

RECLAMATION

Managing Water in the West

Use of Photogrammetry to Document Surface Defects in Concrete Structural Elements

Matthew Klein, PhD

Concrete, Geotechnical and Structural Laboratory



U.S. Department of the Interior
Bureau of Reclamation



US DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION

- Structures: Dams, Powerplants and Canals
- Location: 17 Western States
- Largest Water Wholesaler in the US
- Second Largest Producer of Hydroelectric Power in the US

FACILITY CHARACTERISTICS

- Built between 1930 and 1960
- Concrete Structural Elements:
 - Spillways
 - Dams
 - Buildings
 - Reservoirs
 - Tunnels
 - Canals
 - Bridges
- Harsh Exposures

CONCRETE DETERIORATION

- Detection is 99% Visual
- Geometrically Quantifiable
- Physically Characterizable
 - Spalls
 - Cracks
 - Delamination
 - Scaling
 - Erosion
 - Crumbling
 - Corrosion

WHAT IS PHOTOGRAMMETRY?

The art, science, and technology of obtaining reliable information about physical objects and the environment through the process of recording, measuring, and interpreting photographic images and patterns of EM radiant energy and other phenomena.

WHAT IS PHOTOGRAMMETRY, REALLY?



PHOTOGRAMMETRIC PROCEDURE

1. Data collection

- Cameras and image format
- Disable digital post-processing
- Constrain focal length, focus, aperture, shutter speed, ISO and WB
- Enable GPS (if installed and outdoors)
- 60% overlap
- Perpendicular positioning
- Avoid movement and blur
- Include scale and targets

PHOTOGRAMMETRIC PROCEDURE

2. Software processing

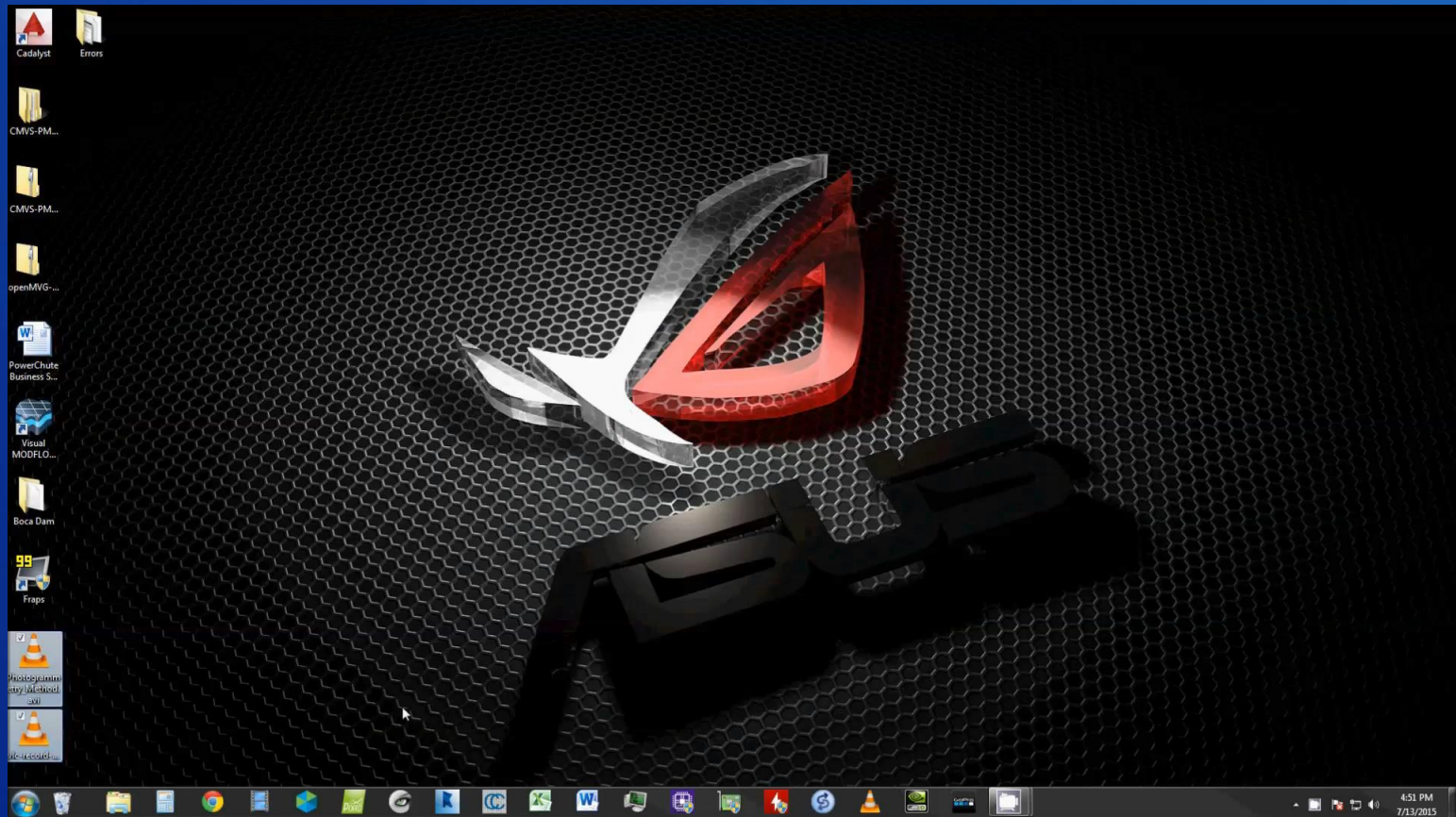
- Detect and match features/ Solve camera positions
- Apply scale and coordinate system
- Iteratively remove weak points and optimize parameters
- Construct point cloud
- Generate mesh
- Apply photorealistic texture

