ABCD Susquehanna Chapter
2014 Technical Conference

Holtwood Expansion Project
PPL Holtwood, LLC.

Cofferdam Design and Construction
(and Destruction)

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WALSH CONSTRUCTION

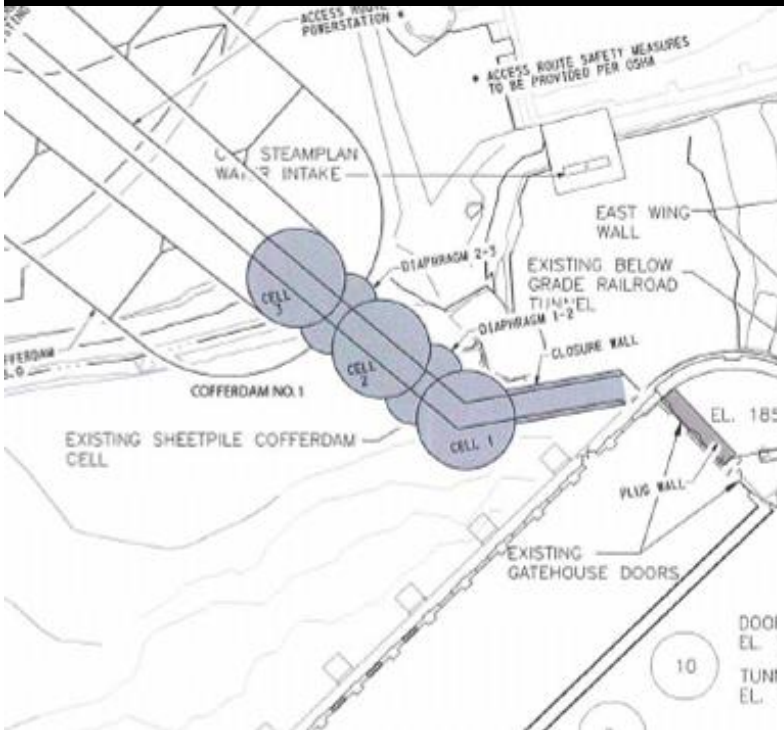
929 West Adams
Chicago, IL 60607

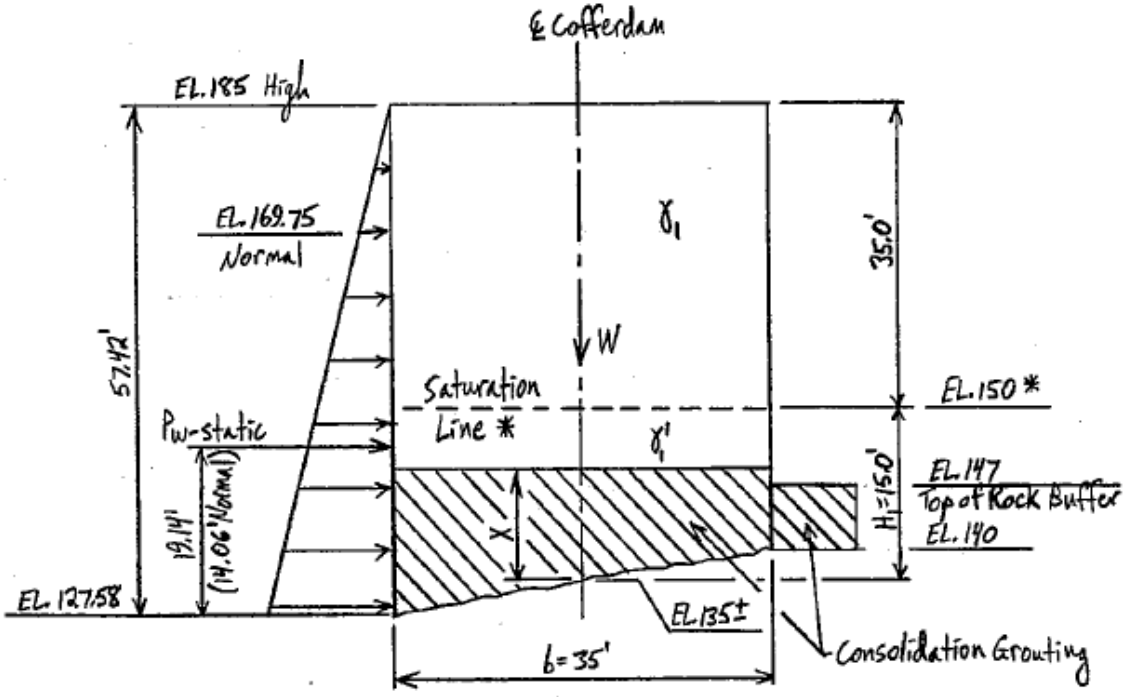
Project Location

Holtwood, PA

Cofferdam 1 Design

- Cellular cofferdam consisting of three 40ô diameter cells founded on rock
- Originally designed for 50ô of water pressure
- Lower rock elevations discovered during construction. Max design water depth of 57.42ô
