

UNDERWATER INSPECTION OF THE GOLDEN GATE BRIDGE: THE IMAGE OF AN ICON

Presented by:

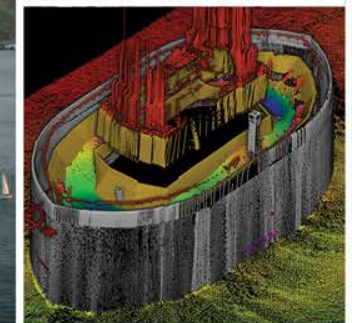
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ENGINEERS INC

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Chief Structural Engineer/Diver

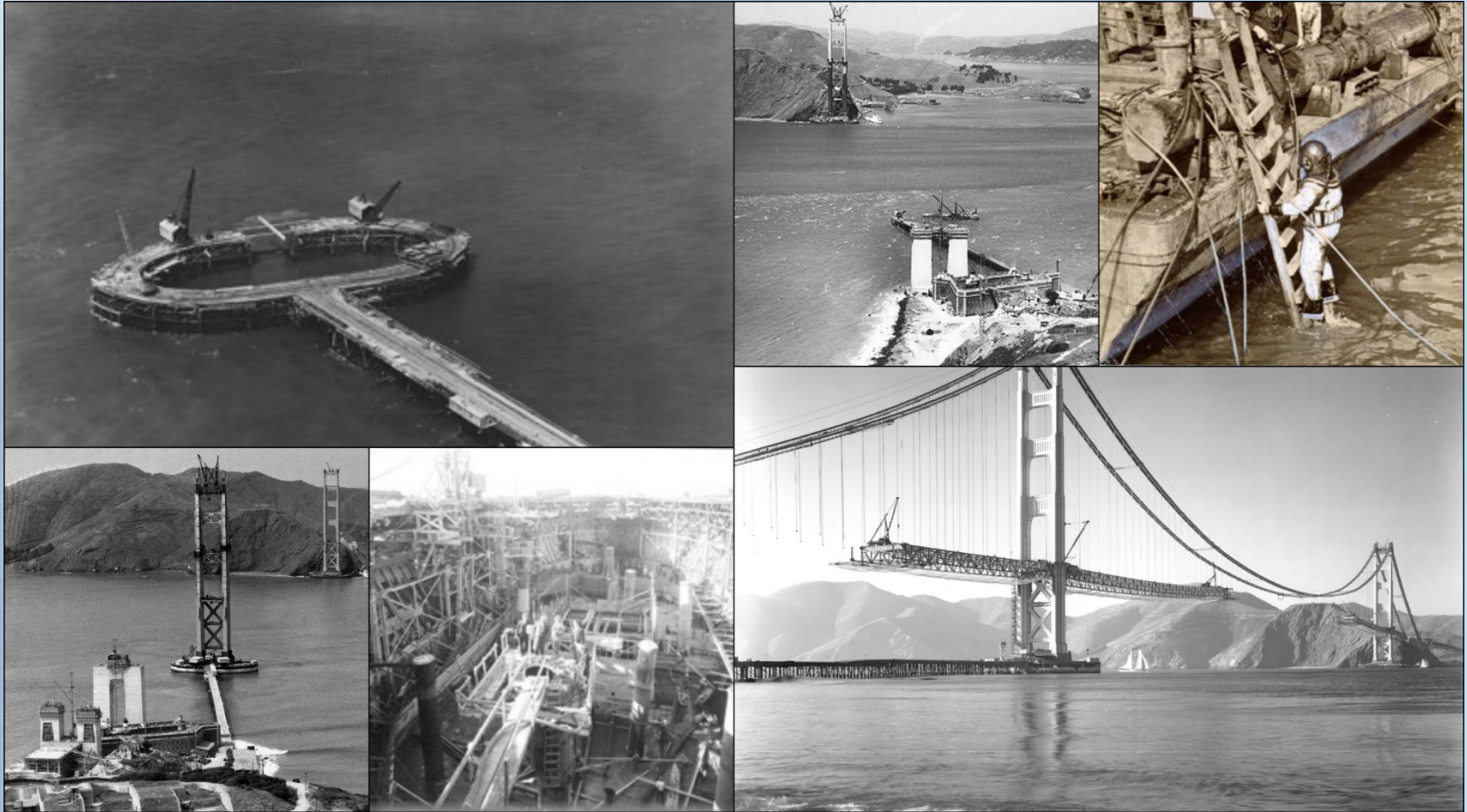
In collaboration with:



John Eberle, P.E.
Deputy District Engineer
&
Wilson Lau, P.E.,
Supervising Civil Engineer

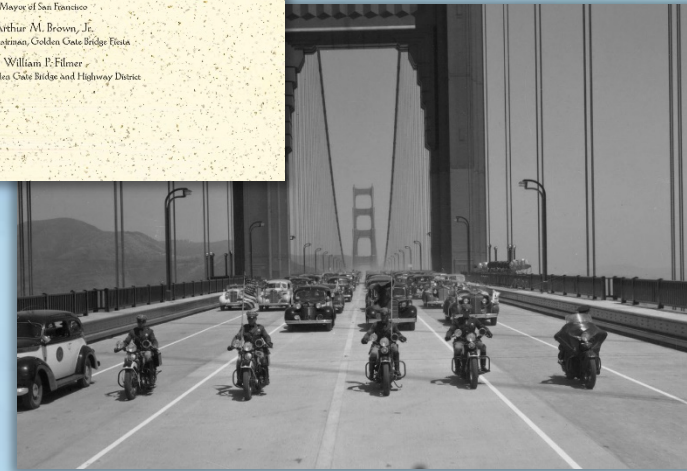
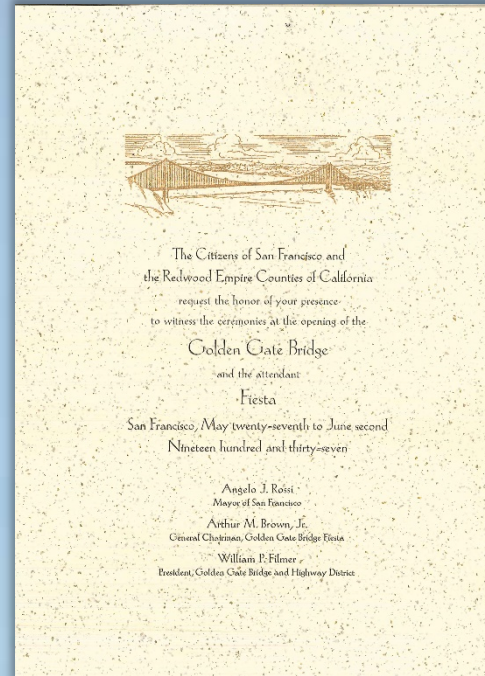


Golden Gate Bridge History



Golden Gate Bridge History

- August 27, 1930: Joseph B. Strauss submits final plans
- January 5, 1933: Construction officially starts
- January-June 1933: Marin pier construction
- November 1933-June 1934: Marin tower construction
- March 1933-November 1934: San Francisco pier fender construction
- November 1934-January 1935: San Francisco pier construction
- January-June 1935: San Francisco tower construction
- August 1935-April 1937: Superstructure construction
- May 27, 1937: Grand Opening



Golden Gate Bridge Statistics

- 8,891 ft. total length with 4,200 ft. main span
- 220 ft. vertical waterway clearance
- 7,260 ft. of 36 in. diameter cable with 80,000 miles of wire
- Towers
 - 746 ft. above water and 500 ft. above roadway
 - 44,000 tons and more than 600,000 rivets in each



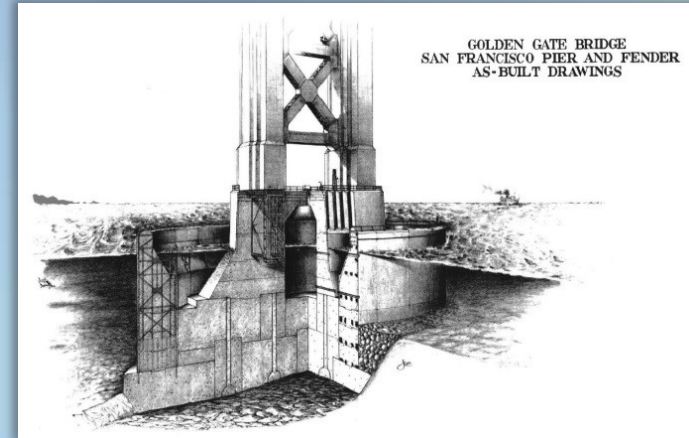
Golden Gate Bridge Statistics

- Maximum design downward deflection = 10.8 ft.
- Maximum design transverse deflection = 27.7 ft.
- 38 million crossings per year (3.3 million in 1937)