PHOTOGRAMMETRIC PROCEDURE

3. Analysis

- Fly-through animations
- Volume and length calculations
- Classify point cloud
- Contours and grids
- Measure differences in position
- Animate 3D frames
- Digital records

PHOTOGRAMMETRIC PROCEDURE



DETERIORATION AND PHOTOGRAMMETRY

- Applications
 - “Arm-chair Inspections”
 - Measure extent of damage
 - Identify seepage or corrosion
 - Map locations
 - Determine movements
 - Compare time-based changes
 - Archival records

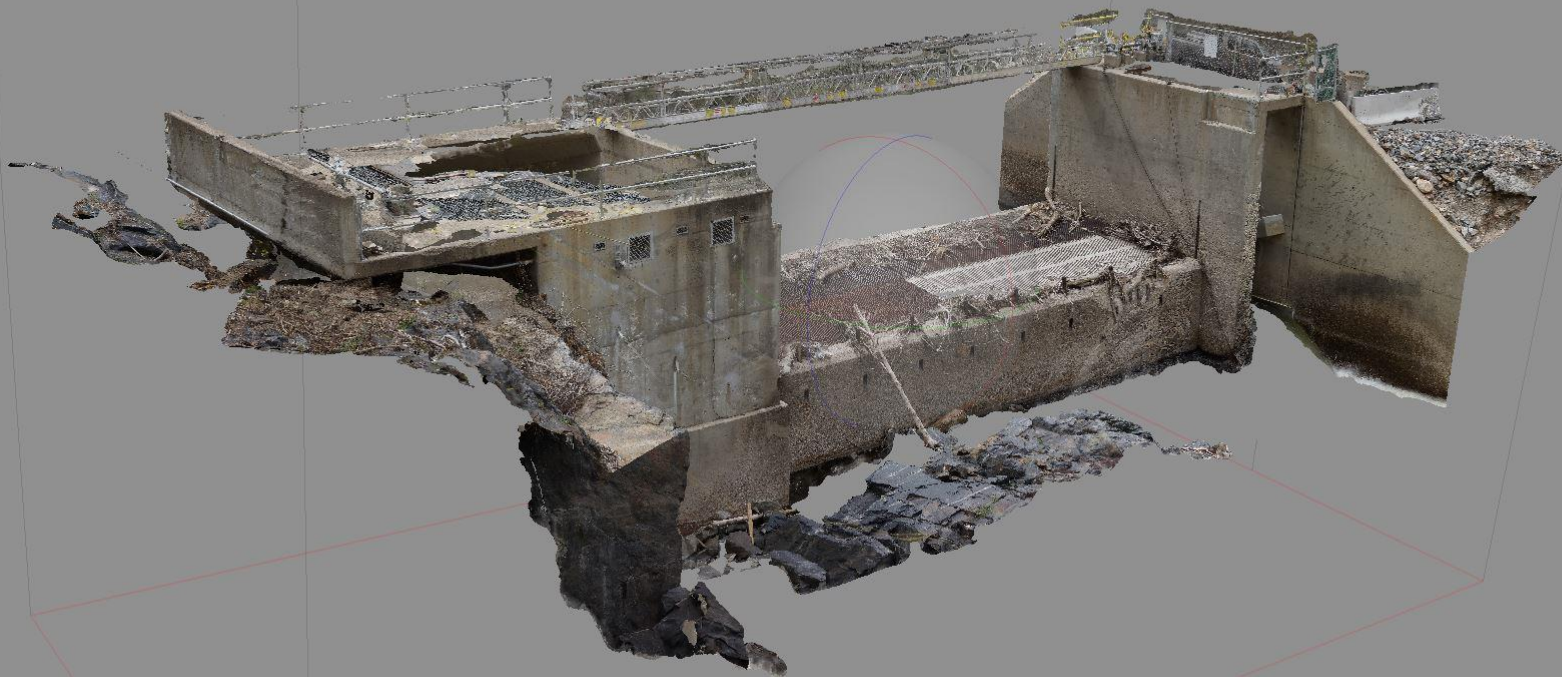
INSPECTIONS

File Edit View Workflow Tools Photo Help

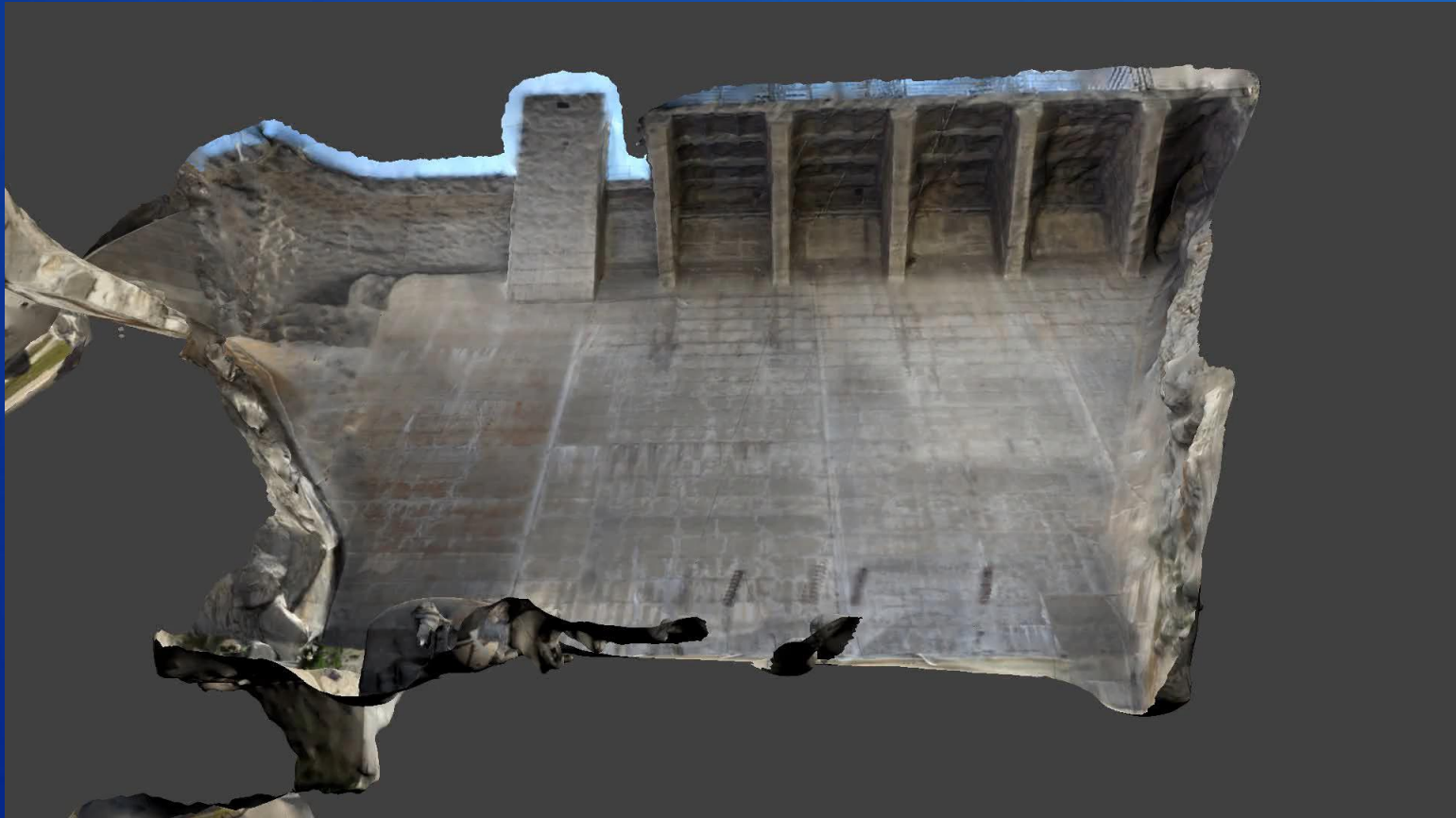


Model