  - Added additional consolidation grouting within cell 1 to add weight and increase sliding resistance
- Main failure modes are sliding of the cell, slipping between piling and cell fill, shear failures of the cell fill and interlock tension.





Cofferdam 1 Construction

Cofferdam 1 Construction (cont.)

- Setting PS sheeting around template for cell 1

Cofferdam 1 Construction (cont.)

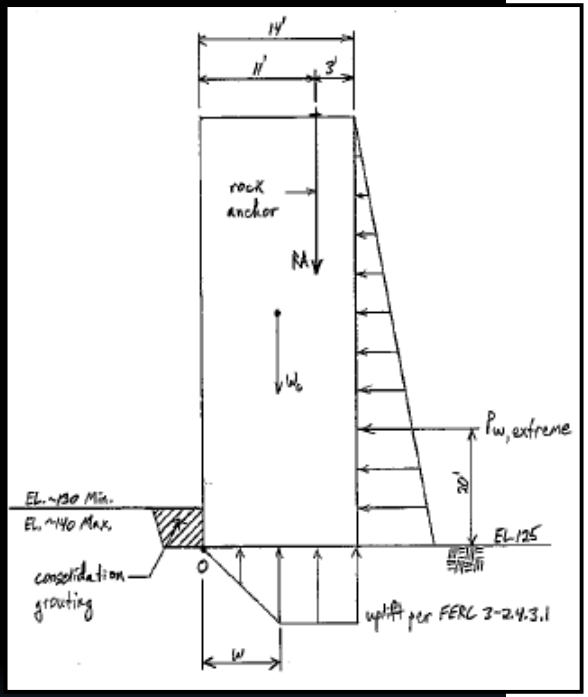
- All sheets in place for the three cells
- Cells constructed in a trench that was blasted/excavated into existing rock

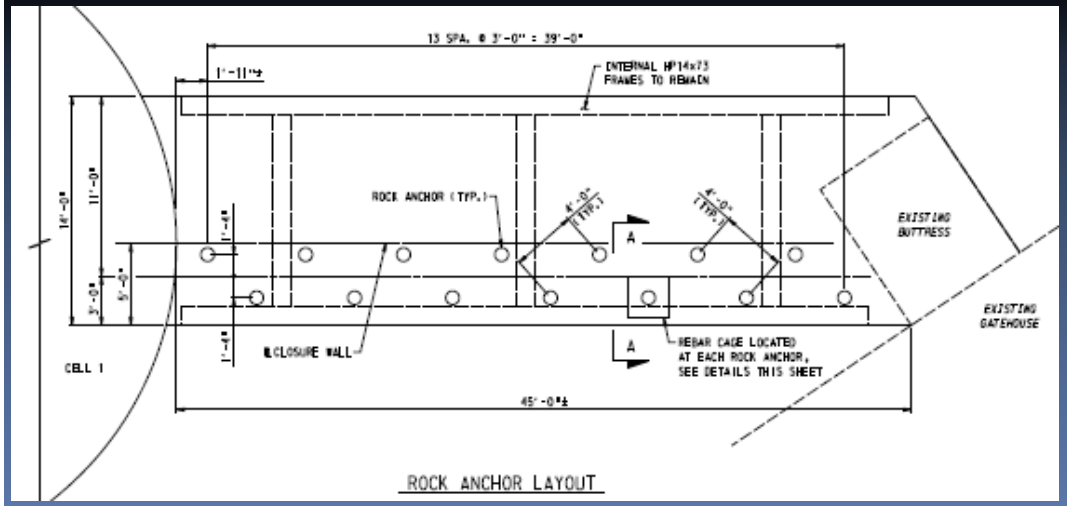
Cofferdam 1 Construction (cont.)

