Developing Accurate Costs to Illustrate Bridge Preservation Benefits

Nancy Huether, P.E.
Bridge Division
NDDOT
North Dakota
Department of Transportation

Bridge Preservation

- Bridge Preservation is doing our best to **cost-effectively** keep our bridges in good condition and extend their useful life.

- Design and Construction
- Maintenance and Rehabilitation

Right Action	Right **Cost**	Right Time

NDDOT
North Dakota Department of Transportation

Effective Bridge Preservation

- Need to define
  - Actions
    - Benefits for those Actions
  - **Costs** of those Actions
    - Accurate Costs
      - Include indirect costs
  - Timing of Action
    - Cyclical
    - Condition-Based
      - Deterioration Rates
- Customize for your Agency

NDDOT
North Dakota
Department of Transportation

Need Accurate Input

- Bridge data: design, highway classification, ADT
- Inspection/condition information
- Deterioration rates
- Actions
- Benefits
- **Costs**

NDDOT
North Dakota Department of Transportation

North Dakota Bridges and Structures

- 1725 State Structures
- 720 Bridges
  - Prestressed Concrete – Prestressed I Beam, Spread Box Beam
  - Reinforced Concrete – Slabs, Tee Beams
  - Steel – Rolled and Welded Plate Beams
  - Few Trusses
  - One Post-Tensioned Segmental Box
- 1005 Other Structures
  - All Box Culverts
  - Structural Plate Pipes ≥ 8′ diameter
  - Multiple Pipes

Bridge Preservation - Maintenance

- Bridge Maintenance Actions
  - Nearly all Maintenance work done in-house
    - No dedicated Bridge Maintenance crews
      - All work done by 8 Districts maintenance crews
      - Bridge work competes with all other work
      - Ability varies based on training and skill level
      - Priority of work determined by Districts
- Actions defined in Maintenance Manual
  - Cyclical & Condition-Based
- Quantify Benefits
- Develop **Costs**
  - Include labor, equipment, materials

NDDOT
North Dakota
Department of Transportation

Bridge Preservation - Rehabilitation

- Bridge Rehabilitation Actions
  - Typically work done under contract
  - Larger projects
    - Deck Overlays or Replacements
    - Pier and Abutment Work
    - Joint Replacement
    - Structure Paint
- Benefits
  - Improved Condition State of Elements
- Determining Accurate **Costs**
  - Include Indirect **Costs**

Past Bridge Management at the NDDOT

- Where we have been . . .
  - History of our Bridge Management System (BMS)
- Prior to 1995 used only main frame for bridge data/inspection/reporting
- 1995-1996 began using Pontis for element inspection
  - Continued to use main frame for data storage and reports, including NBI
- 2009 Transitioned to using only Pontis
  - Database
  - Inspection
  - Reporting

NDDOT
North Dakota
Department of Transportation

Current Bridge Management at the NDDOT

- Where we are now . . .
- 2017 Upgraded to AASHTOWare Bridge Management (BrM) 5.2.3
  - Inspections
    - Simple in-house developed app
  - Database
  - Reporting (FHWA)
  - Create reports/SI&A sheets
  - Sort, filter, create layouts, compare NBI & Element data
  - Export data to spreadsheets for analysis
- Manage our bridges and structures using data *from* our BMS

NDDOT
North Dakota
Department of Transportation

Future Bridge Management at the NDDOT

- Where we want to be . . .
- Utilize our Bridge Management System (BMS) for
  - Long-term Planning
  - Deterioration Modeling
  - Recommending Preservation and Rehabilitation work
  - Optimizing Costs and considering Trade-offs
  - BrM 5.2.3 has these capabilities – need to use them

- Goal - Manage structures *in* our BMS
  - Let BrM do more of the work!