Perspective 30°



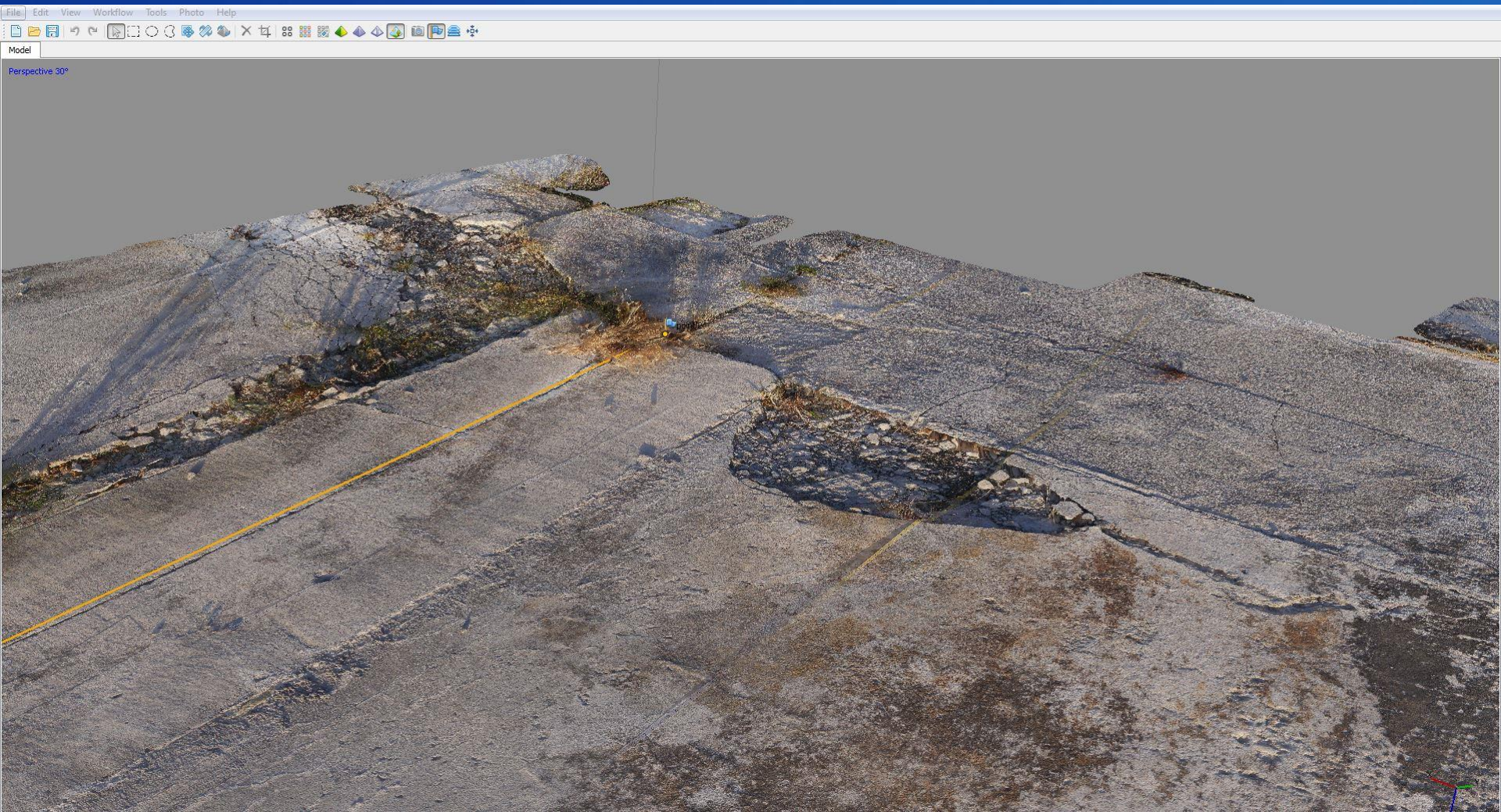
INSPECTIONS



DIVERSION STRUCTURE CRACK

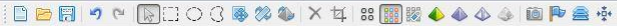


SPALL VOLUME



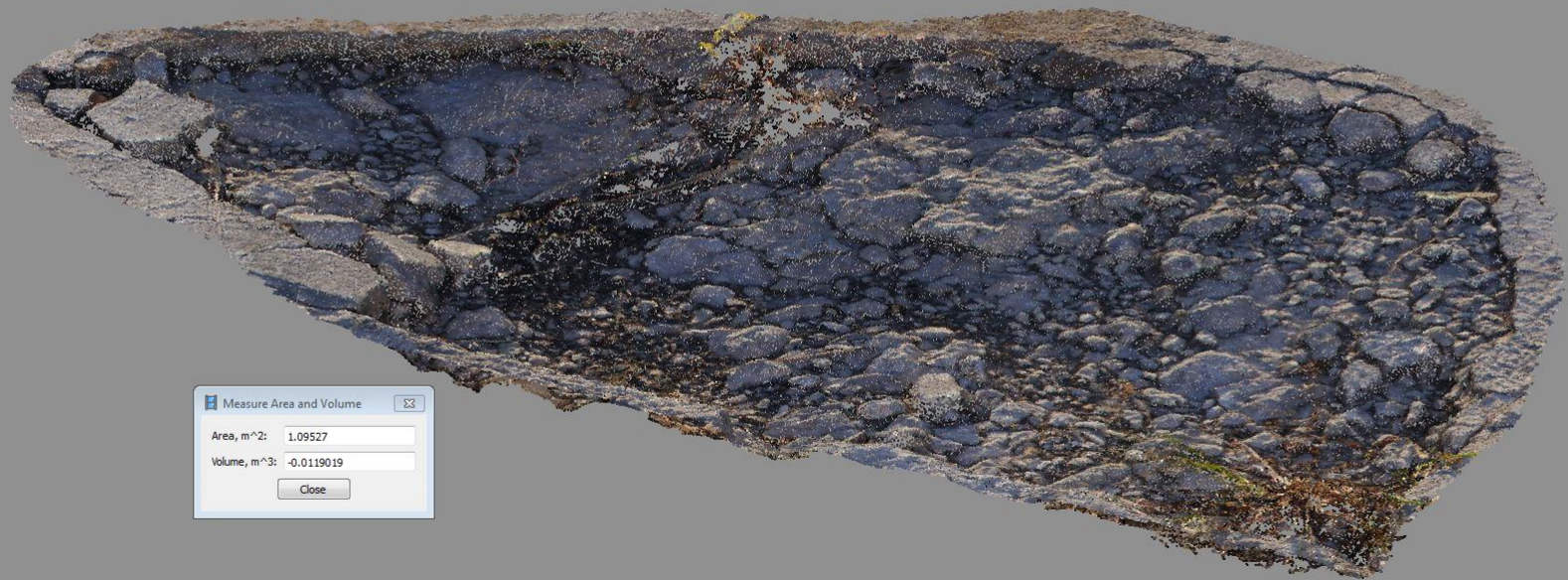
SPALL VOLUME

File Edit View Workflow Tools Photo Help



Model P1020601.JPG

Orthographic



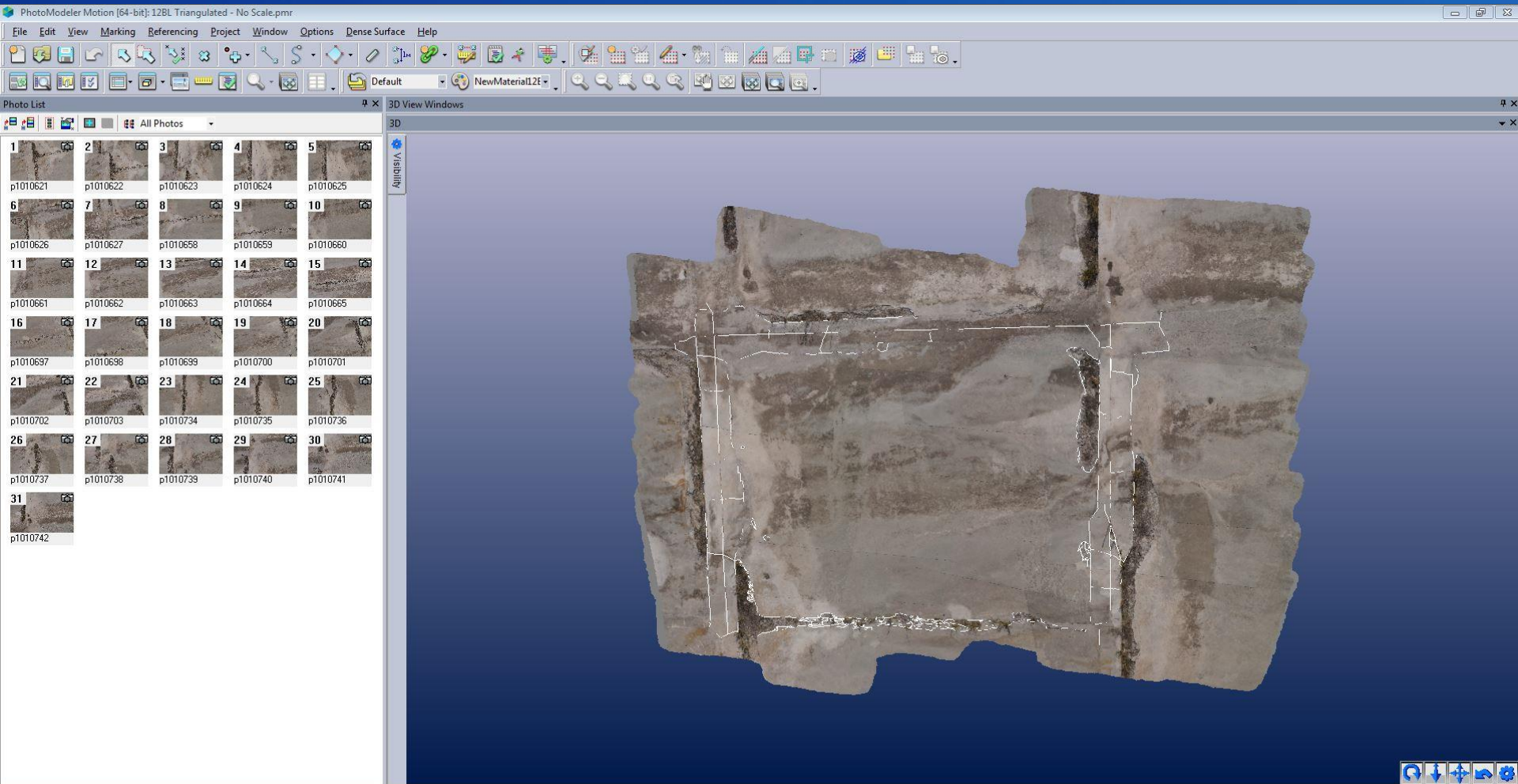