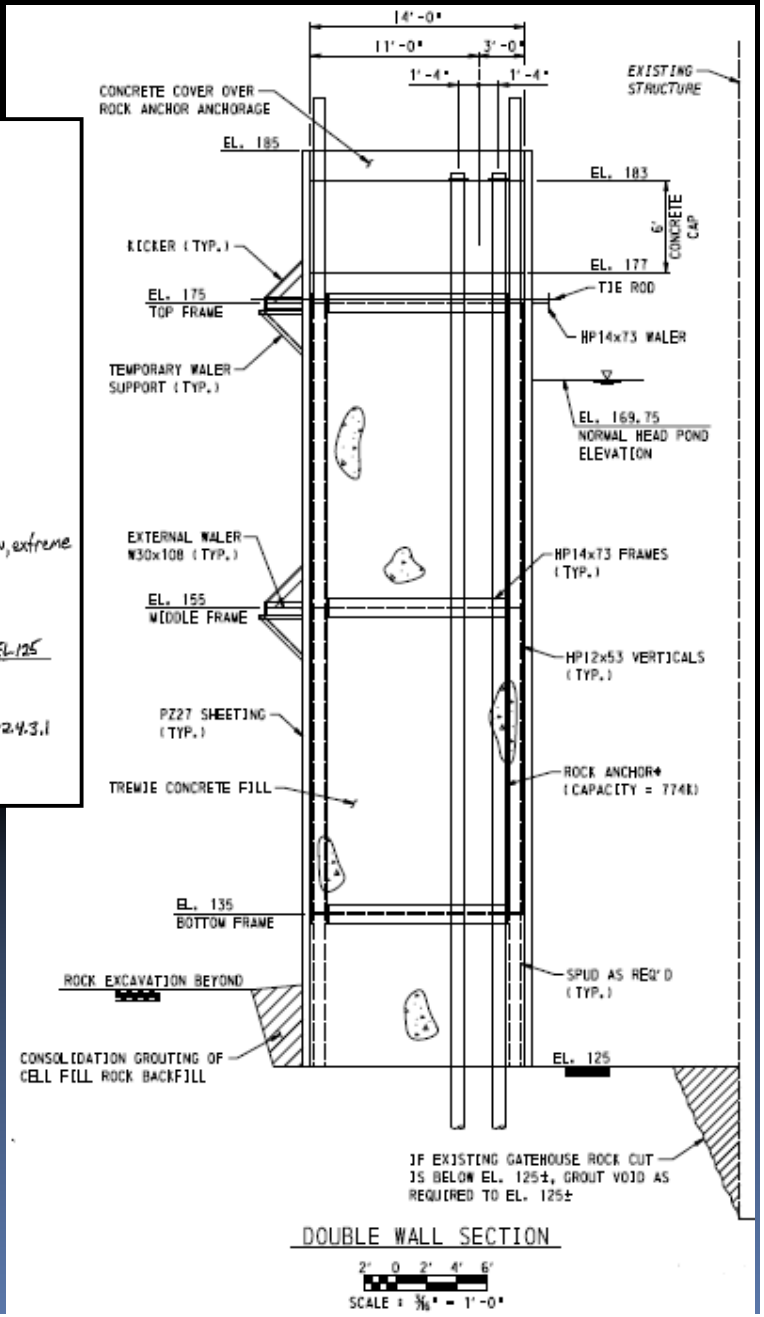
- Cells partially filled with stone
- Upstream diaphragm sheets placed
- Placing concrete in closure wall (discussed in next couple slides)
- Beginning to construct earthen cofferdam which ties into the end of cell 3

