WJE

Assess and Prioritize

Keys to Asset Management

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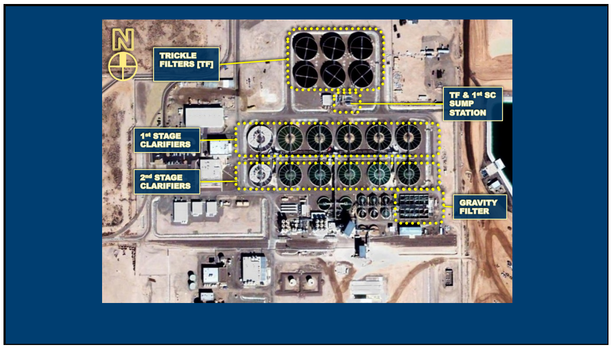
Presentation Outline

- Assessment
- Prioritization Ideas
- Approach for Multiple, Large Assets
  - Developing an Elemental Approach
  - Inspection Types
  - Scoring Methodology

Asset Management

- Establish Priorities
- Develop Input Parameters
- Scoring Methodology

Example: Waste Water Treatment Plant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Establish Priorities
Structural
Operational
Environme
Cost
Safety Hazards
Return on Investment
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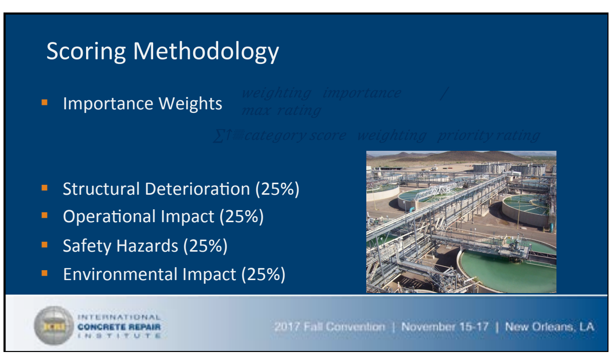
Scoring Methodology
Importance Weights
Structural Deterioration (25%)
Operational Impact (25%)
Safety Hazards (25%)
Environmental Impact (25%)
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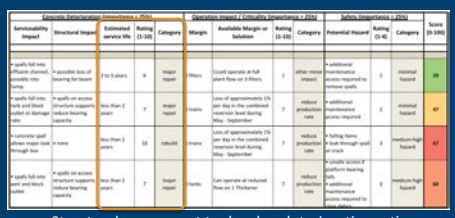
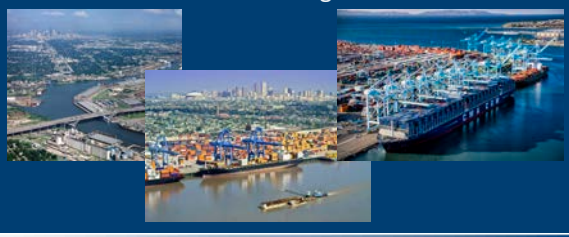
Prioritization Matrix



- Structural assessment to develop deterioration ratings

Port Facilities - Asset Management



Basis for Prioritization

Wharf Characteristics

- Dock Configuration
- Area
- Usage
- Load Rating
- Location on Site
- Channel

Condition Assessment

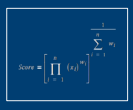
- Element-by-Element
- Current Condition
- Future Condition
- Years of Service Remaining

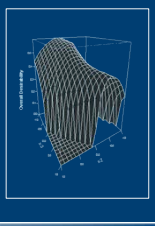
Cost & Revenue

- Cost of Repair Program
  - Maintain current loads?
  - Upgrade to greater loads?
- Revenue
  - Current
  - Projected (no repairs)
  - Projected (with repairs)

Final Scoring

- Desirability Approach
  - Individual Score: 0 to 1
  - Overall Score: Geometric Mean

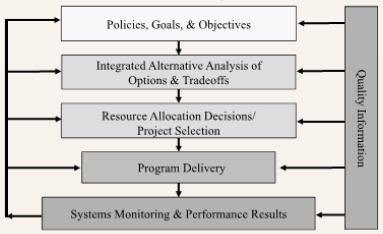




Asset Management Plan

- Objectives and Measure
- Performance Gap Identification
- Lifecycle Cost & Risk Management Analysis
- Financial Planning – Capital Budget