Measure Area and Volume

Area, m ² :	1.09527
Volume, m ³ :	-0.0119019

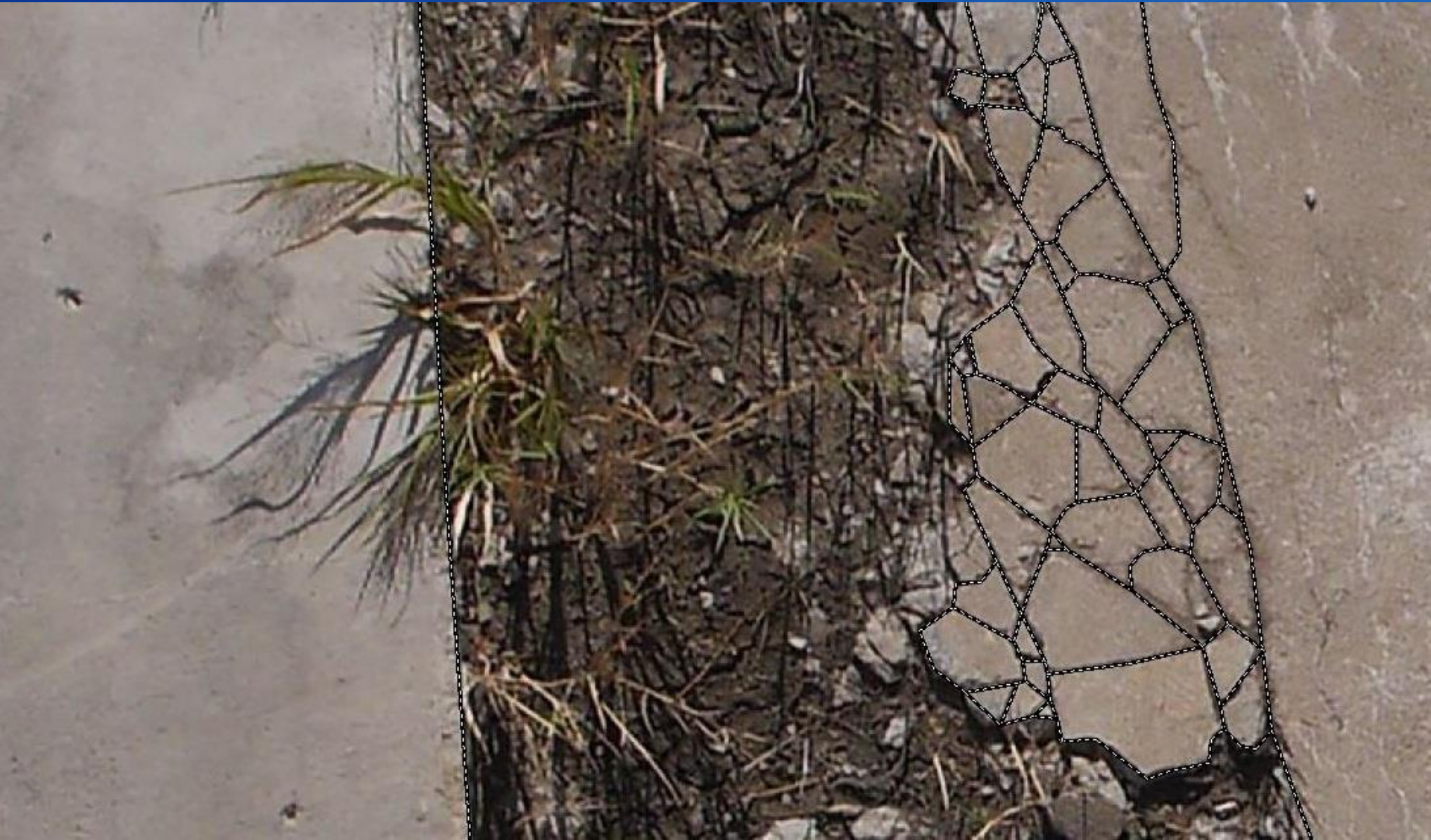
Close



CRACK MAPPING



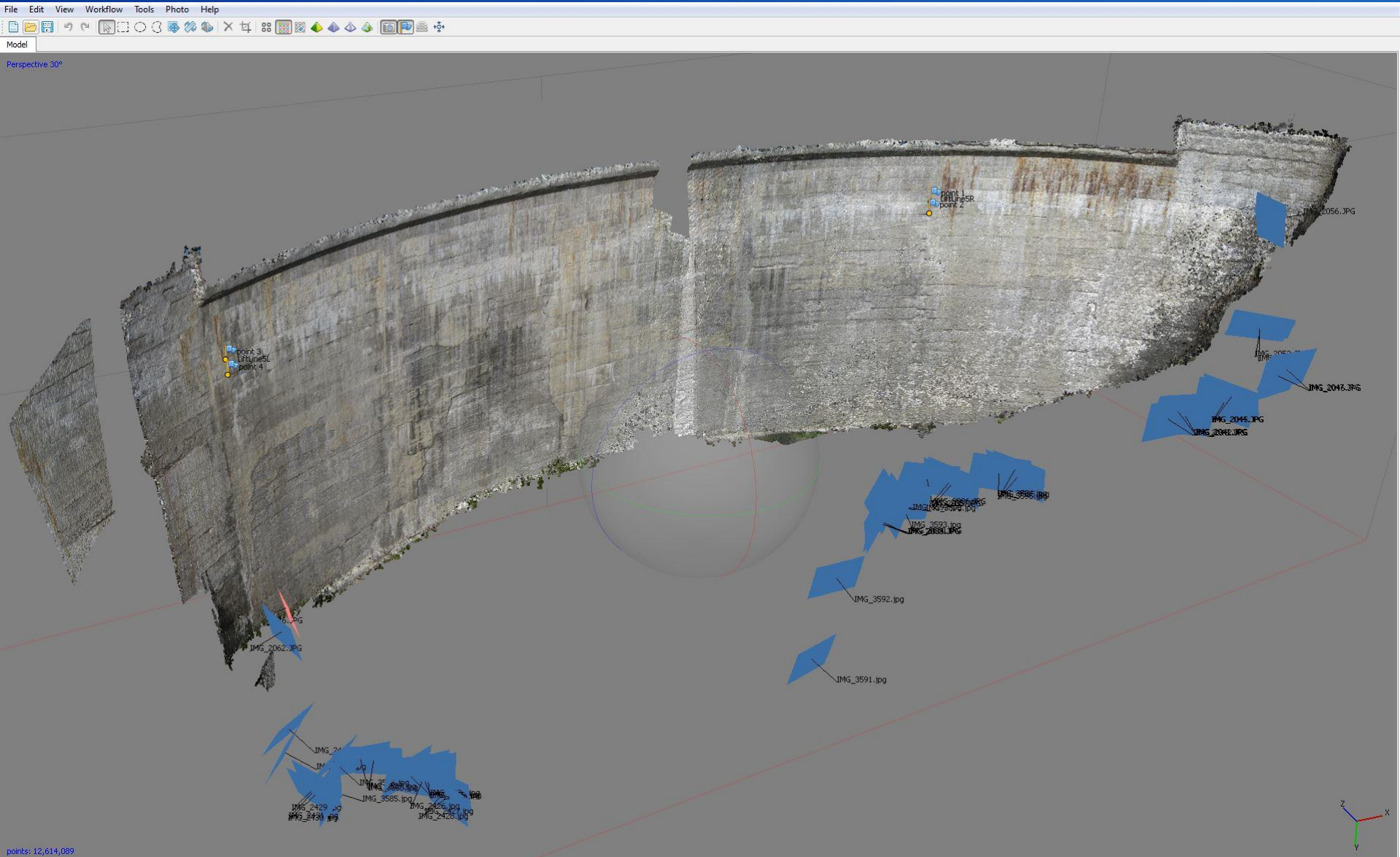
CRACK MAPPING



DELAMINATION DETECTION



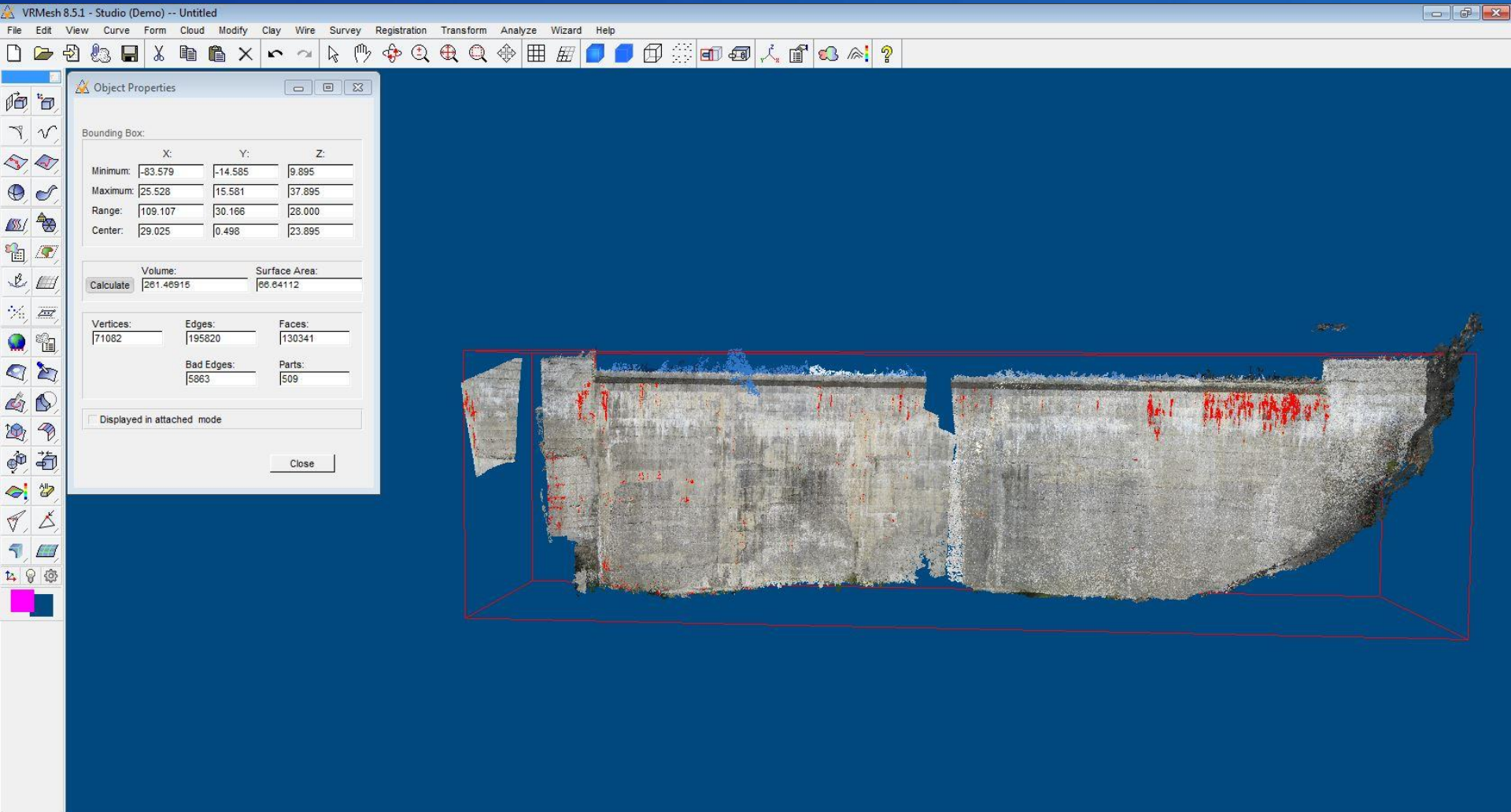
CORROSION DETECTION