NDDOT
North Dakota
Department of Transportation

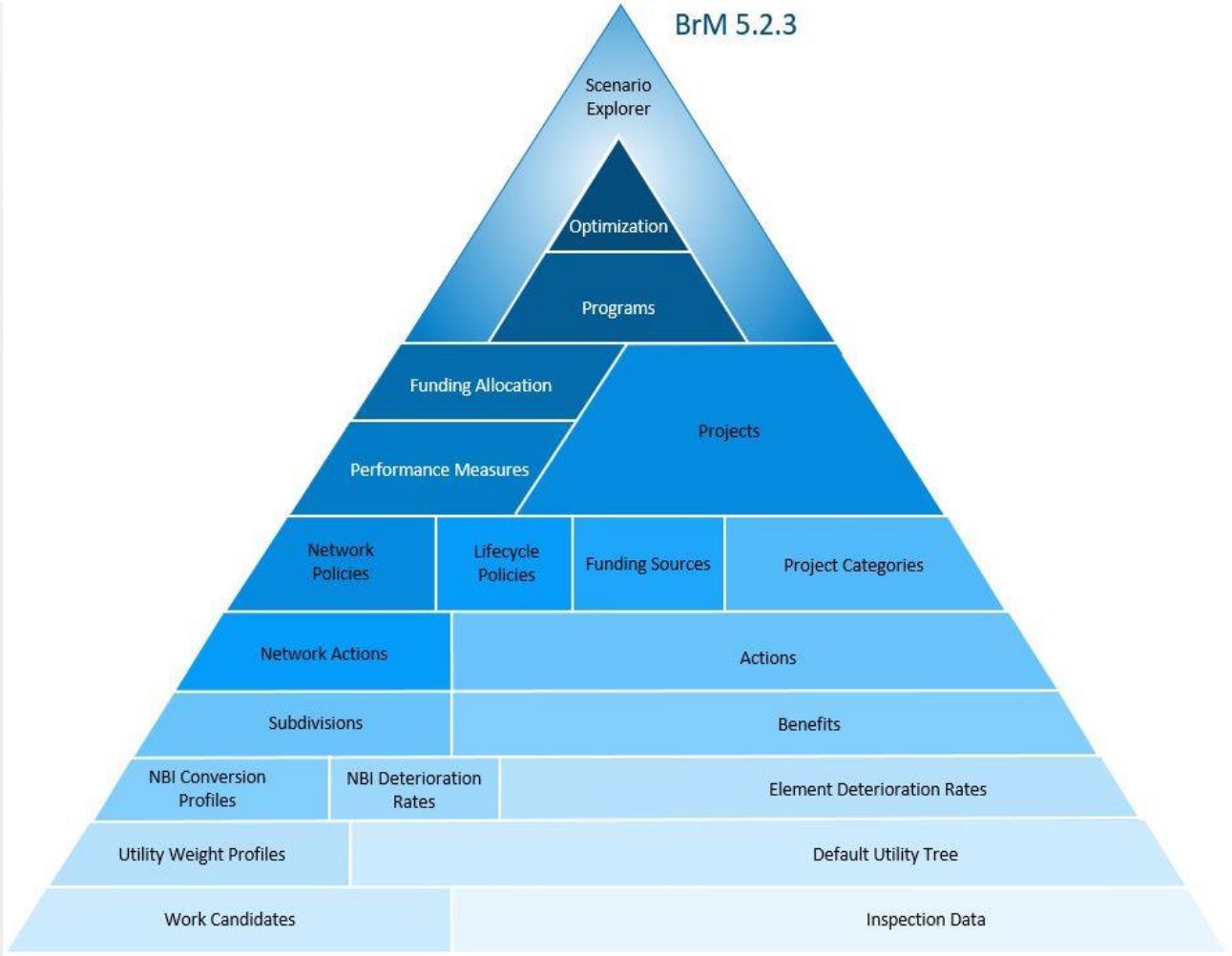
Using the BMS to Support Bridge Preservation

- Describe Maintenance & Rehabilitation Actions
  - Bridge Maintenance Manual
  - Typical NDDOT Rehabilitation Actions
- Quantify **Costs** and Benefits of Actions
  - Maintenance & Rehabilitation
- Define Timing for Actions
  - Schedule
  - Condition
    - % in Condition State
    - NBI Rating
- Incorporate into BMS