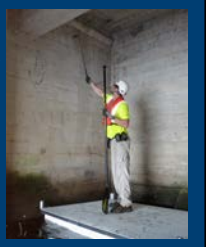
Asset Management



Source: NCHRP 20-24 (11) - Asset Management Guidance for Transportation Agencies

Facility Inspection Program

- Database of Asset Inspection and Inventory
- Element-level Inspection
  - Feeds into Component-level Data
  - Rates Asset Performance
  - Monitors Deterioration
- Maximizes Owner Benefits
- Minimizes Owner Costs



Element-based Inspection Approach

- Inspections are conducted at the **element level**
  - Provides level of detail necessary for credible condition assessment
  - Damage/deterioration characterized by element and material type
- Element condition used to determine **component ratings**
  - Engineering interpretation of element condition states and corresponding impact on component condition
  - Guides Follow-up Actions
- Component ratings used to determine overall **asset condition assessment**

Hierarchy of Facility Terms – Elemental-based

Property or Terminal → **Maritime Asset** → **Component** → **Element**

- Consists of several maritime assets
- e.g., Container Terminal, Bulk Caro Terminal, Transportation Area

Maritime Asset

- Wharf
- Boat Dock
- Bulkhead
- Shoreline
- Consists of One or More Components

Component

- Structural or Non-structural System of Elements
- Structural (e.g., superstructure, bulkhead)
- Berthing System
- Shoreline
- Ancillary (e.g., crane rails, access systems)

Element

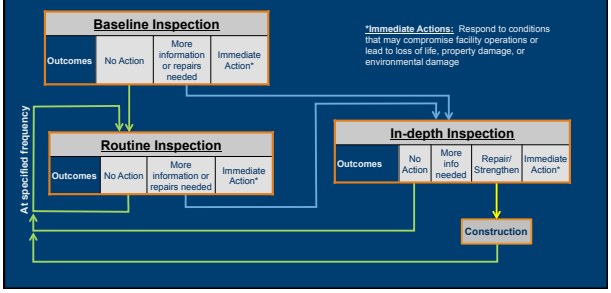
- Individual Elements that Make Up a Component
- Structural or Non-structural
- e.g., RC slab, RC deck beam, steel pile, timber pile, cleat, bollard, wearing surface

Inspection Types

Primary aspects

Type	Sub-type	Primary Objective
Baseline	Above Water	Inspection to establish the baseline (initial) asset inventory information, element condition states, component ratings, and asset condition for a new asset or for an existing asset where no previous record exists.
	Underwater	
Routine	Above Water	Regularly-scheduled inspection to define asset condition, component ratings, and element condition states at a point in time and to allow tracking of conditions over time.
	Underwater	
Special	Post-event	Rapid inspection to assess overall condition following an extreme event such as a hurricane, flood, or vessel impact.
	In-depth	In-depth inspection to determine cause and/or significance of damage or distress, to aid in determining a suitable repair approach, or to define quantities necessary for repair purposes.
	Due Diligence	Inspection to establish the general condition, asset value, or need for and approximate cost of repairs, at times of change of ownership, lease, or for insurance purposes.

Relationship Between Inspection Types



Baseline Inspection

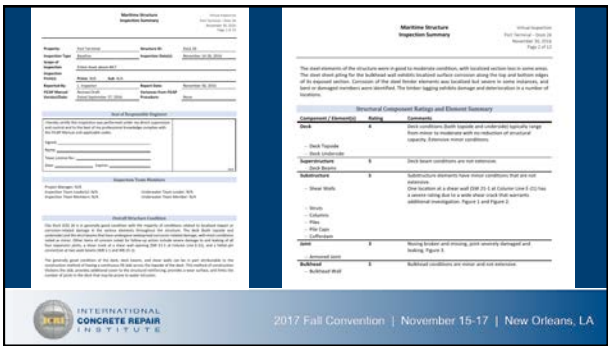
- Applies to:
  - New assets
  - Existing assets without previous inspection documentation
  - Above water (visual) and underwater
- Objectives:
  - Develop asset inventory record (reference for future inspections)
  - Inspect elements to set baseline condition states
  - Determine component condition ratings & asset condition assessment

Baseline Inspection

- Deliverables:
  - Asset Inventory Record (standard form created during baseline inspection)
    - Asset Description and History
    - List of Components and Elements
    - Photographs (typical)
  - Standard Inspection Drawings
    - Cumulative As-built
    - Using standard reference grid system and component/element names