points: 12,614,089

Open an existing file

CORROSION DETECTION



Done!
Only process the data displayed on the screen.
Point Number: Low Point 0, Model Key-Point 0, Water 0, Others 0, Reserved11 0, Overlap Points 0, Reserved13 0 Trees 0
Point Number: Default 2631988, Unclassified 0, Ground 0, Low vegetation 0, Medium vegetation 0, High vegetation 0, Building 47
Done!
Selected Group ID: 0 Selected Object ID: 1 -- Points: 75307 Triangles: 0
Point Number: Low Point 0, Model Key-Point 0, Water 0, Others 0, Reserved11 0, Overlap Points 0, Reserved13 0 Trees 0
Point Number: Default 200, Unclassified 0, Ground 0, Low vegetation 0, Medium vegetation 0, High vegetation 0, Building 75107
Done!

X: -18.100 Y: -5.637
Z: 37.345 D: 15.632

MEASURING MOVEMENT



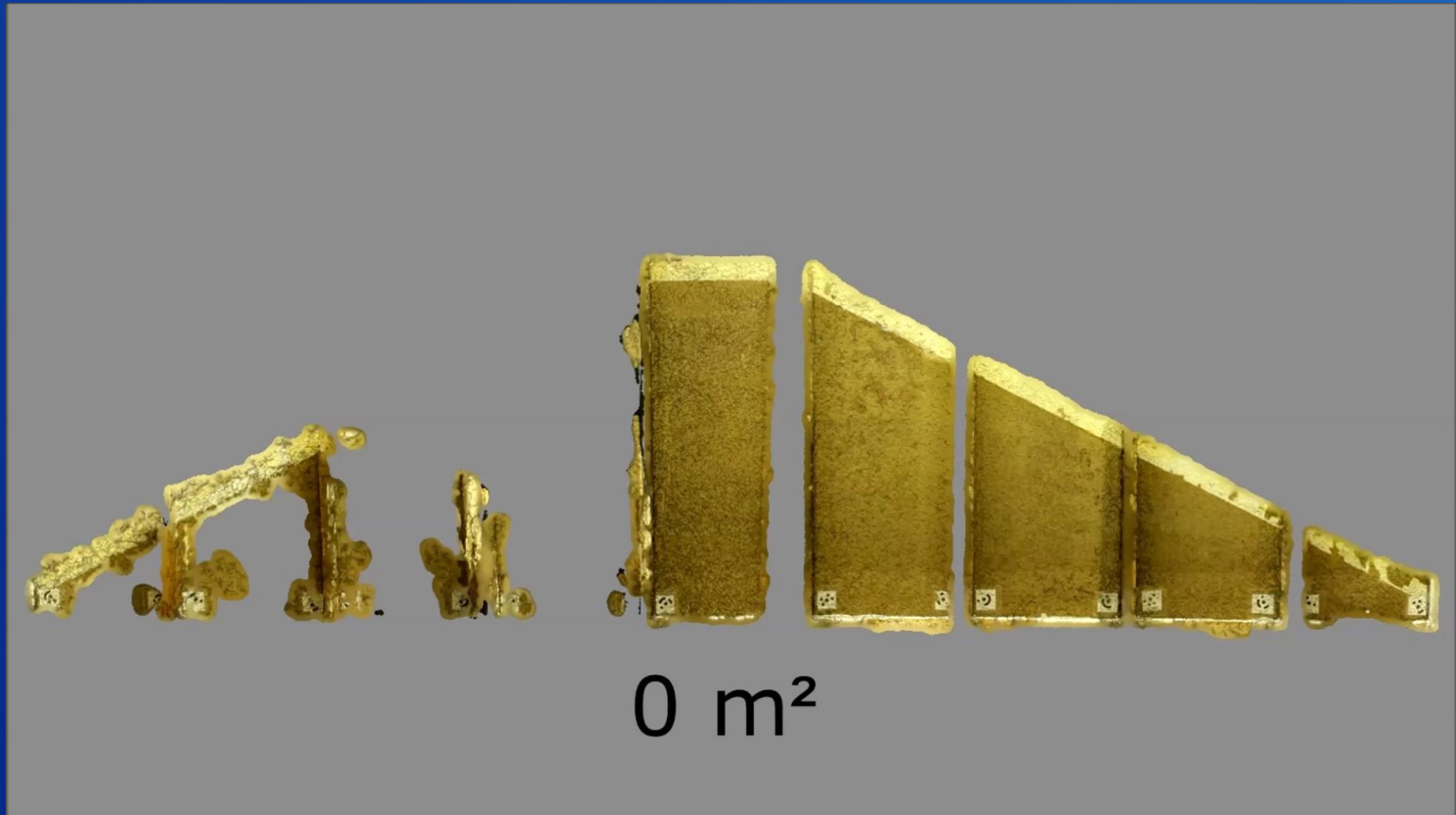
MEASURING MOVEMENT



4D MODELING



4D MODELING



QUESTIONS?

- For further information contact
Matthew Klein
mjklein@usbr.gov
303.445.2398