NDDOT
North Dakota
Department of Transportation

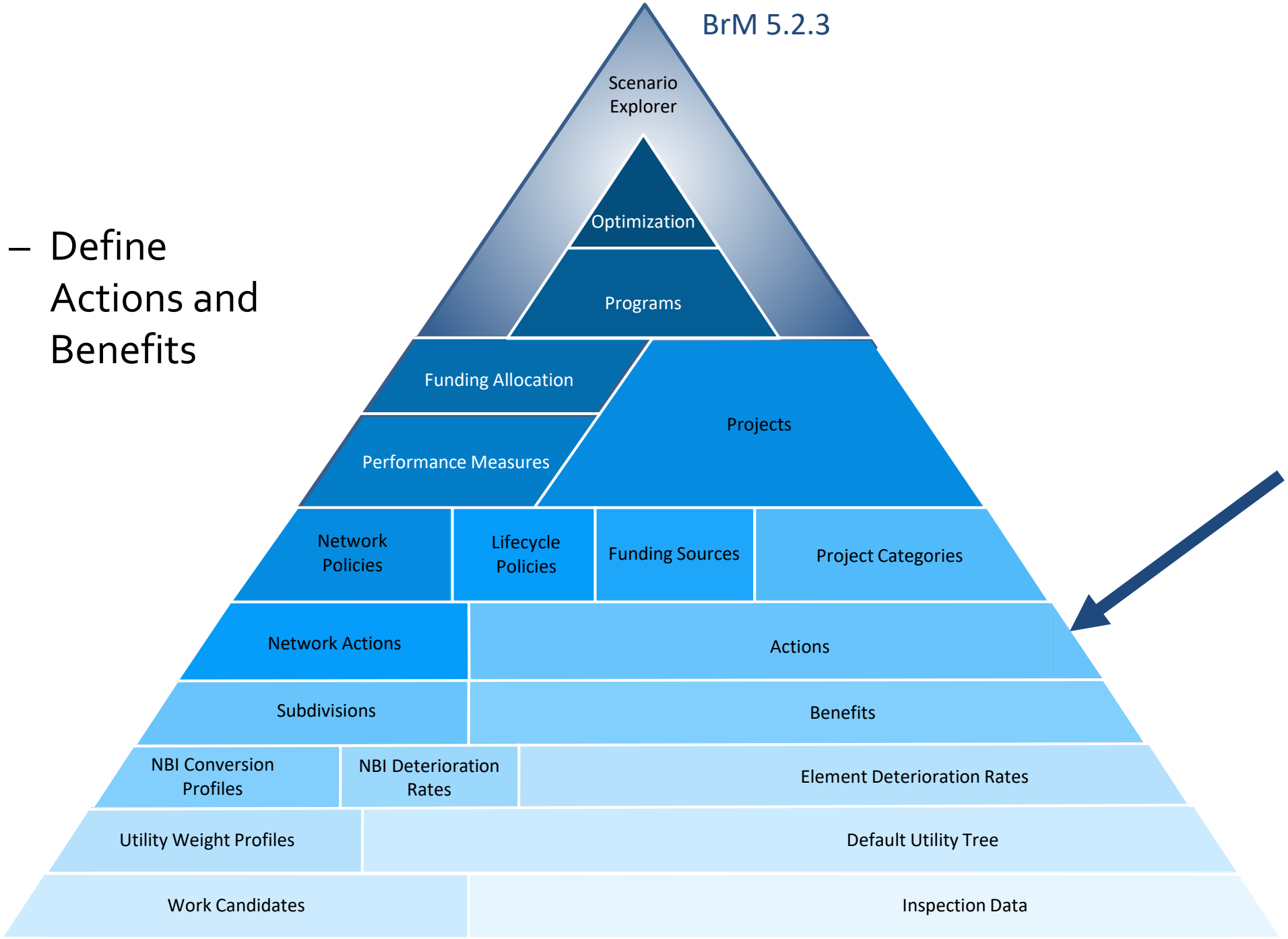
Actively Moving Forward

- BrM Training on Version 5.2.3
  - October 2017
- The BrM pyramid
  - Accurate Inspection Data
  - Develop Utility Tree and Weights
    - Defines the value of the bridge
  - Refine Deterioration Rates



BrM 5.2.3

– Define Actions and Benefits



Benefits . . .

- Benefits – the impacts to structure as a result of an Action
  - Revisions to elements when work is done
- Based on typical work done by your Agency