Baseline Inspection

- Deliverables *(continued)*:
  - Baseline Condition
    - Element condition states and quantities (Elemental Inspection Form)
    - Component condition rating and overall asset condition (Inspection Summary Form)
  - List of recommended follow-up actions (Follow-up Actions Form)



Routine Inspection

- Applies to:
  - Existing assets with previous Baseline Inspection
  - Above water (visual) and underwater
- Objectives:
  - Document asset condition at pre-defined time intervals
    - Visual inspection of elements to set current condition states
    - Determine component ratings & overall asset condition assessment
    - Allows tracking of conditions over time

Routine Inspection

- Routine Inspection Frequency
  - Max. once every 3 years for above water
  - Max. once every 6 years for underwater *Determined by AHJ
  - May be more frequent* for assets with severe deterioration or heavy use
  - May be less frequent* for new assets
- Works from Existing Documentation (from Baseline Inspection):
  - Asset Inventory Record
  - Standard Inspection Drawings
  - Previous Inspection Records (forms, quantities, previous condition, etc.)

Discussion – Inspection Frequency

Source	Max. Above Water	Max. Underwater	Comments
WJE	3 yrs	6 yrs	• Interval may be reduced or increased depending on condition or use • Specific guidance is not provided in Manual • Engineer recommends, PHA decides
Bridges (FHWA BIRM)	2 yrs	5 yrs	• Interval may be reduced or increased depending on condition or use • FHWA must approve increases
Waterfront Structures	0.5 to 6 yrs (ASCE 130)	0.5 to 6 yrs (ASCE 101)	• Interval depends on previous condition rating, material and environment (see ASCE 130 Table 2-2)

Routine Inspection

- Deliverables:
  - Current Condition
    - Element condition states and quantities (Elemental Inspection Form)
    - Component ratings and overall asset condition (Inspection Summary Form)
  - List of Recommended Follow-up Actions (Follow-up Actions Form)

Baseline and Routine Inspection Outcomes

- No further action required, schedule next Routine Inspection
- More information or repairs are required
  - In-depth Inspection is needed to assess cause/severity of condition, determine repair quantities, etc.
  - Engineering Analysis may be recommended
  - Followed by implementation of repairs/strengthening
- Immediate action required
  - Address conditions that may compromise facility operations or lead to loss of life, property damage or environmental damage

Element-type Descriptions

- Components of an asset are made up of individual elements
- Element types are defined by structural or functional purpose and material type
  - Structural: load-carrying elements, such as a beam, slab, or pile
  - Non-structural: wearing surface, railing, or coating
- Element types need to be provided
- Elements for a particular asset must be listed on Asset Inventory Record form

Element-type Descriptions

- Defined in Terms of:
  - Associated Component
  - Element Code
  - Element Descriptor
  - Element Identification
  - Measured Units

Associated Component	Element Code(s)	Element Descriptor	Element Identification	Units[1]
Deck	DK001 DK002 DK003 DK004 DK005	RC Deck PC Deck ST Deck, Open Grid TI Deck OT Deck	Top surface of a structure, primarily horizontal. Carries and distributes loads to superstructure elements below.	SF
	DK006 DK007	RC Wearing Surface OT Wearing Surface	Wearing materials 1/2-inch in thickness or more on a deck surface. Wearing slabs do add structural capacity to the deck. Includes asphalt overlays.	SF
	DK008	RC Bonded Overlay	Concrete material cast on top of and bonded to a deck surface. This type of overlay may add structural capacity to the deck.	SF
Super-structure	SP001 SP002	RC Deck Beam PS Deck Beam	Horizontal structural elements that transmit load directly from the deck to a supporting element(s).	LF
	SP003	RC Frontal Beam	The first beam at the front of the wharf, contiguous with the wharf deck.	LF
	SP004 SP005	RC Girder PS Girder	Horizontal element that transmit load from a beam element or deck directly to the substructure.	LF
	SP006	Timber Stringer	Repeating horizontal elements that transmit loads from deck to supporting element(s). Member is 5 inches or more thick.	LF
	SP007	Timber Joist	Repeating horizontal elements that transmit loads from deck to supporting element(s). Member is less than 5 inches thick.	LF

