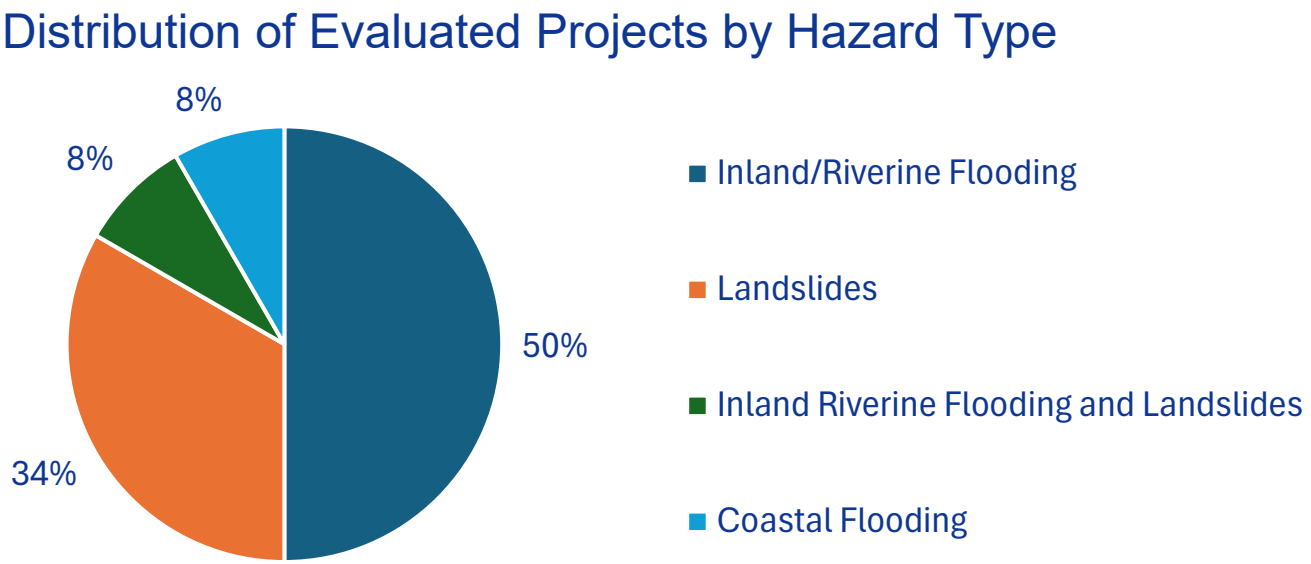
3 BCA Tool → Benefit Cost Ratio

Enter design size, unit cost, O&M, and life expectancy; the tool compares traffic, maintenance (routine and emergency), user and ecosystem benefits against annualized cost.

Recommend Resilience Practice

Estimating the Cost of Resilience – Analyze Sample Set

- Started with 71 projects using Visualization Tool for screening vulnerabilities
- 35 were excluded from the analysis:
  - 24 projects were deemed not vulnerable based on detailed project data (elevations, slopes, etc.)
  - 11 projects were excluded based on lack of relevance (no plan project, vulnerable segments outside project limits, etc.)
- Of the 36 projects that were evaluated:



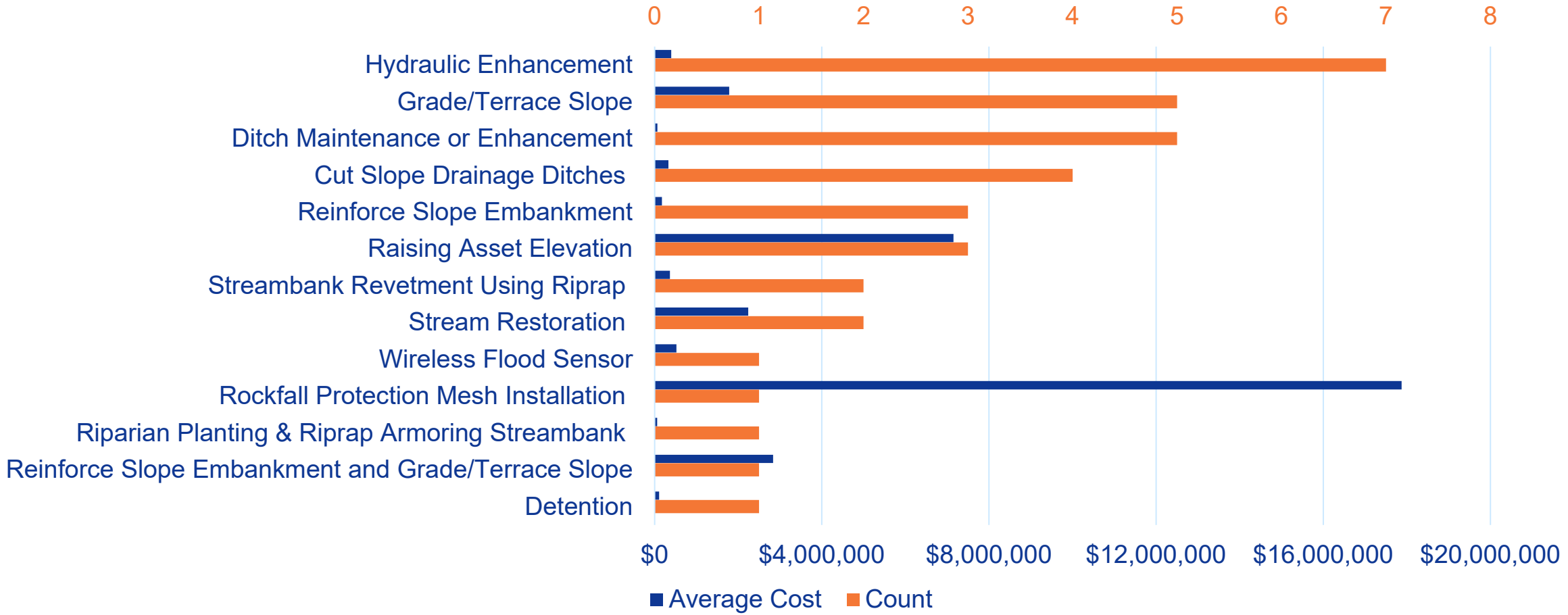
Sample Set Analysis – Results

Total Incremental Cost of Adding Resilience per Hazard

Total Incremental Cost of Adding Resilience (% increase from baseline)			
Functional Class	**Coastal Flooding**	**Inland/Riverine Flooding**	**Landslides**
Interstate	$521,625 (9%)	$7,662,250 (1%)	$6,431,939 (6%)
Primary		$13,237,842 (4%)	$25,453,632 (11%)
Secondary	$8,702,600 (83%)	$166,813 (1%)	$35,391 (0.1%)
Grand Total	**$9,224,225 (46%)**	**$ 21,066,905 (3%)**	**$31,920,962 (8%)**

Sample Set Analysis – Results

Frequency of Recommended Resilience Practices

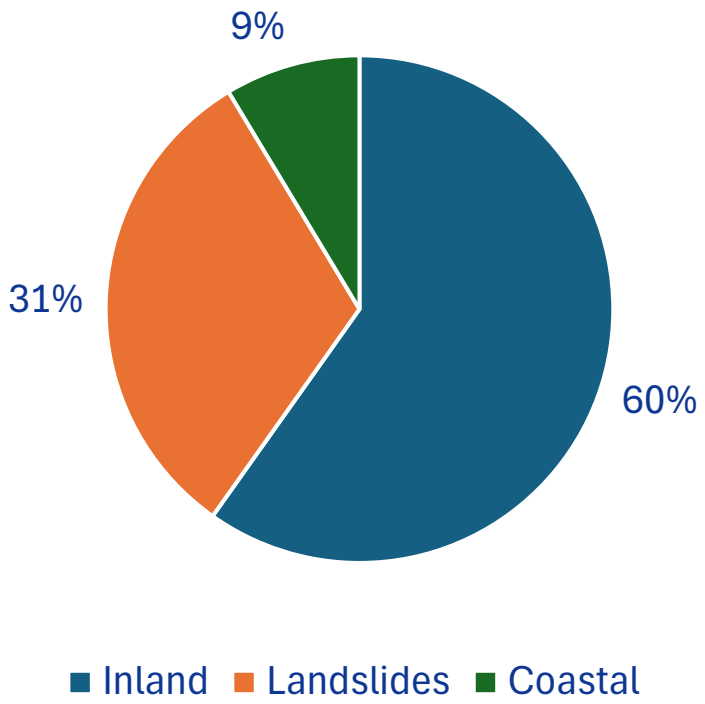


Estimating the Cost of Resilience – Extrapolation

Extrapolating Results Across Construction Program (SYIP)

Screening	No. of Projects
Starting SYIP projects	1,675
Screened and removed projects based on: • Vulnerability removed projects that have no or low vulnerability to coastal and inland flooding and landslides • Relevance removed signalization, bike/ped, trails, re-surfacing	- 674 - 665
SYIP projects used to extrapolate cost increase data from pilot results across Construction Program	**336**

Distribution of the 336 Construction Projects by Hazard



Estimating the Cost of Resilience – Extrapolation

Extrapolating Results Across Construction Program (SYIP)

Functional Class	Coastal	Inland	Landslides
Interstate	$1,022,538,116	$8,289,880,371	$3,046,642,504
Primary	$1,413,057,728	$3,171,414,606	$1,664,142,693
Secondary	$12,356,016	$459,975,812	$65,305,009
Urban/Miscellaneous	$23,532,856	$62,638,504	$13,801,028
Total	**$2,471,484,716**	**$11,983,909,293**	**$4,789,891,234**
Average % Increase from Baseline Cost from Pilot per hazard	**46%**	**3%**	**8%**
Resilience Incremental Cost*	**$682,000,000- $910,000,000-**	**$216,000,000- $288,000,000-**	**$230,000,000- $307,000,000-**

*Based on results of Pilot Study, assuming 20-40% of the SYIP projects screened will be deemed not vulnerable upon verification with project details (elevation, % slope, etc.)

Estimating the Cost of Resilience – Key Takeaways

- Important to account for factors beyond direct cost of resilience practices
  - ROW acquisition, permitting, utility relocation
- Incorporating resilience on interstates yields the highest benefit in the construction program
  - Avoid road closures affecting large number of users
- Coastal flooding is the most expensive hazard to address due to high price of mitigation practices
  - Raising bridges and roadways
- Cost-beneficial construction resilience practices were not identified for all vulnerable SYIP projects
- Many vulnerable assets were not impacted by SYIP projects
  - Cost-beneficial O&M practices should be evaluated to provide resilience statewide

Next Step: Resilience Practices in VDOT O&M

- Currently performing a similar analysis in maintenance program
  - Do processes and workflows, using the 3 tools, need to be revised?
  - Are there additional practices that are lower upfront cost, shorter timeline, and wider scale than construction alone?
  - Do we need to improve mapping of hazard incidents and hazard-driven maintenance work?
  - Do we need improved early warning device technology, detour planning and redundancy?
- Continue this discussion in December


VDOT
Virginia Department of Transportation