Admin > Modeling Config > Benefit Groups

Benefit Groups

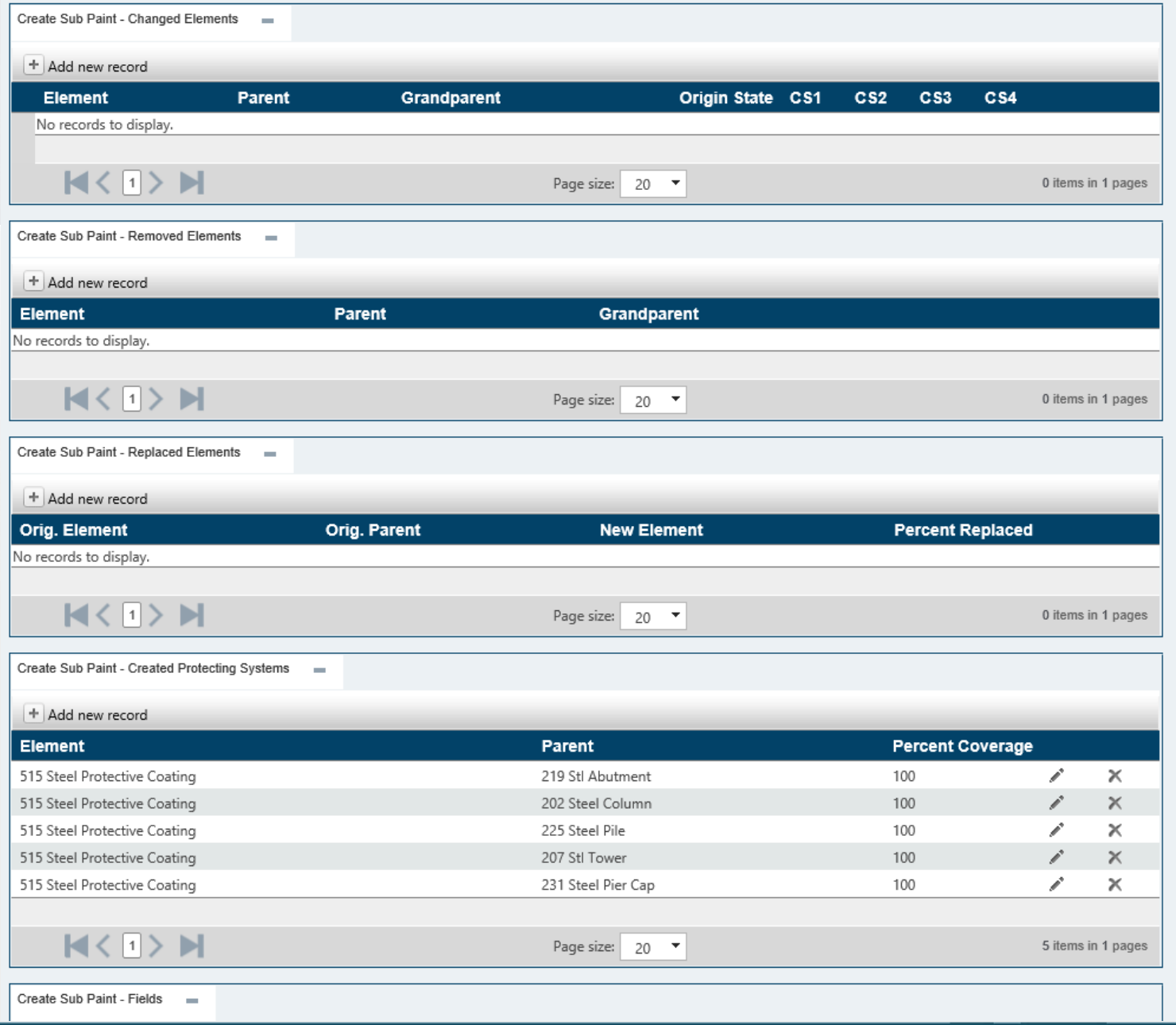
Add New Benefit Group

Benefit Group Name	Description	Linked Actions	Sort Order	Child Benefit Groups
Create Sub Paint	Create Elem 515	Paint Sub - Network	9999	Link to Child Groups
Create Super Paint	Create Elem 515	Paint Super - Network	9999	Link to Child Groups
Create Wearing Surface	Create Elem 510	Place Wearing Surface - Network	9999	Link to Child Groups
Rehab Culvert	Rehab Culvert	Rehab Culvert - Network	9999	Link to Child Groups
Rehab Deck Conc	Concrete Deck elem to CS2	Rehab Deck - Network	9999	Link to Child Groups
Rehab Deck Steel	Replace Steel &Timber sections	Rehab Deck - Network	9999	Link to Child Groups
Rehab Railings	Repair Concrete, Replace Others	Rehab Deck - Network, Rehab Culvert - Network	9999	Link to Child Groups
Rehab Sub Abutments	Repair Abutment Elements	Rehab Sub - Network	9999	Link to Child Groups
Rehab Sub Columns & Piles	Repair Concrete, Steel, Replace Timber	Rehab Sub - Network	9999	Link to Child Groups
Rehab Sub Piers & Caps	Repair Pier & Cap Elements	Rehab Sub - Network	9999	Link to Child Groups
Rehab Super Beams	Repair Super Beams		9999	Link to Child Groups
Rehab Super Other Elems	Replace paint and repair bearins		9999	Link to Child Groups

NDDOT
North Dakota Department of Transportation

Benefits . . .

- Change Elements
  - Element does not change but CS changes
- Remove Elements
- Replace Elements
  - Can replace with same element or different element
- Create Protective Systems
- Changes to data fields
  - NBI ratings
  - Scour rating
- Change risk factors



Create Sub Paint - Changed Elements

Add new record

Element	Parent	Grandparent	Origin State	CS1	CS2	CS3	CS4
No records to display.							

Page size: 20 — 0 items in 1 pages

Create Sub Paint - Removed Elements

Add new record

Element	Parent	Grandparent
No records to display.		