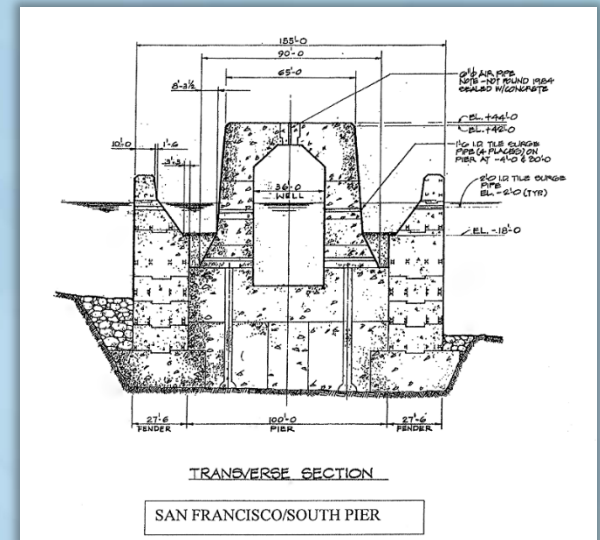
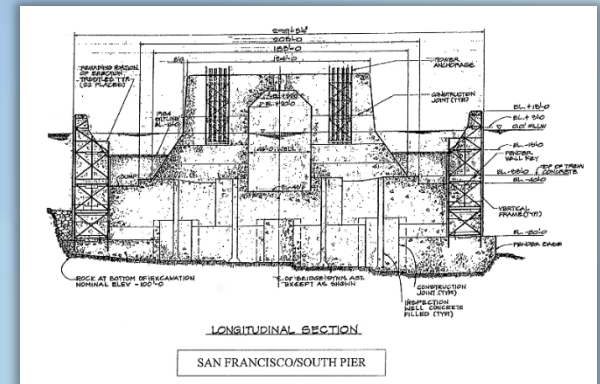
San Francisco (South) Tower Pier

- Constructed within dewatered fender
- Fender details
 - Encloses football field-sized area
 - Over 120 ft. maximum height in 75 ft. average water depth
 - 40 ft. maximum wall thickness
 - Over 105,000 cu. yds. of concrete
 - Pier protection from fog-bound ships



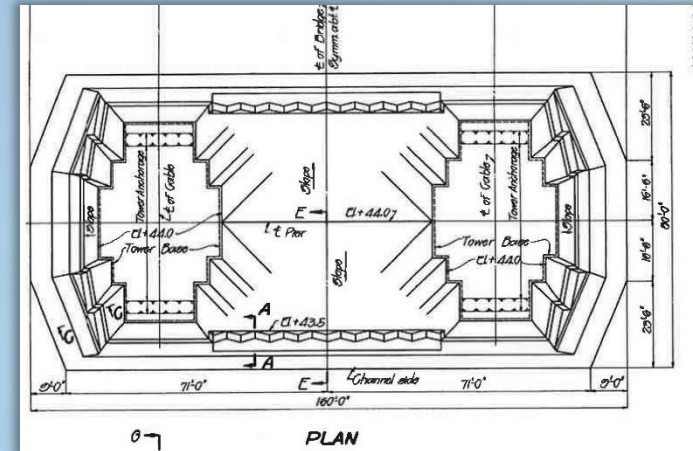
San Francisco (South) Tower Pier

- 140 ft. long by 66 ft. wide
- Supports two 34 ft. by 33 ft. tower legs
- Foundation keyed into bedrock at 110 ft. below sea level
- 23,500 cu. yds. of concrete
- Within 40 ft. thick fender walls



Marin (North) Tower Pier

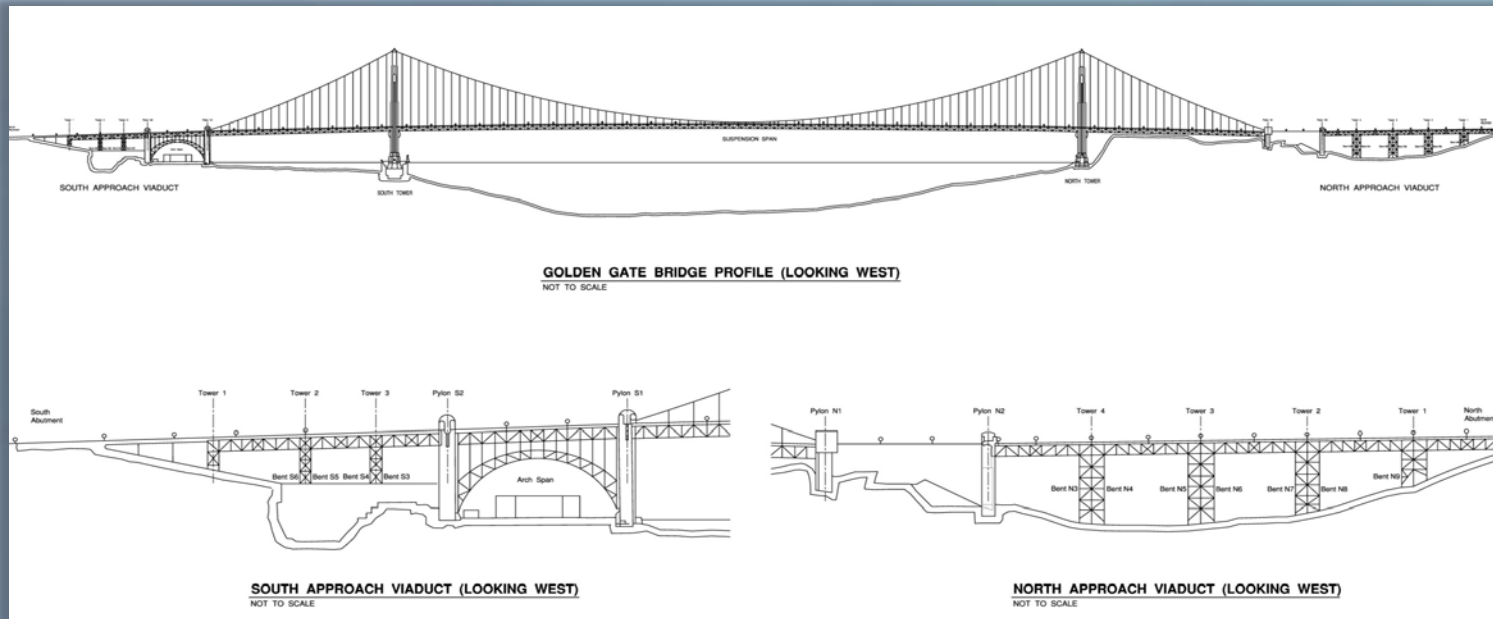
- Constructed within dewatered cofferdam
- Same general size as South Tower Pier
- Supports two 54 ft. by 33 ft. tower legs
- Keyed into bedrock with 160 ft. by 80 ft. base dimension
- 23,500 cu. yds. of concrete



Golden Gate Bridge Bridge Inspection Program

Golden Gate Bridge Structures

- South approach viaduct (girder spans, truss spans and arch span)
- Suspension spans
- North approach viaduct



Golden Gate Bridge Bridge Inspection Program

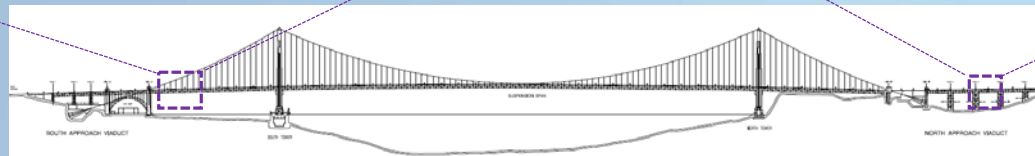
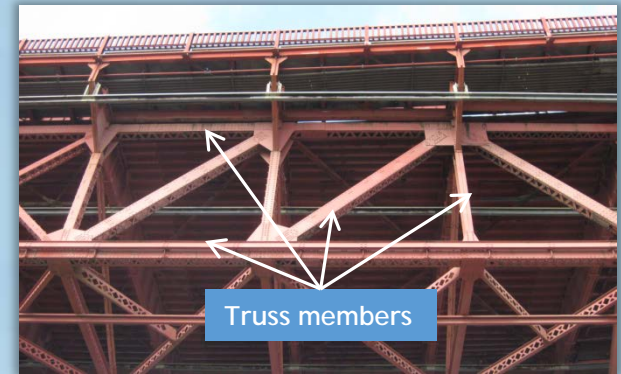
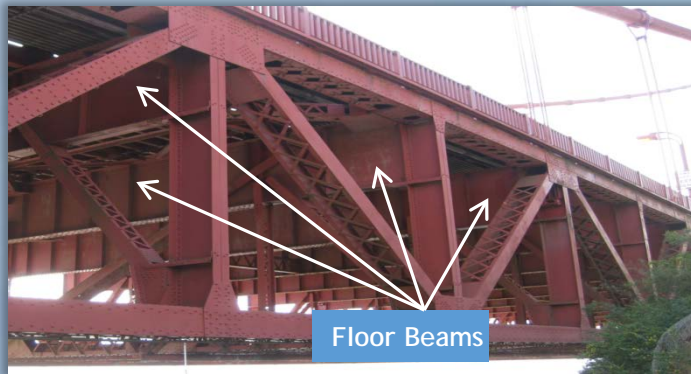
- Inspection Frequency and Elements
 - Fracture Critical Inspection: every 24 months
 - Complex Bridge Inspection: every 24 months
 - Routine Bridge Inspection: every 24 months
 - Underwater Bridge Inspection: every 60 months
- Inspection Team and Qualifications
 - Program Manager
 - Team Leaders and Inspectors: 8 engineers/inspectors
 - Training: Current certification in compliance with FHWA bridge inspection requirement, approved comprehensive bridge inspection training course, and Fracture Critical Inspection Techniques for Steel Bridges