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Element Condition States

- Fundamental aspect of element-based inspection *(applies to Baseline, Routine and Due Diligence Inspections)*
- Used to document condition of individual elements
  - Type of damage or deterioration *(e.g., structural steel or reinforcement corrosion, concrete spalling, wood decay, impact damage, or wear)*
  - Severity of damage or deterioration *(e.g., type and size of defects, section loss, etc.)*
  - Scope or extent of damage or deterioration *(quantified by the length, area, or number of units having the condition state in question)*

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FICAP Manual – Chapter 3 Elements & Element Condition States

Four Element Condition States

Condition State	Damage or Deterioration	Impact on Structural or Functional Performance	Need for Further Inspection or Structural Review
CS1 Good	None or Acceptable	None	Not Required
CS2 Fair	Minor	None or Negligible	Not Required
CS3 Poor	Moderate	May be Affected	May be Required
CS4 Severe	Significant	Use of Asset is Affected	Required

Table 3.3. Example of Selected Condition States for Reinforced Concrete

Code	Condition	Definition	Condition States			
			CS1 (Good)	CS2 (Fair)	CS3 (Poor)	CS4 (Severe)
ABWC	Abrasion / Wear (Concrete)	Abrasion or wear in concrete elements (RC, PC, PS, or UC)	No observable abrasion or wear	Coarse aggregate is exposed but remains secure in concrete matrix	Coarse aggregate has been exposed and is loosened from concrete matrix due to wear	N/A
CRKC	Crack (Concrete)	Cracking in concrete elements (RC, PC, PS, or UC)	Insignificant cracks or moderate-width cracks that have been sealed.	Unsealed moderate-width cracks or moderate map cracking.	Wide cracks (excluding shear-type cracks) or severe map cracking.	Wide shear cracks or other cracks that could impact capacity of the element
DLSP	Delamination / Spall	Spalls or delaminations in concrete elements (RC, PC, PS, or UC)	No delaminations or spalled areas	Distressed area less than 1 foot in length or width, and depth not in excess of first layer of reinforcement	Distressed areas less than 5 feet in length or width and not in excess of first layer of reinforcement	Distressed areas exceed 5 feet in length of width or deeper than first layer of reinforcement
EXPR	Exposed Reinforcement	Exposed conventional reinforcement in concrete elements (RC, PC, PS, or UC). Excludes prestress strands.	No exposed reinforcement	Present without measurable section loss.	Present with measurable section loss.	Present with measurable section loss that could impact capacity of element.

Documenting Element Condition States

(recorded on Elemental Inspection Form)

Table 3.4. Example of Condition States for Deck Elements

Element Location ID	Element / Condition Code	Units	Total Quantity	In-accessible	Condition States (quantity [counted with other CS])			
					CS1	CS2	CS3	CS4
DT5-1	DK001	SF	400	0	350	0	30	20
	– *DLSP*	*SF*	*50*				*30*	*20*
	– *EXRB*	*SF*	*15*			*0 [15]*		
DT5-2	DK001	SF	400	20	160	145	75	0
	– *CRKC*	*SF*	*200*			*125 [20]*	*75*	
	– *DLSP*	*SF*	*20*			*20*		
Deck Subtotal	**DK001**	**SF**	**800**	**20**	**510**	**145**	**105**	**20**

Element Type | Condition Code | Total Element Area | Total Area at CS2 | Area of DLSP at CS2 | Area of CRKC at CS2

Components

- Group of elements forming a structural or non-structural system
- Boundaries dictated by structural or functional purpose, changes in structural system, framing, or construction material
- Component types are defined during the Baseline Inspection
  - Should be referred to for all subsequent routine or other inspections

Component Types and Definitions

Structural Components: group of elements that comprises a structural system (e.g., deck, superstructure, bulkhead)

Berthing Components: group of elements that serves a functional purpose related to the berthing of vessels (e.g., mooring system or fender system)

Shoreline Components: group of elements (or single element) that defines channel shoreline (e.g., unprotected shoreline, rip-rap)

Ancillary Components: group of elements that serves a purpose other than categorized as above (e.g., utility systems, paint and markings, personnel access systems)

Four Primary Asset Types

- Wharves
  - Open platform with open structure
  - Open platform with solid structure
  - Solid bulkhead
  - Solid bulkhead with relieving platform
- Boat Docks
- Bulkheads (not associated with a wharf or boat dock)
- Shoreline (protected or unprotected)