Page size: 20 — 0 items in 1 pages

Create Sub Paint - Replaced Elements

Add new record

Orig. Element	Orig. Parent	New Element	Percent Replaced
No records to display.			

Page size: 20 — 0 items in 1 pages

Create Sub Paint - Created Protecting Systems

Add new record

Element	Parent	Percent Coverage
515 Steel Protective Coating	219 Stl Abutment	100
515 Steel Protective Coating	202 Steel Column	100
515 Steel Protective Coating	225 Steel Pile	100
515 Steel Protective Coating	207 Stl Tower	100
515 Steel Protective Coating	231 Steel Pier Cap	100

Page size: 20 — 5 items in 1 pages

Create Sub Paint - Fields

Actions . . .

- Actions – Any work that can be done to a structure
  - Should be customized to reflect Actions done in your Agency

Admin > Modeling Config > Action Defs

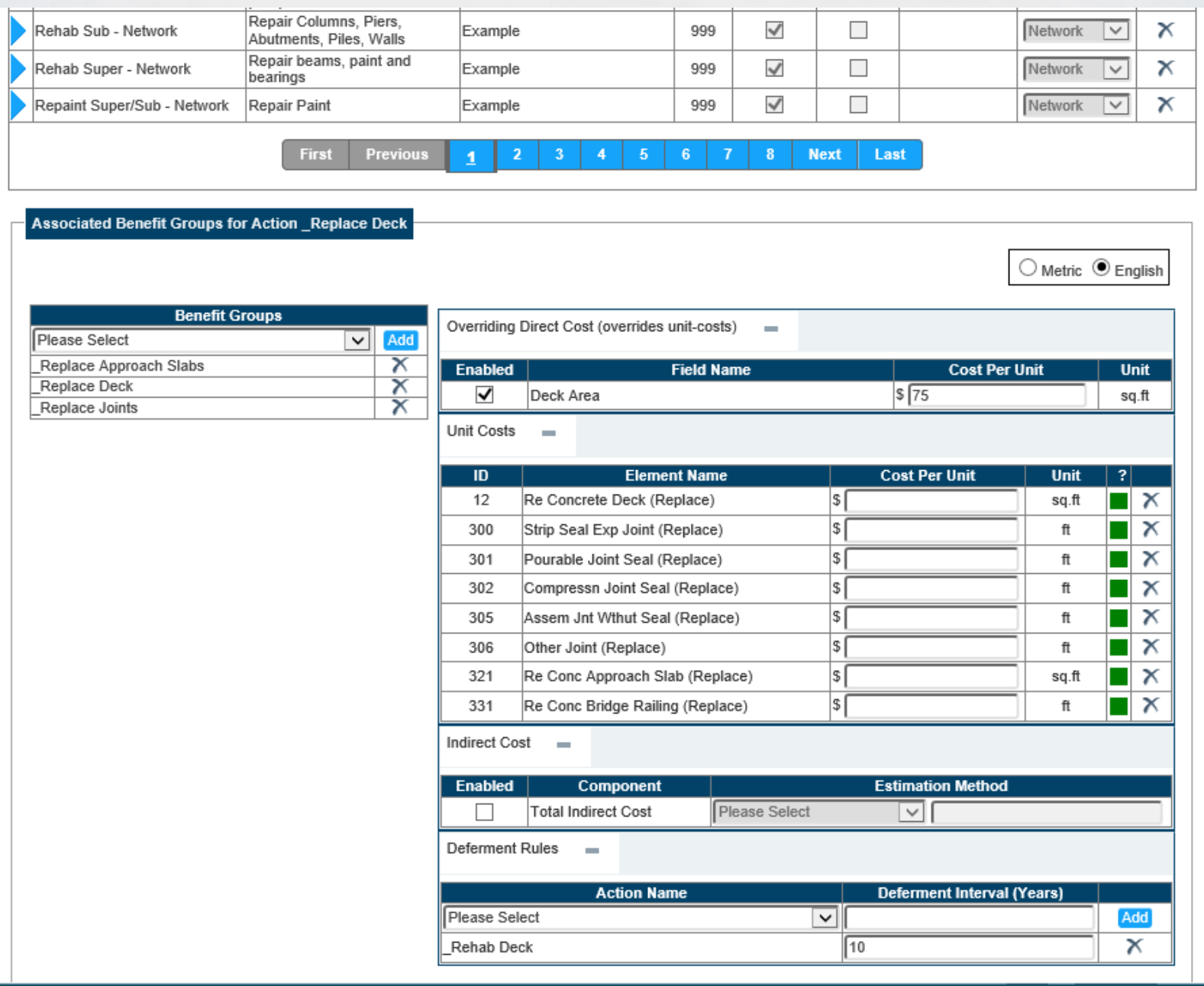
	_Replace Culvert	Replace Culvert		101	☑	☐		Network	✕
	_Replace Deck	Replace Deck and Barrie		101	☑	☐	$	Network	✕
	Paint Sub - Network	First Painting	Example	999	☑	☐		Network	✕
	Paint Super - Network	First Painting	Example	999	☑	☐		Network	✕
	Place Wearing Surface - Network	First Wearing Surface	Example	999	☑	☐		Network	✕
	Preserve Deck - Network	Thin-Bonded / Repair Joints	Example	999	☑	☐		Network	✕
	Rehab Culvert - Network	Rehab culvert, parapets, approaches	Example	999	☑	☐		Network	✕
	Rehab Deck - Network	Repair deck, joints and parapets	Example	999	☑	☐		Network	✕
	Rehab Sub - Network	Repair Columns, Piers, Abutments, Piles, Walls	Example	999	☑	☐		Network	✕
	Rehab Super - Network	Repair beams, paint and bearings	Example	999	☑	☐		Network	✕
	Repaint Super/Sub - Network	Repair Paint	Example	999	☑	☐		Network	✕