Golden Gate Bridge Bridge Inspection Program

Fracture Critical Element Inspection

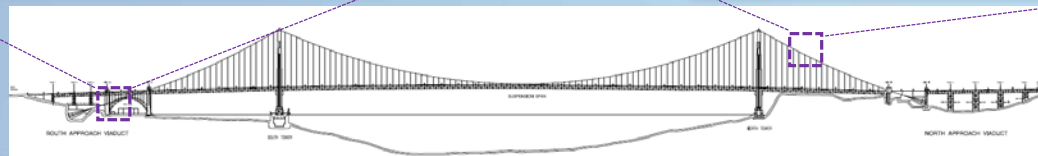
- Fracture Critical Element (FCM) is a steel member in tension, whose failure would probably cause a portion of or the entire bridge to collapse
- Requires hands-on inspection within arms' length
- Utilizes outer and inner travelers for FCM inspection



Golden Gate Bridge Bridge Inspection Program

Complex Bridge Element Inspection

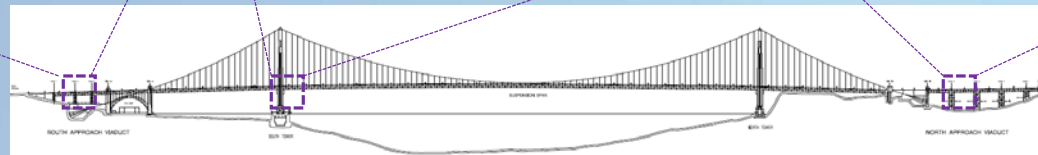
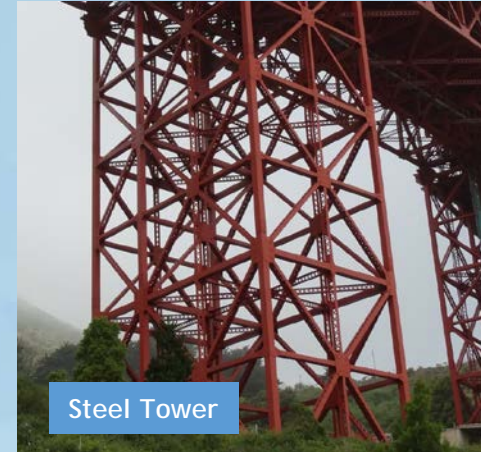
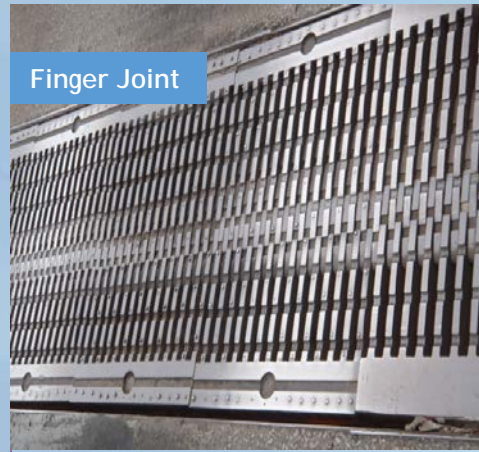
- Complex Bridge Elements (CBEs) are related to suspension features and seismic devices of the bridge
- Visual inspection by utilizing the best available access for this inspection, e.g., fall protection, catwalk, ground, ladder and etc.



Golden Gate Bridge Bridge Inspection Program

Routine Bridge Element Inspection

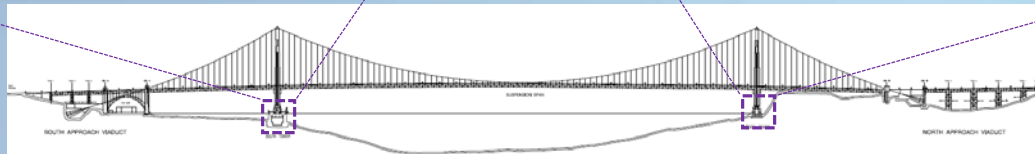
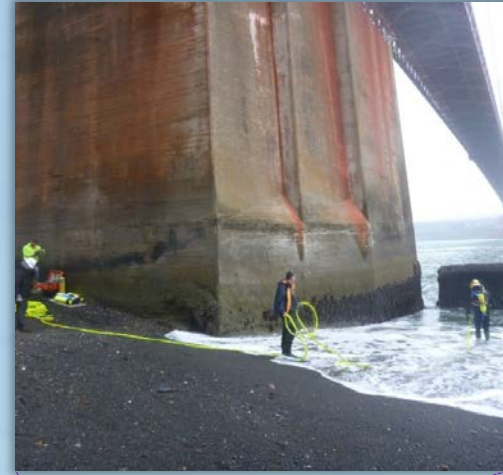
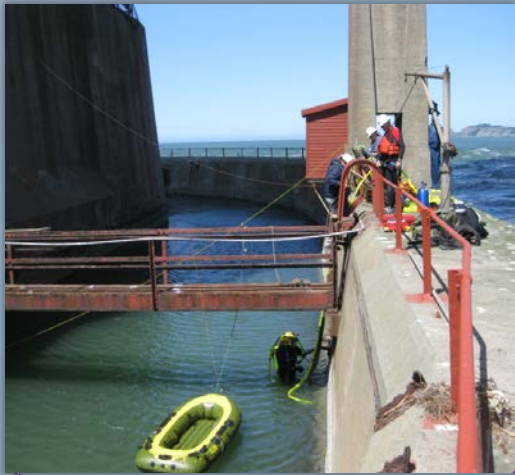
- Routine Bridge Elements (RBEs) cover most areas and elements of the bridge
- Perform visual inspection and utilize the best available access for this inspection, e.g., fall protection, catwalk, ground, ladder, etc.



Golden Gate Bridge Bridge Inspection Program

Underwater Bridge Inspection

- Level 1 – Visual, tactile inspection
- Level 2 – Detailed inspection with partial cleaning
- Level 3 – Highly detailed inspection with NDT or PDT based on Level 1 and 2 results



South and North Tower Piers Underwater Bridge Inspection Services

- Underwater sonar scanning and imaging
 - All submerged South and North Tower Pier fender surfaces
 - Channel bottom bathymetry around piers
- 100% Level I inspection of piers
- Over 600 sq. ft. of marine growth cleaning and Level II inspection
- Level III (coring) inspection as needed
- Assessment and recommendations



South Tower Pier



North Tower Pier



Imaging Operations



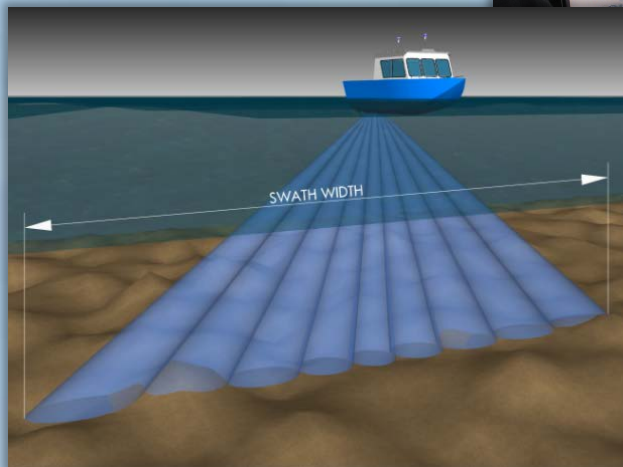
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Imaging Operations