Condition Rating – Components and Assets

- Primary Objectives of Condition Rating:
  - Provide the condition information to support asset management and maintenance programs
  - Identify conditions requiring actions
- Condition information is provided in terms of:
  - Component Ratings: based on engineering assessment of element condition states
  - Overall Asset Condition Assessment: based on Component Ratings

Component Rating

- Applicable to Baseline, Routine, and Due Diligence Inspections
- Assigned relative to assumed as-built condition
  - Intended to reflect effects of defects, deterioration, or damage
  - Not intended to reflect current or future use/loading, which may be different from that at the time of original construction
- Consider implication of observed element condition(s) on structural integrity, serviceability, and functionality of component

Table 6.1. Ratings for Structural and Berthing Components

Rating	Description
6 Good	Minor or no problems noted. Also applies to newly constructed or rehabilitated components.
5 Satisfactory	Minor defects, damage or deterioration - not extensive.
4 Fair	Extensive minor or limited moderate defects, damage or deterioration. Structural capacity of primary structural components and functional use of fender or mooring systems are not affected.
3 Poor	Moderate or extensive defects, damage or deterioration that affects structural capacity of primary structural components or functional use of fender or mooring system components.
2 Serious	Defects, damage or deterioration significantly reduces structural capacity of primary structural components or reduces functional use of fender or mooring systems.
1 Critical	Advanced defects, damage or deterioration with localized failure(s) of components imminent or observed. Immediate load or use restrictions, including closing of the asset should be considered.
Applicable Component Types: Deck, superstructure, substructure, bearings, bulkheads, mooring and fender systems.	

Table 6.2: Ratings for Shoreline Components

Rating	Description
6 Good	Minor or no problems noted. Also applies to newly constructed or rehabilitated shoreline components.
5 Satisfactory	Minor defects, damage or deterioration - not extensive.
4 Fair	Protected shoreline: Extensive minor or limited moderate defects, damage or deterioration observed but does not affect shoreline protection. Unprotected shoreline: Extensive minor or limited moderate indications of shoreline beginning to slump. May be minor movement of shoreline.
3 Poor	Protected shoreline: Moderate or extensive deterioration or displacement that affects shoreline protection. Unprotected shoreline: Moderate or extensive indications of shoreline slumping or movement.
2 Serious	Protected shoreline: Deterioration, displacement, or breakage significantly affects the shoreline protection and local failures are possible. Unprotected shoreline: Shoreline is being eroded. Local slump or embankment failures are present. Use restrictions may be necessary for roadways, railways and working areas near shoreline.
1 Critical	Protected shoreline: Very advanced deterioration, displacement, or breakage with localized failure(s) of primary shoreline protection imminent or observed. Shoreline is being eroded and/or shoreline movement has occurred. Unprotected shoreline: Widespread erosion and/or slump or embankment failures have occurred. More widespread failures are possible or likely to occur. Immediate actions, such as emergency shoreline protection measures, use restrictions, or barricading of roadways, railways and working areas near the shoreline should be considered.
Applicable Component Types: Protected shoreline, unprotected shoreline.	

Table 6.3: Functional Ratings for Ancillary Components

Rating	Description
6 Good	Minor or no problems noted. Also applies to newly constructed or rehabilitated protective components.
5 Satisfactory	Minor defects, damage or deterioration - not extensive.
4 Fair	Extensive minor or limited moderate defects, damage or deterioration. All primary elements and their attachment to the asset are sound and functional purpose/use of the component is not affected. Minor repairs or maintenance may be required.
3 Poor	Moderate or extensive defects, damage or deterioration that affects functional purpose/use of the component or compromises attachment of the component to the asset.
2 Serious	Defects, damage or deterioration significantly affects functional purpose/use of the component and/or local failures of the attachment to the asset are present.
1 Critical	Advanced damage or deterioration has resulted in frequent imminent or observed failure(s) of the attachment of the component to the asset. The component may no longer serve its functional purpose/use and/or conditions are present that may lead to property damage or environmental damage. Immediate repairs or other protective measures should be considered, and/or immediate use restrictions should be considered for components affected.
Applicable Component Types: Joints, utility system supports, paint and markings, crane and train rails, personnel access systems.	