First | Previous | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Next | Last

NDDOT North Dakota Department of Transportation

Actions . . .

- Linked to Benefits
- Include
  - Work to be done
  - Linked Benefit Groups
  - Deferment rules for future work



Rehab Sub - Network	Repair Columns, Piers, Abutments, Piles, Walls	Example	999	☑	☐		Network	✕
Rehab Super - Network	Repair beams, paint and bearings	Example	999	☑	☐		Network	✕
Repaint Super/Sub - Network	Repair Paint	Example	999	☑	☐		Network	✕

First | Previous | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Next | Last

Associated Benefit Groups for Action _Replace Deck

○ Metric ◉ English

Benefit Groups	
Please Select	Add
_Replace Approach Slabs	✕
_Replace Deck	✕
_Replace Joints	✕

Overriding Direct Cost (overrides unit-costs)

Enabled	Field Name	Cost Per Unit	Unit
☑	Deck Area	$ 75	sq.ft

Unit Costs

ID	Element Name	Cost Per Unit	Unit	?	
12	Re Concrete Deck (Replace)	$	sq.ft	■	✕
300	Strip Seal Exp Joint (Replace)	$	ft	■	✕
301	Pourable Joint Seal (Replace)	$	ft	■	✕
302	Compressn Joint Seal (Replace)	$	ft	■	✕
305	Assem Jnt Wthut Seal (Replace)	$	ft	■	✕
306	Other Joint (Replace)	$	ft	■	✕
321	Re Conc Approach Slab (Replace)	$	sq.ft	■	✕
331	Re Conc Bridge Railing (Replace)	$	ft	■	✕

Indirect Cost

Enabled	Component	Estimation Method
☐	Total Indirect Cost	Please Select

Deferment Rules

Action Name	Deferment Interval (Years)	
Please Select		Add
_Rehab Deck	10	✕

and Costs . . .

Associated Benefit Groups for Action _Replace Deck

○ Metric ◉ English

Benefit Groups	
Please Select	Add
_Replace Approach Slabs	✕
_Replace Deck	✕
_Replace Joints	✕

Overriding Direct Cost (overrides unit-costs)

Enabled	Field Name	Cost Per Unit	Unit
☑	Deck Area	$ 75	sq.ft

Unit Costs

ID	Element Name	Cost Per Unit	Unit	?	
12	Re Concrete Deck (Replace)	$	sq.ft		✕
300	Strip Seal Exp Joint (Replace)	$	ft		✕
301	Pourable Joint Seal (Replace)	$	ft		✕
302	Compressn Joint Seal (Replace)	$	ft		✕
305	Assem Jnt Wthut Seal (Replace)	$	ft		✕
306	Other Joint (Replace)	$	ft		✕
321	Re Conc Approach Slab (Replace)	$	sq.ft		✕
331	Re Conc Bridge Railing (Replace)	$	ft		✕

Indirect Cost

Enabled	Component	Estimation Method
☐	Total Indirect Cost	Please Select

Deferment Rules

NDDOT North Dakota Department of Transportation

Actions & Costs for NDDOT – Maintenance Work

- Maintenance Work
  - Routine/Cyclical/Scheduled work
  - Condition-Based
- Typically done by in-house forces; Complex work may be contracted
- Total costs need to include
  - Material
  - Labor
  - Equipment
  - Additional costs, if contracted

Actions & Costs for NDDOT – Rehabilitation Work

- Rehabilitation Work
  - Rehab Deck (Deck Overlay)
  - Rehab Bearings (Repair Bearings)
  - Rehab Superstructure (Rehab Beams and Girders)
- Typically done under contract
- Total costs need to include costs of
  - Either
    - Overriding Direct Cost (per Deck Area) or
    - Unit Costs for Elements
  - Can also include Indirect Costs
    - Engineering
    - Mobilization
    - Other associated costs (Environmental, Permits, Traffic Control, etc.)