Teledyne Reson Seabat 7125 System Specifications

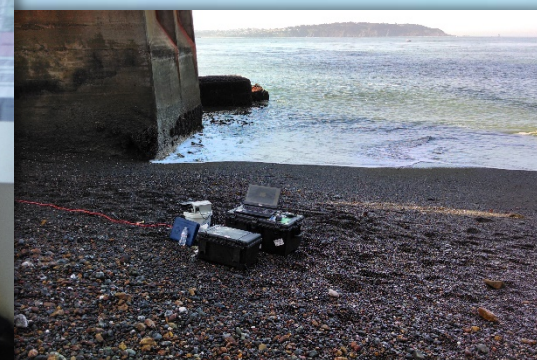
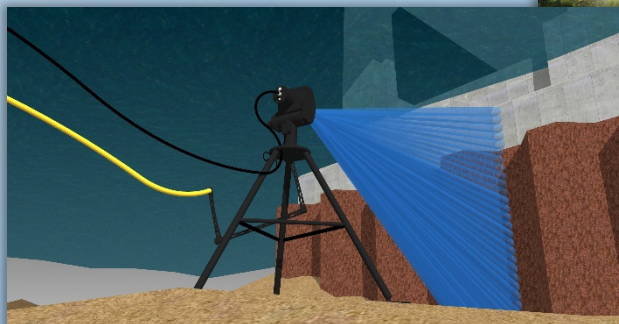
- User selectable frequency 200 or 400 kHz
- Focused $0.5^\circ \times 1^\circ$ beam widths at 400 kHz
- 0.25° spacing
- 512 beams
- Range resolution of 0.60 cm
- Selectable swath coverage from 140° to 165°
- 0.5 to 150 meter range at 400 kHz
- Vessel mounted on pole



Imaging Operations

BlueView BV5000-1350 Scanning Sonar System Specifications

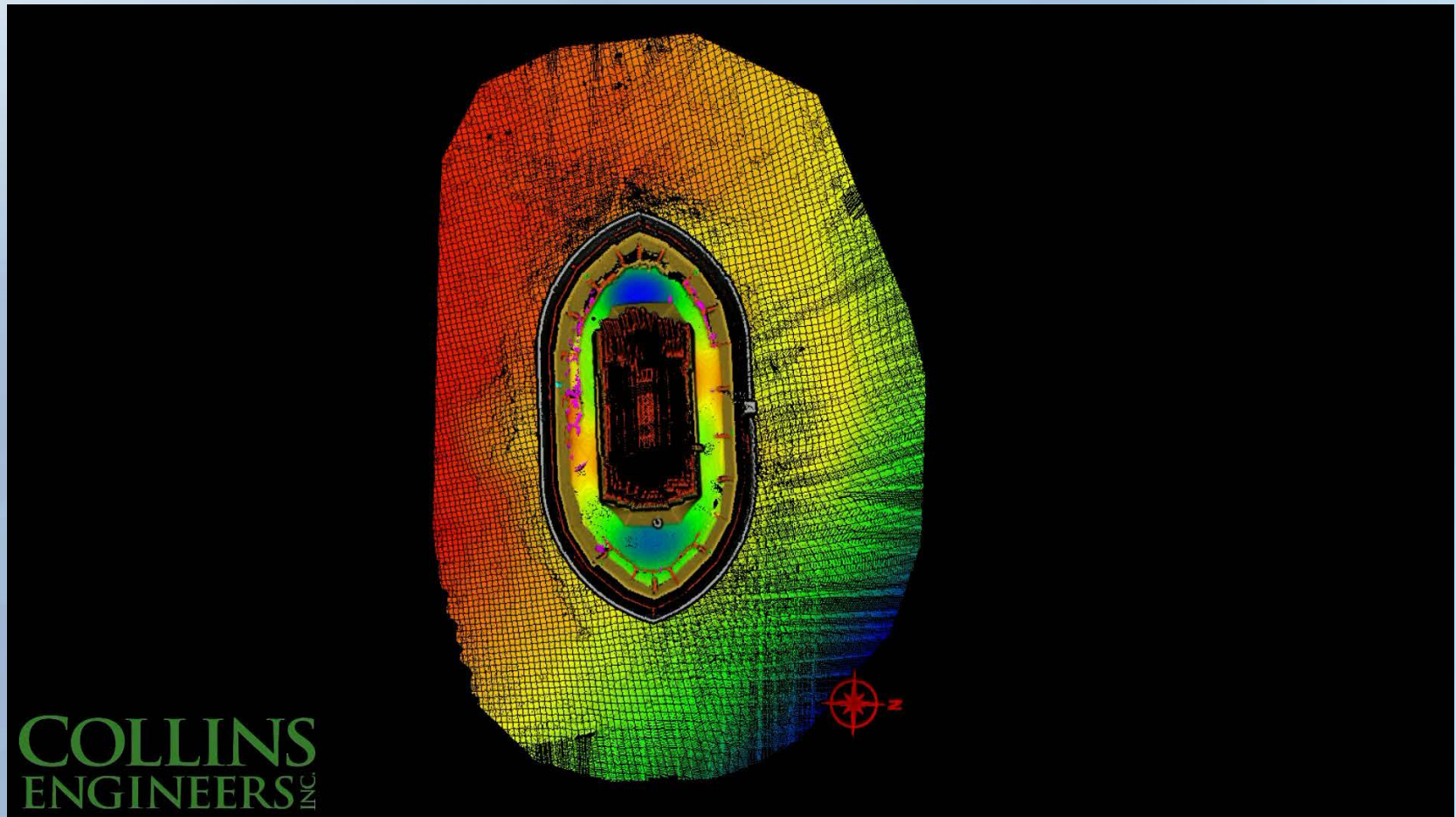
- High frequency 1350 kHz
- 1° x 1° beam widths
- 0.175° beam spacing
- 256 beams
- Range resolution of 1.5 cm
- 30 meter maximum range
- Fixed tripod or stationary pole deployment