Overall Asset Condition Assessment

- Overall Asset Rating (AR) for Baseline, Routine, and Due Diligence Inspections
  - Reflects overall adequacy and safety of the asset
  - Based on ratings for structural and non-structural components

$AR = SR + FR$ for all assets except shorelines

$AR = 4 \times FR$ for shoreline assets

$0 \le AR \le 100$

Entirely deficient — Entirely adequate and safe

Structural Component Combined Rating (SR)

- Combined rating based on adequacy and safety of structural components (deck, superstructure, substructure, and bulkhead)

$SR = 75 - (SP + SB + DK + BH) \ge 0$ *(max. 75)*

Deductions based on Component Ratings

Depends on

- Significance of component to safety (structural, personnel, environmental) of asset
- Significance of component to functional adequacy of asset
- Ease of maintenance, repair, and/or replacement of component

Functional Component Combined Rating (FR)

- Combined rating based on adequacy and safety of functional components (bearings, joints, fender and mooring systems, shoreline, and ancillary)

$$FR = 25 - (BR + JN + FS + MS + SH + AC) \geq 0 \quad (max.\ 25)$$

Deductions based on Component Ratings

Depends on

- Significance of component to safety (structural, personnel, environmental) of asset
- Significance of component to functional adequacy of asset
- Ease of maintenance, repair, and/or replacement of component

Deduction Tables

Table 6.5: SR Deduction Table

Component Rating	SR Deductions by Component: Super-structure (SP)	Sub-structure (SB)	Deck (DK)	Bulkhead (BH)
= 1	50	60	20	60
= 2	25	30	10	30
= 3	13	15	5	15
= 4	6	8	3	8
= 5	3	4	1	4
= 6	0	0	0	0

Table 6.6: FR Deduction Table

Component Rating	FR Deductions by Component: Slabs & Wearing Surfaces SL, WS	Joints & Bearings JN, BR	Fender System FS	Mooring System MR	Shoreline SH	Ancillary Comp. AC
= 1	20	15	25	25	25	10
= 2	10	8	13	13	13	5
= 3	5	4	6	6	6	3
= 4	3	2	3	3	3	1
= 5	1	1	2	2	2	1
= 6	0	0	0	0	0	0

Sample Calculations for 4 Hypothetical Assets

Components: Group	Type	Component Ratings: Dock1	Dock 5	Wharf 20	Dock 10		Deductions by Component: Dock1	Dock 5	Wharf 20	Dock 10
Structural Components	Superstructure	3	6	5	4	SP	13	0	3	6
	Substructure	4	5	5	4	SB	8	4	4	8
	Deck	4	5	3	4	DK	3	1	5	3
	Bulkhead	5	5	4	2	BH	4	4	8	30
Non-Structural Components	Bearings	NA	NA	NA	NA	BR	0	0	0	0
	Joints	4	6	4	4	JN	2	0	2	2
	Fender System	2	6	4	2	FS	13	0	3	13
	Mooring System	5	6	5	5	MS	2	0	2	2
	Shoreline Comp.	NA	NA	NA	NA	SH	0	0	0	0
	Ancillary Comp.	3	5	5	4	AC	3	1	1	1
	Asset Rating	52	90	72	35	SR =	47	66	55	28
Note: NA = component type not applicable to asset.						FR =	5	24	17	7

Example Dock 1

Component	SR Deduction	Comments
Superstructure:	For component rating of 3, SP is 13	A component rating of 3 represents poor condition in a key structural component, resulting in a substantial deduction of 13.
Substructure:	For component rating of 4, SB is 8	While the ratings for these components are the same, the deduction for the deck (DK) is less. While the deck is structurally significant, this slightly lower deduction reflects the fact that deck repairs are more easily implemented, and thus have a slightly lower negative impact on the overall condition of the asset.
Deck:	For component rating of 4, DK is 3	
Bulkhead:	For component rating of 5, BH is 4	Minor deduction for component rating of 5 reflects satisfactory condition and limited impact on asset condition.