Structure Replacement Alternatives at NDDOT

- Replace Structure with Similar Structure
  - Culverts & Standard Bridges
- Replace Bridge with Box Culvert
- Replace Bridge with Longer/Wider Bridge
- Replace "Mega" Bridge

- More accurate costs will result in better decisions

NDDOT
North Dakota
Department of Transportation

Structure Replacement – Similar Structure

- Replace Structure with Similar Structure
  - Culverts
  - Bridges that meet current standards
    - Waterway adequacy
    - Traffic (ADT)
    - Approach roadway width and alignment
- Action: Replace Structure
- Cost: Can use
  - Direct Cost (per deck area)
  - Can use Costs for each Element
  - Can include Indirect Costs
- Benefit:
  - Replace all elements

Overriding Direct Cost (overrides unit-costs)

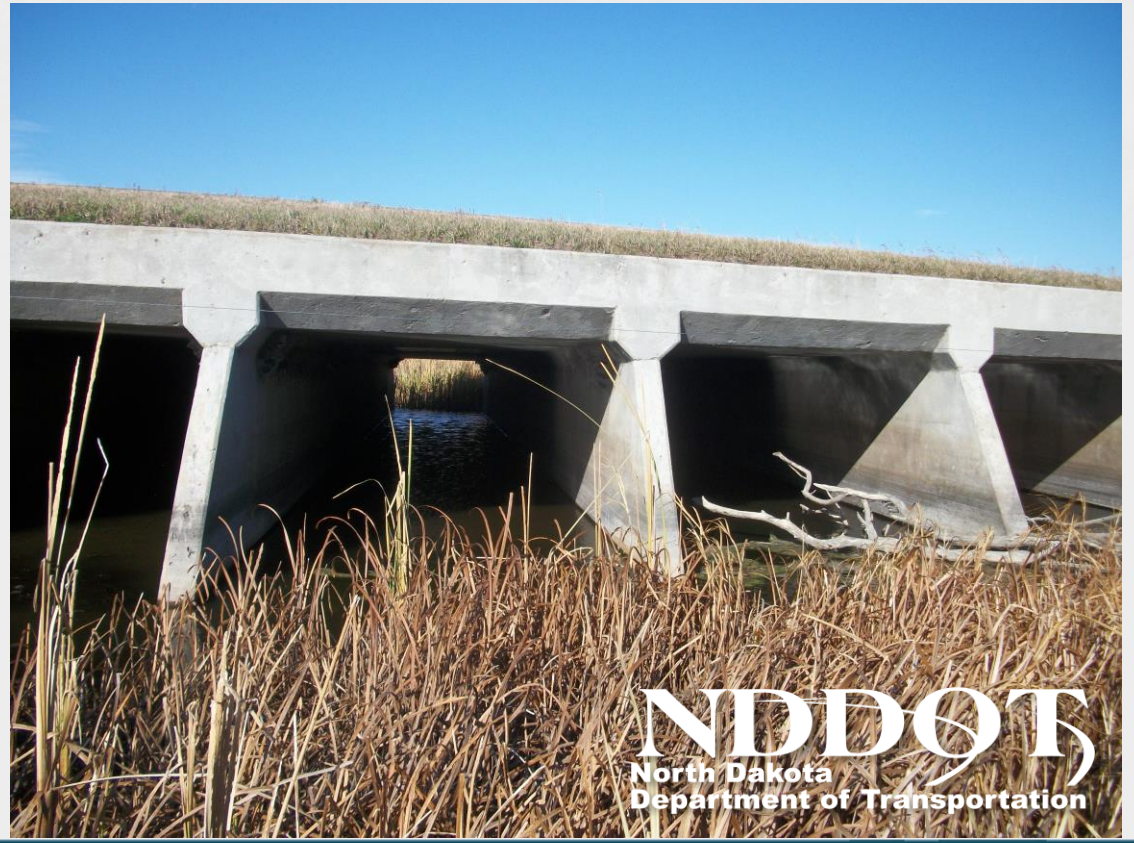
Enabled	Field Name	Cost Per Unit	Unit
☑	Deck Area	$ 400	sq.ft