South Tower Pier



South Tower Pier



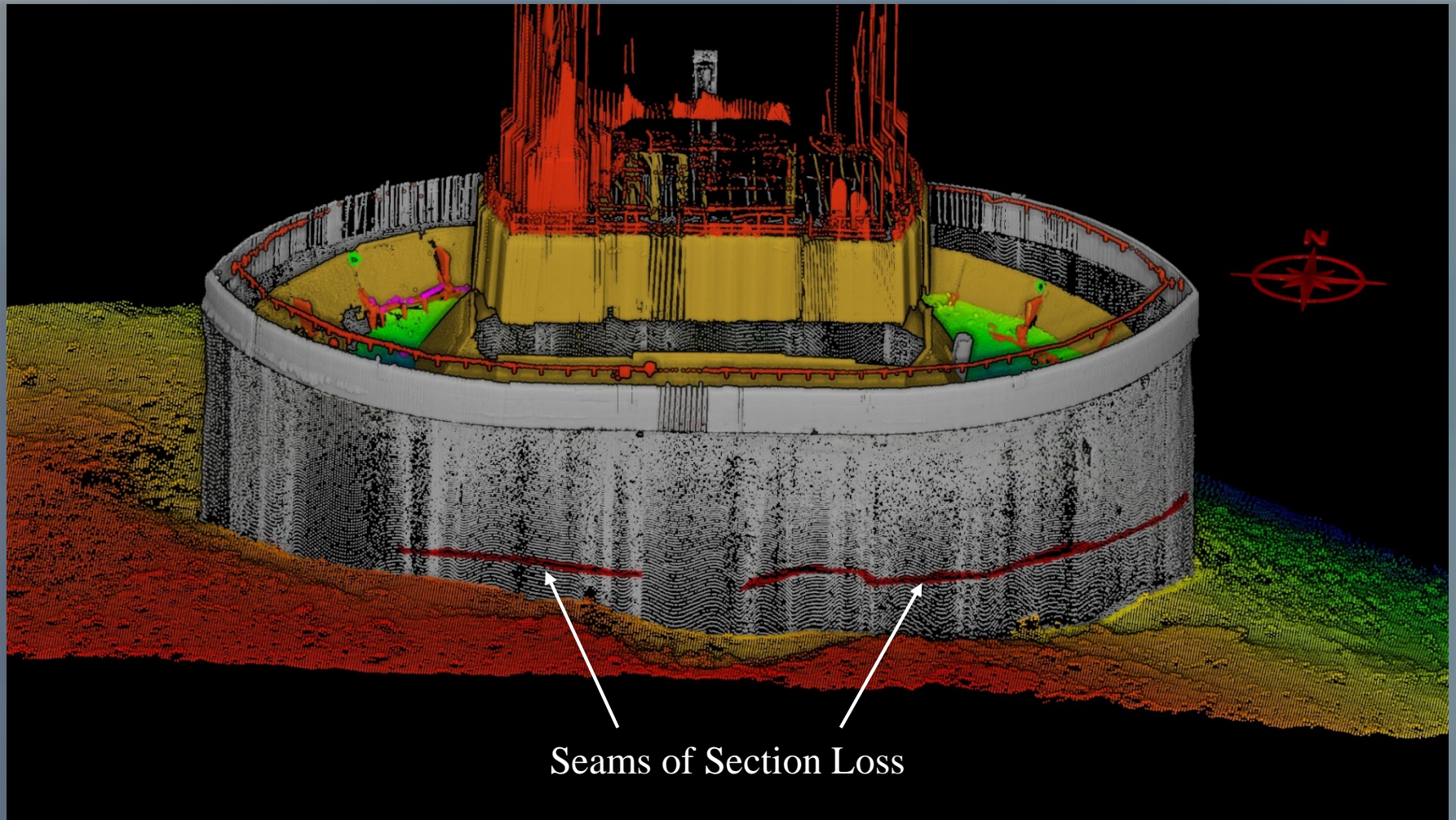
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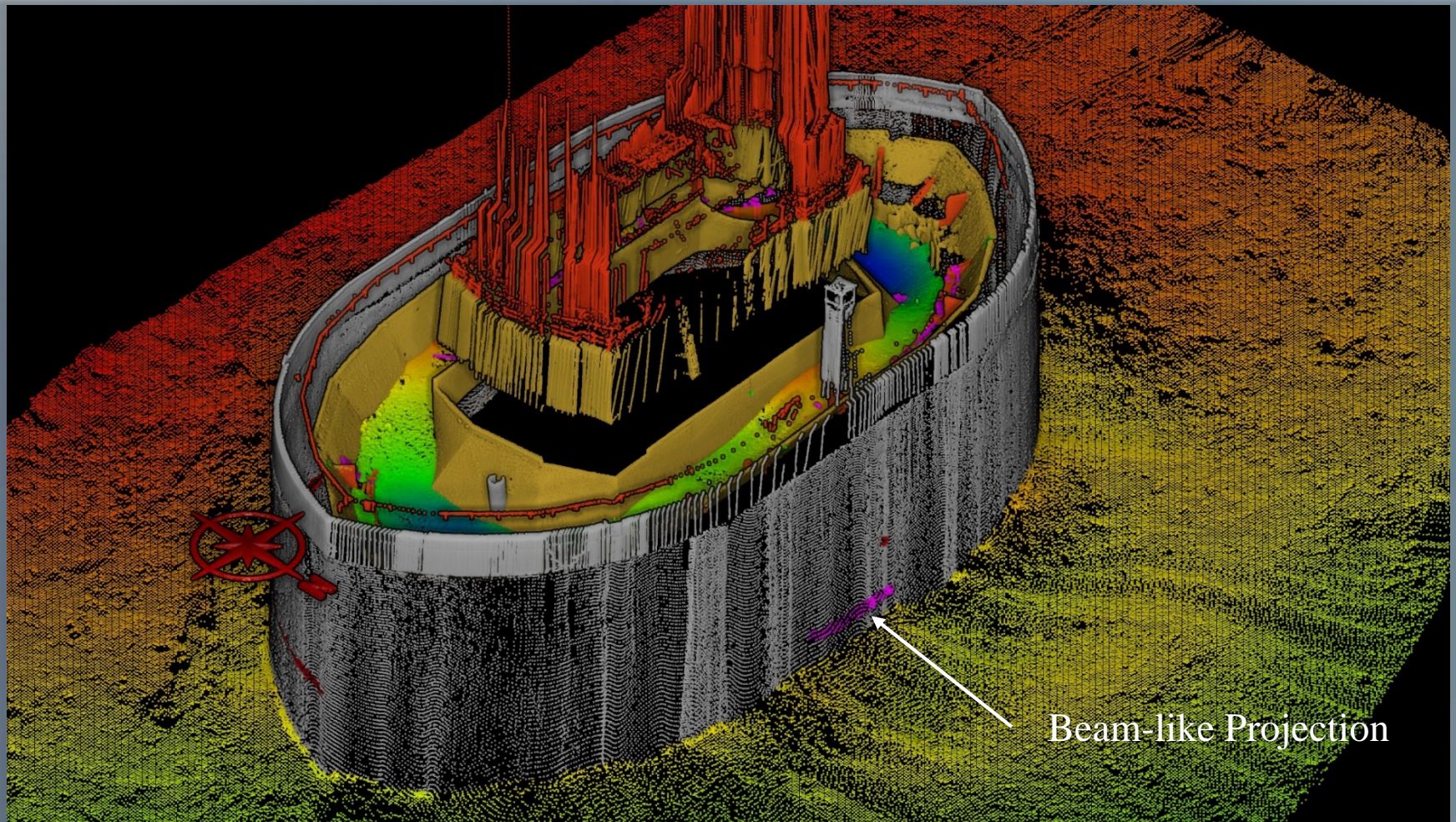