Calculate SR:

$SR = 75 - (SP + SB + DK + BH) \geq 0$
$= 75 - (13 + 8 + 3 + 4)$
$= 47$

Calculate FR:

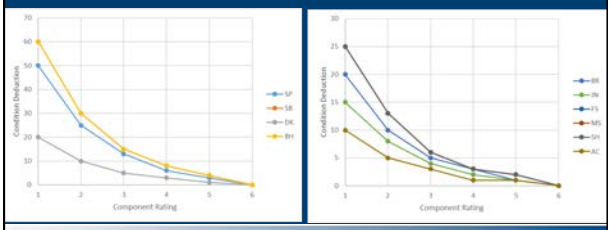
$FR = 25 - (BR + JN + FS + MS + SH + AC) \geq 0$
$= 25 - (0 + 2 + 13 + 2 + 0 + 3)$
$= 5$

Calculate ACR:

$ACR = SR + FR$
$= 47 + 5$

ACR = 52 for Asset 1

Geometric Series



Recommended Follow-up Action Guidelines

- Each inspection must include recommended Follow-up Actions
  - Five categories: Immediate Action, Investigation Recommendations, In-depth Investigation, Engineering Analysis, No Action Required
  - Depends on the severity and implications of the conditions observed
  - More than one action may arise from an inspection (must be prioritized)
  - Brief justification must be provided for any recommended actions
- Recommended actions documented on Follow-up Actions Form

Follow-up Action Types

1. Immediate Actions

Follow-up Action Types

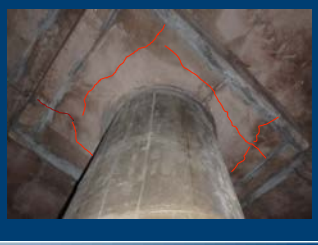
2. Investigation Recommendations
   - Actions required to address non-urgent (not safety related) conditions

Follow-up Action Types

3. In-depth Investigation
   - May be recommended to provide more information to assess atypical conditions observed during Routine, Baseline, or Due Diligence Inspections
     - Determine the cause or significance of deterioration
     - Collect detailed condition and quantity information necessary to develop repair design
     - Verify or determine as-built conditions (where information is unavailable)
   - Normally required for the preparation of repair design and construction documents for all but the most routine of repairs

Follow-up Action Types

4. Engineering Analysis
   - May be recommended to provide more thorough assessment of asset condition



Follow-up Action Types

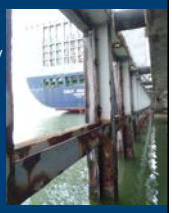
5. No Action Required
   - Observed conditions are such that none of the preceding Follow-up Actions are required
   - No further action is required until next Routine Inspection
   - Inspection Team/Engineer should provide recommendation for timing of next Routine Inspection

Standardized Reporting

- Documentation and reporting is standardized
  - Efficiency in inspection and reporting
  - Enable comparison among assets
  - Facilitate data storage and analysis
- Form-based approach is used for Baseline, Routine, Due Diligence, and Post-event Inspections (In-depth requires "custom" reporting)
- Two categories of documentation
  - Asset Description (1 form plus standard drawings)
  - Inspection Documentation (4 forms)

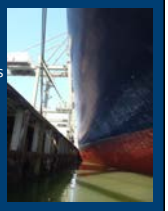
Asset Description Reporting

- Inventory Record Form
  - Describes as-built condition of the asset and history
  - Revised after modifications or significant repairs
  - Created as part of a Baseline Inspection
- Standard Inspection Drawings
  - Documents cumulative as-built configuration
  - May be adapted for use as inspection drawings (field notes, documentation of conditions)
  - Created as part of a Baseline Inspection



Inspection Documentation

- Inspection Summary Form
  - Asset Condition Rating (AR) and Narrative
  - Component Condition Ratings & Element Summaries
  - Representative Photos
  - Baseline, Routine, Due Diligence, and Post-event Inspections
- Element Inspection Form
  - Documents Element Condition States
  - Baseline, Routine, and Due Diligence Inspections

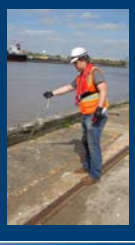


Inspection Documentation

- Inspection History Form
  - Record of all inspections
  - Summary of component and asset ratings
- Follow-up Action Form
  - Documents recommended follow-up actions
  - Created for Baseline, Routine, Due Diligence, and Post-event Inspections

Documentation for In-Depth Inspections

- Objective and Scope can vary
- Documentation does not use standard forms
- Report requirements:
  - Objective and Scope
  - Methodology and reference to standards
  - Record and interpretation of observations and data, including field or laboratory data
  - Recommendations
  - Summary



Summary: Assess and Prioritize

1. Establish Priorities for Asset Management
2. Condition Assessment
   - ✓ Concrete Inspection & Evaluation
   - ✓ Predicting Service Life
3. Prioritize Based on Assessment Results
4. Use AR to develop long-time capital expenditures

Questions…?

WJE

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