Unit Costs

ID	Element Name	Cost Per Unit	Unit	?
12	Re Concrete Deck (Replace)	$	sq.ft	
13	Pre Concrete Deck (Replace)	$	sq.ft	
15	Pre Concrete Top Flange (Replace)	$	sq.ft	
16	Re Conc Top Flange (Replace)	$	sq.ft	
28	Steel Deck - Open Grid (Replace)	$	sq.ft	
29	Steel Deck - Conc Fill Grid (Replace)	$	sq.ft	
30	Steel Deck - Orthotropic (Replace)	$	sq.ft	
31	Timber Deck (Replace)	$	sq.ft	
38	Re Concrete Slab (Replace)	$	sq.ft	
54	Timber Slab (Replace)	$	sq.ft	
60	Other Deck (Replace)	$	sq.ft	
65	Other Slab (Replace)	$	sq.ft	
102	Steel Clsd Box Gird (Replace)	$	ft	
104	Pre Clsd Box Girder (Replace)	$	ft	
105	Re Clsd Box Girder (Replace)	$	ft	
107	Steel Opn Girder/Beam (Replace)	$	ft	
109	Pre Opn Conc Girder/Beam (Replace)	$	ft	

Structure Replacement – Replace Bridge with Box Culvert

- Only applicable for
  - Bridges over a waterway (not over roadways, railroads, etc.)
  - Only model those bridges 30’ or shorter
- Action: Replace Bridge with Box Culvert
- Cost
  - Use cost for Reinforced Concrete Culvert Element
- Benefits
  - “Remove” all bridge elements except Abutments
  - “Replace” Abutments with Culvert
  - The New Structure will consist of the replacement element - Reinforced Concrete Culvert



Structure Replacement – Replace Bridge with Box Culvert

- **Admin>Modeling Config>Benefit Groups** Tab
- Remove
- Replace

_Replace Barriers			101			Link to Child Groups
_Replace Bridge w Box Culvert	Replace Bridge w Box Culvert		101			Link to Child Groups
_Replace Deck		_Replace Deck	101			Link to Child Groups
_Replace Joints		_Replace Deck	101			Link to Child Groups
_Replace Paint	Total Re-paint		101			Link to Child Groups
_Replace Wearing Surface			101			Link to Child Groups
Approach Slab Repair	Approach Slab Repair	Approach Slab-Repair				Link to Child Groups
Approach Slab-Overlay	Approach Slab-Overlay	Approach Slab-Overlay				Link to Child Groups
Approach Slab-Replace	Approach Slab-Replace	Approach Slab-Replace				Link to Child Groups

1 2 3 4 Page size: 20 66 items in 4 pages

_Replace Bridge w Box Culvert - Changed Elements

Add new record

Element	Parent	Grandparent	Origin State	CS1	CS2	CS3	CS4
No records to display.							

1 Page size: 20 0 items in 1 pages

_Replace Bridge w Box Culvert - Removed Elements

Add new record

Element	Parent	Grandparent
113 Steel Stringer	None	None

_Replace Bridge w Box Culvert - Replaced Elements

Add new record

Orig. Element	Orig. Parent	New Element	Percent Replaced
215 Re Conc Abutment	None	241 Re Conc Culvert	100

Structure Replacement – Replace Bridge with Longer/Wider Bridge

- Factors that indicate current structure not adequate
  - Deck Geometry (NBI Item 68)
  - Waterway Adequacy (NBI Item 71)
  - Scour Critical (NBI Item 113)
- Action
  - Replace Bridge with Longer/Wider Bridge
- Costs
  - Increase Indirect Cost to (%) to model increased length/width of bridge
- Benefits
  - "Replace" Elements

NDDOT
North Dakota
Department of Transportation

Structure Replacement – "Mega" Bridge

- Larger Bridges: ≥ 20,000 sf
- Over Waterways: Particularly Missouri, Red River, etc.
  - Specialized Design
  - Cofferdams
  - Longer Spans (Barge traffic)
  - Additional Permits
    - Railroad
    - Environmental
- Action: Replace Mega Bridge
- Costs
  - Increase Cost/Deck Area
  - Increase Indirect Cost (%)
- Benefits
  - "Replace" all Elements

Challenges

- Deriving Unit Costs
  - Average per sf Deck cost for some Actions
    - Deck Overlay
    - Deck Replacement
    - Structure Replacement
  - Other Actions not directly related to Deck area
    - Rehab Super
    - Repair Sub (Abutment, Pier)
  - Converting Bid Costs to Element Costs
    - CY Concrete Deck to SF Deck
    - Lb. of Steel to LF Beam
    - CY Concrete Abutment to LF Abutment

NDDOT
North Dakota
Department of Transportation

Questions?


Thank you!
NDDOT
North Dakota
Department of Transportation