South Tower Pier



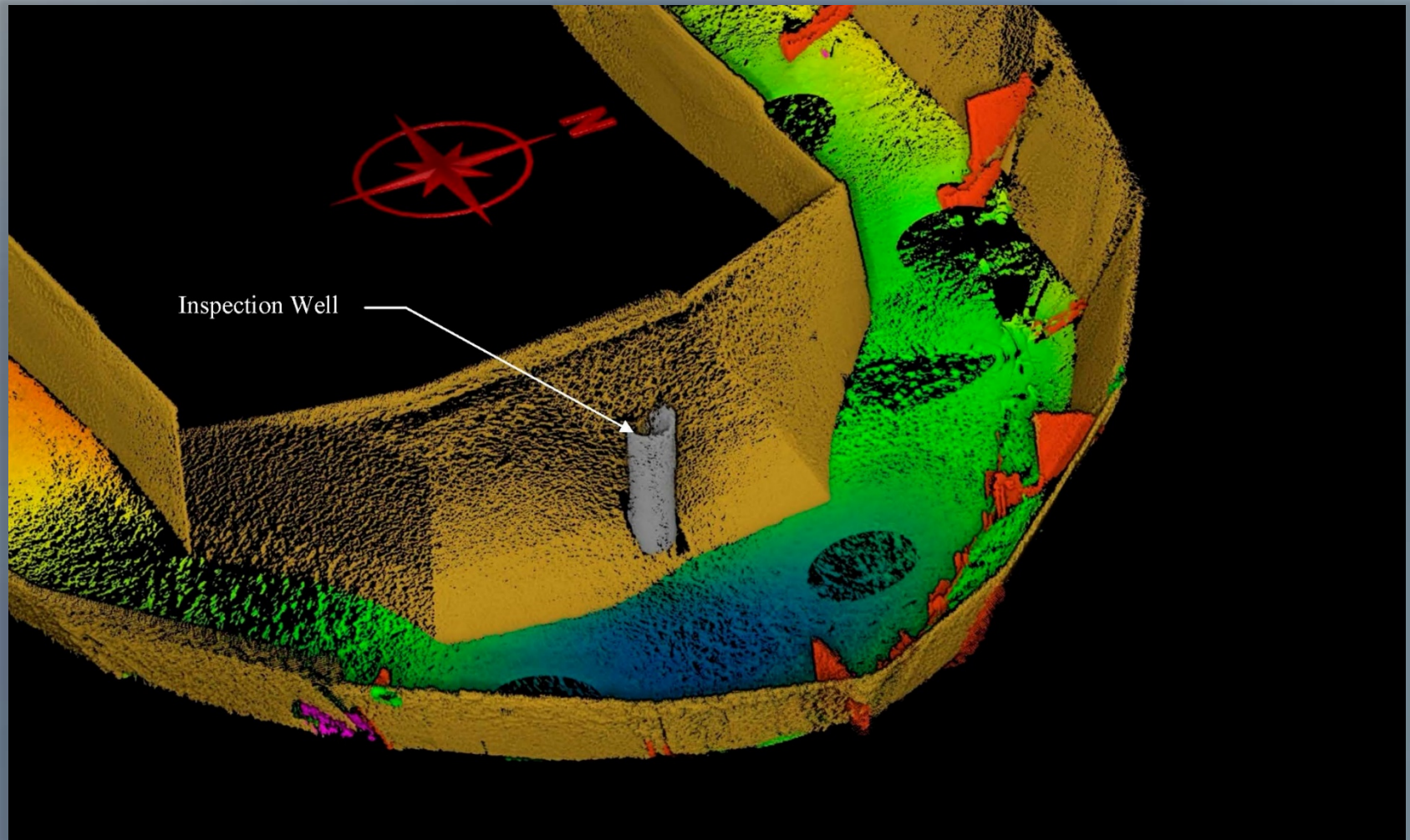
Seams of Section Loss

South Tower Pier



Beam-like Projection

South Tower Pier



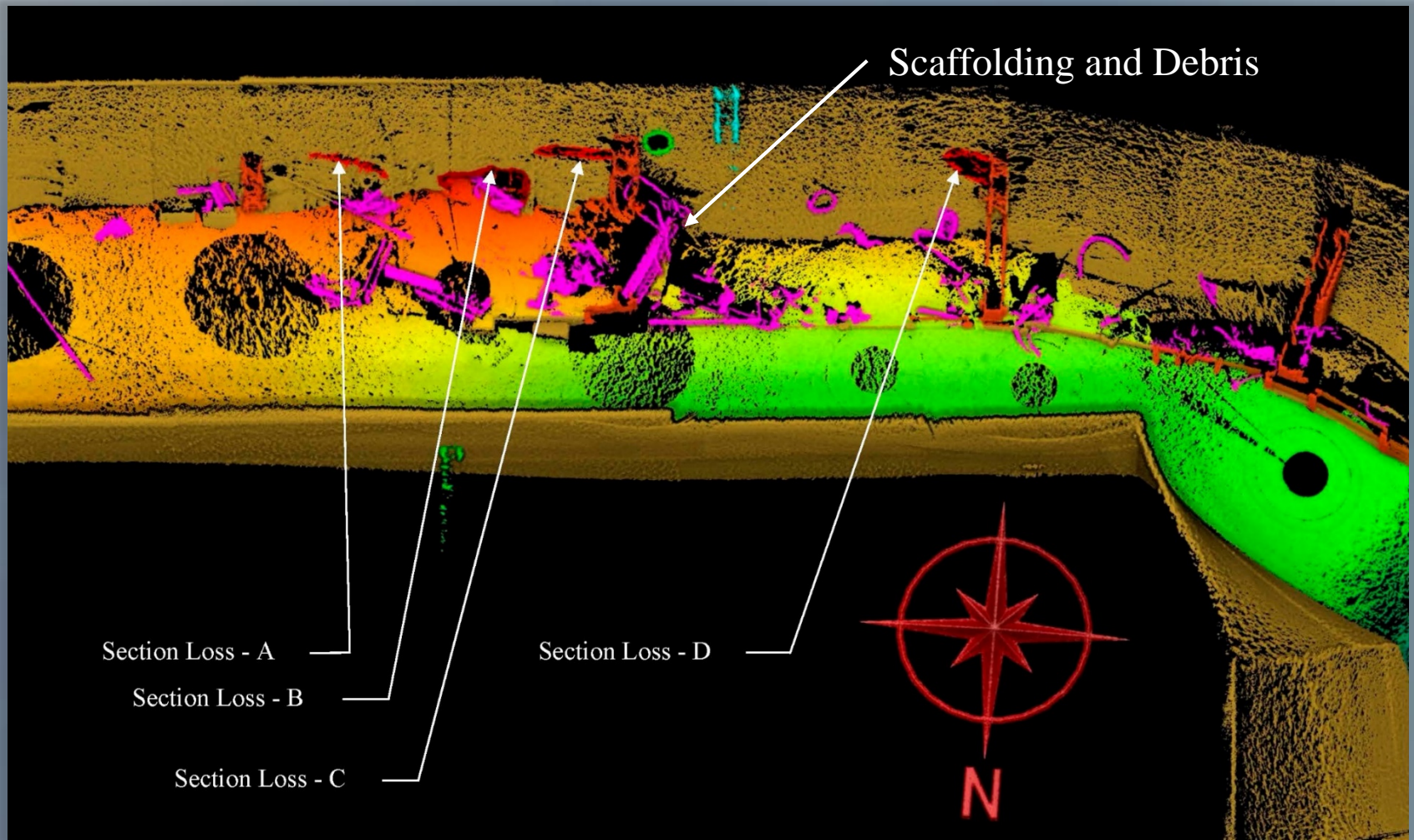
Inspection Well

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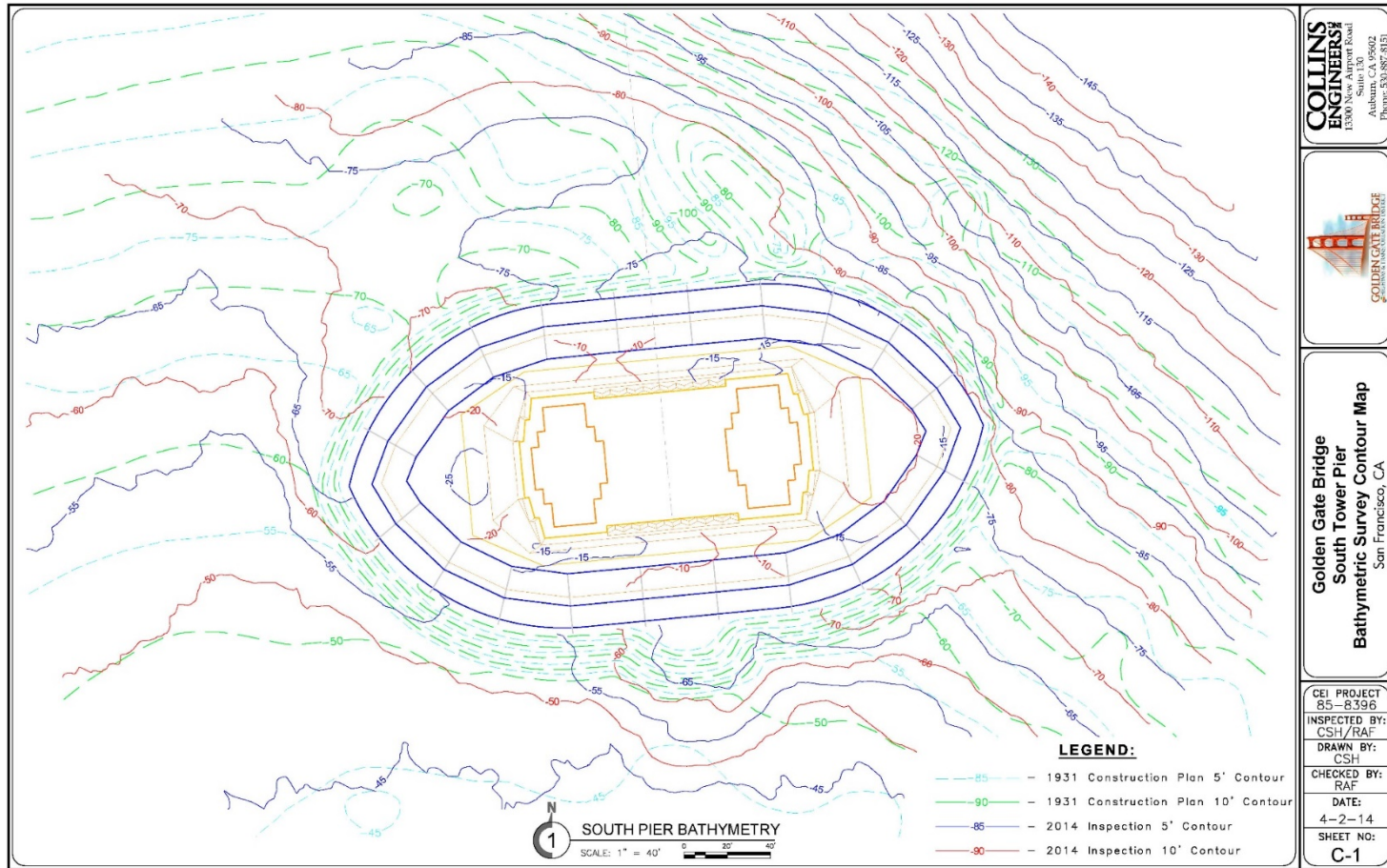
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South Tower Pier



South Tower Pier



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Suite 130
Ashland, CA 94002
Phone: 530.837.8155



**Golden Gate Bridge
South Tower Pier
Bathymetric Survey Contour Map**
San Francisco, CA

CEI PROJECT
85-8396
INSPECTED BY:
CSH/RAF
DRAWN BY:
CSH
CHECKED BY:
RAF
DATE:
4-2-14
SHEET NO:
C-1



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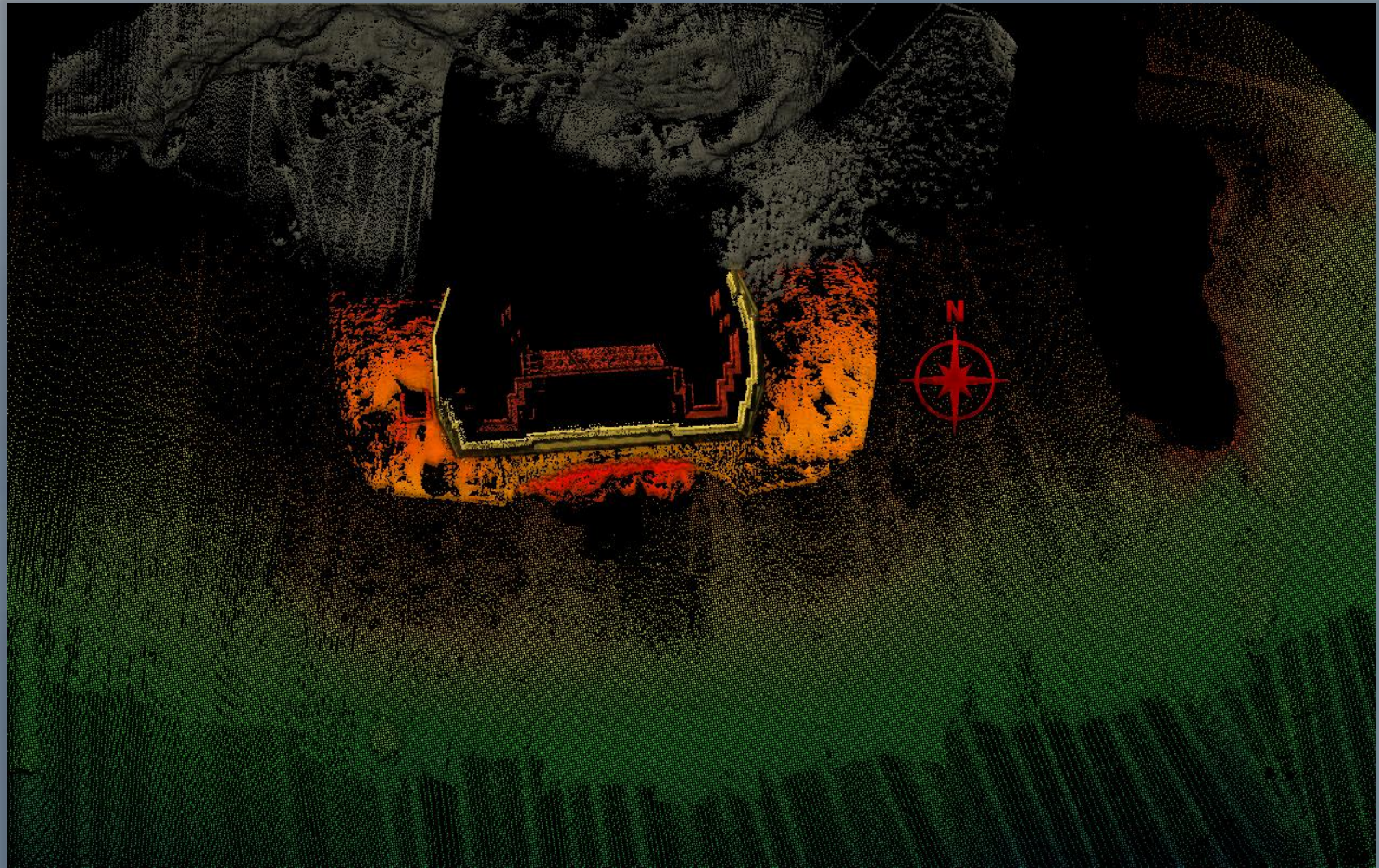
North Tower Pier



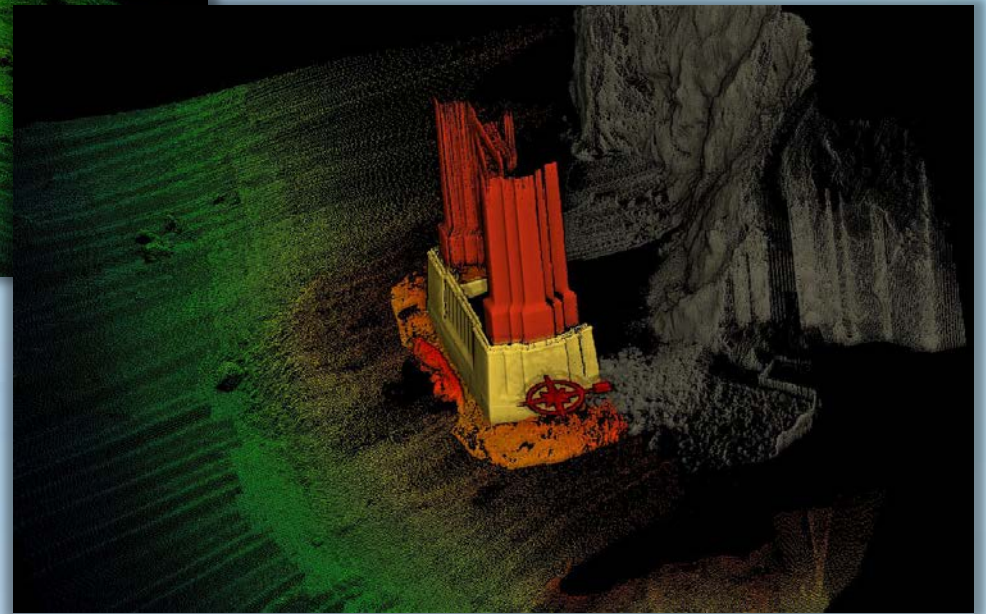
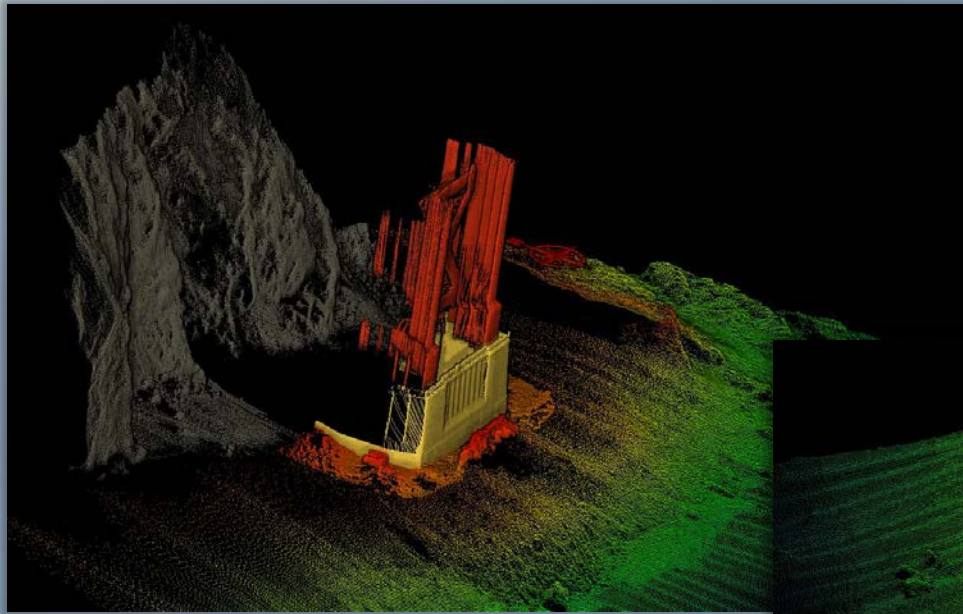
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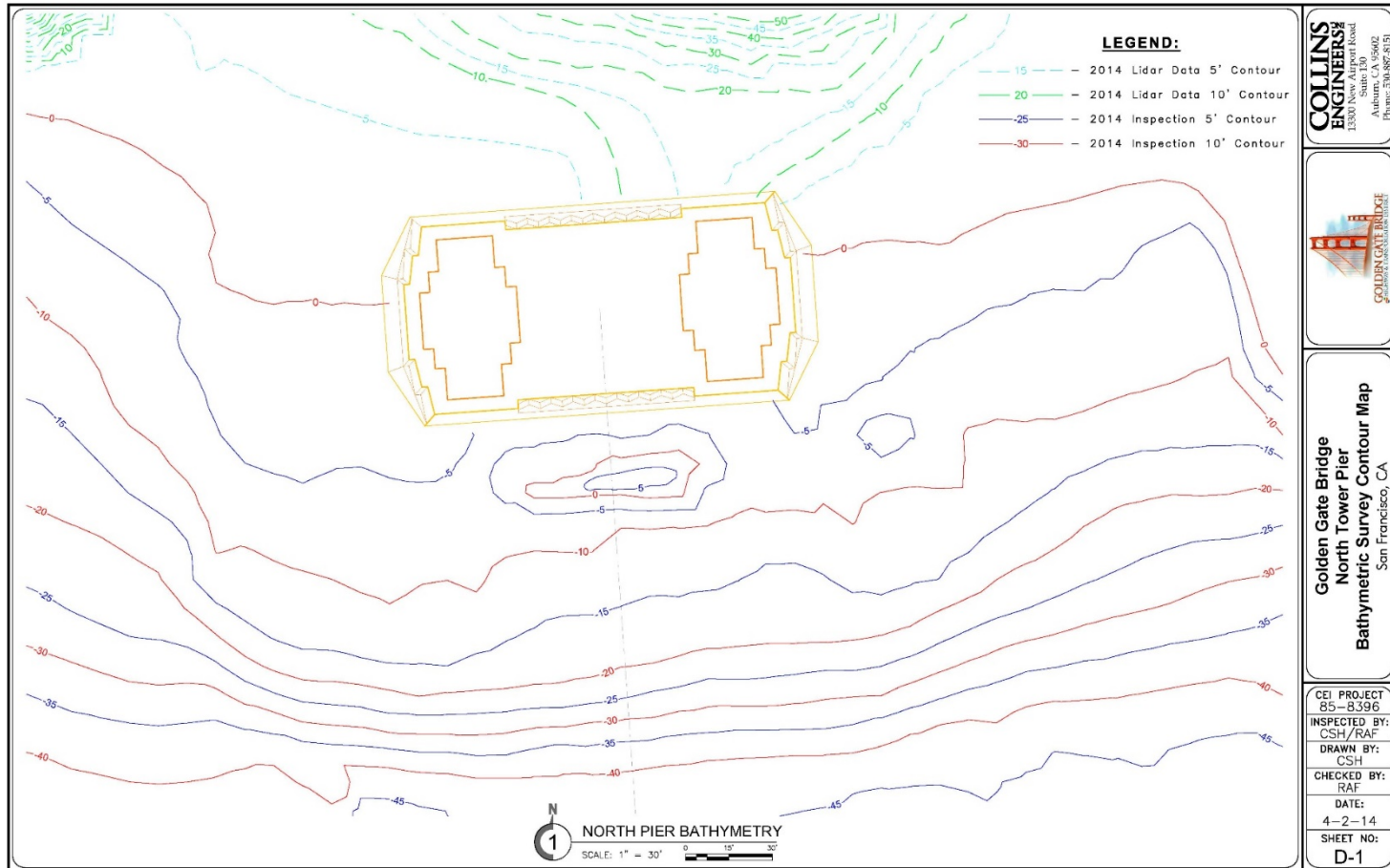
North Tower Pier



North Tower Pier



North Tower Pier



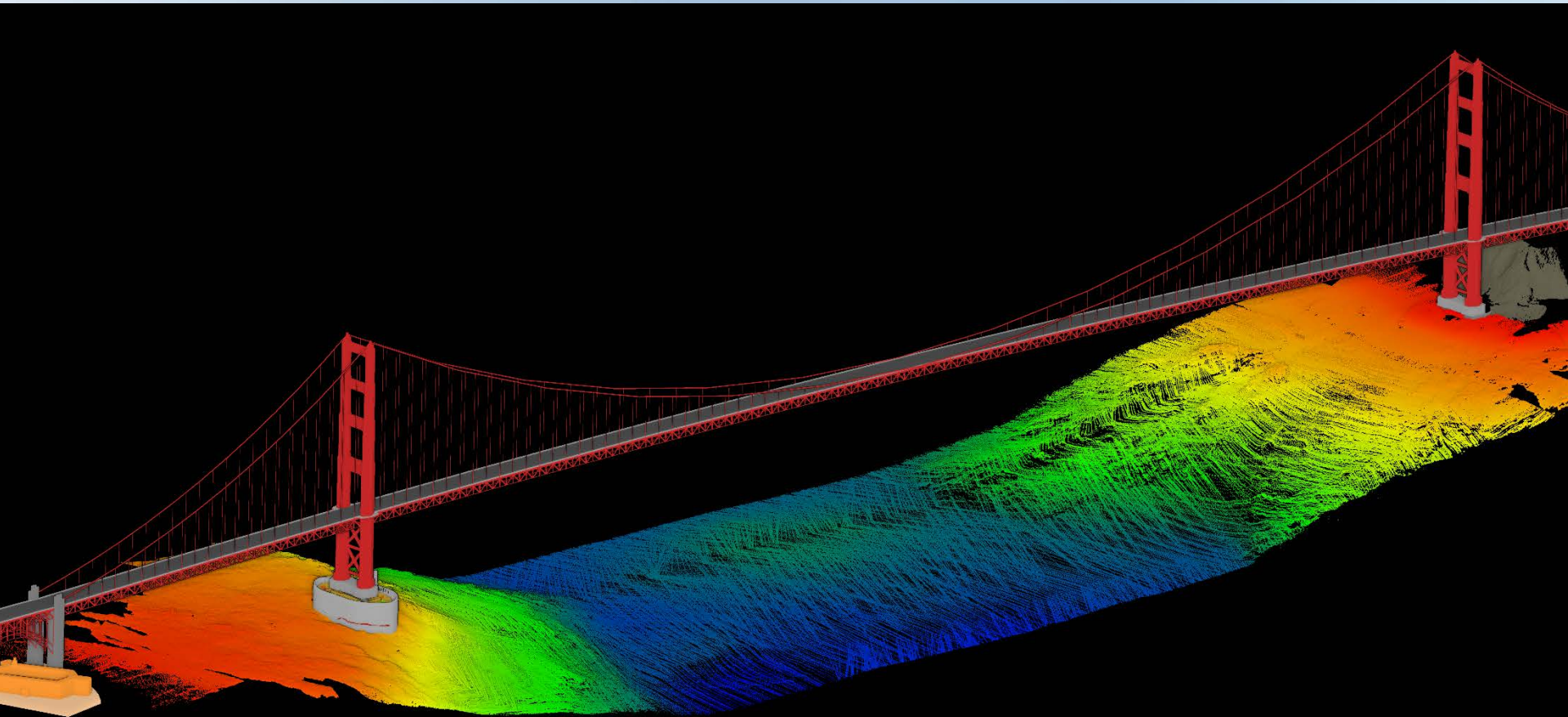
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Overall Waterway Image



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Diving Inspection



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South Tower Pier



South Tower Pier—Findings

- Generally remarkably good concrete surfaces
- Minimal loss of original section
- Structurally insignificant section loss along construction joints
- Up to 26 ft. of sediment in moat



South Tower Pier—Findings

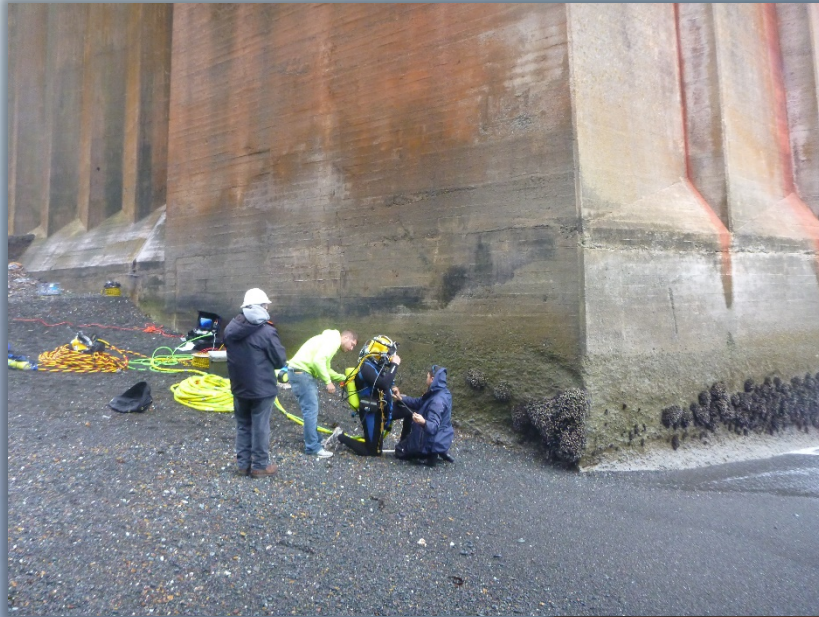
- Random vertical cracks around perimeter of shaft
- Random steel protrusions at base of shaft



South Tower Pier



North Tower Pier



North Tower Pier—Findings

- Generally remarkably good concrete surfaces
- Minimal loss of original section
- Erosion-related section loss
- Sound shaft-bedrock interface



North Tower Pier



Assessment, Recommendations & Conclusions

- Remarkable concrete condition
 - Some 80 years old
 - Exceptional workmanship
 - No need for Level III inspection
- Underwater imaging
 - Excellent Level I inspection tool
 - Identified any structural or safety concerns
- Possible future evaluation of anomalies on fender exterior
- Re-inspect by diving and/or imaging at accepted intervals

Questions



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