Cofferdam 1 Closure Wall Design

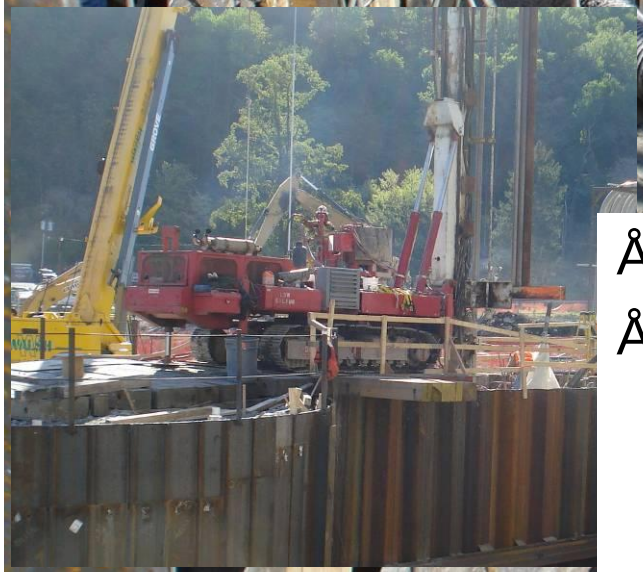
- Designed for 60ô of water pressure
- Multi-strand rock anchors (22 - 0.6ò dia strands per anchor)
- 14 total anchors along 42ô length of wall
- Each anchor tested to 1032 kips then locked off at 903 kips







Cofferdam 1 Closure Construction



- Strand anchors installed 53ô into rock, prior to tensioning
- After tensioning, a concrete cap was poured over the anchor heads to provide a smooth walking surface, because this cofferdam became the only access into the existing powerhouse during construction

Cofferdam 1 Construction (cont.)

- Completed cofferdam

Cofferdam 1 Construction (cont.)

Å Aerial view of completed cofferdam


The Hole
#1
Elev.
185
Elev. 25

Cofferdam 1
Near Destruction

Cofferdam 1 Near Destruction, 9-9-11

Historical Crests for Susquehanna River at Marietta

(P): Preliminary values subject to further review.

(1) 64.54 ft on 06/23/1972
(2) 60.73 ft on 03/19/1936
(3) 58.30 ft on 06/02/1889
(4) 58.16 ft on 09/09/2011

Cofferdam 1 Near Destruction, 9-9-11

(cont.)

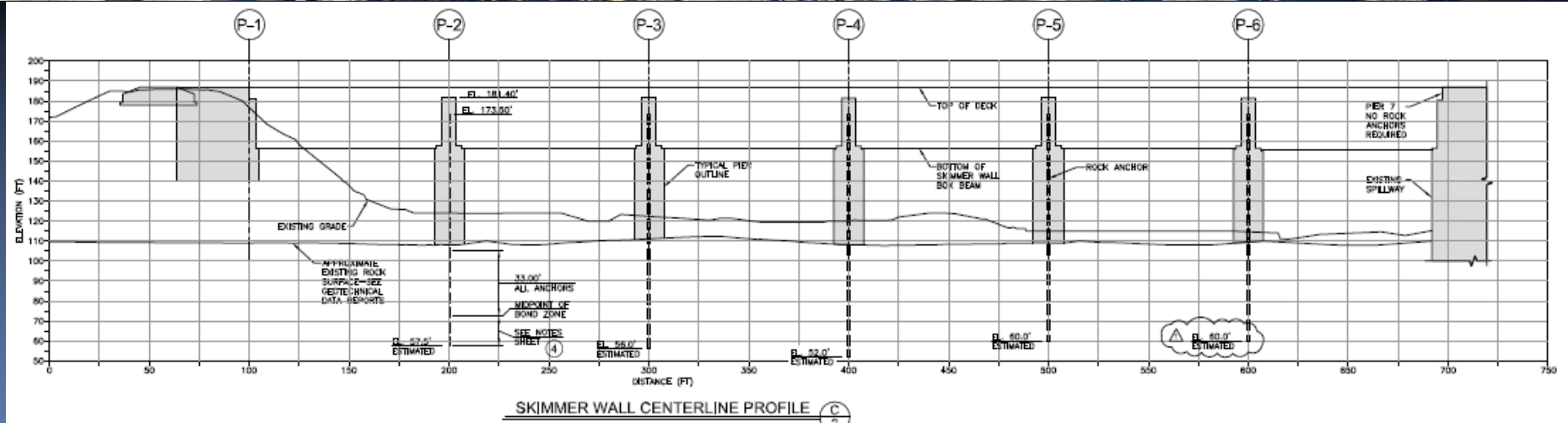
- Downstream cofferdam intentionally breached

Cofferdam 3

#3

#1

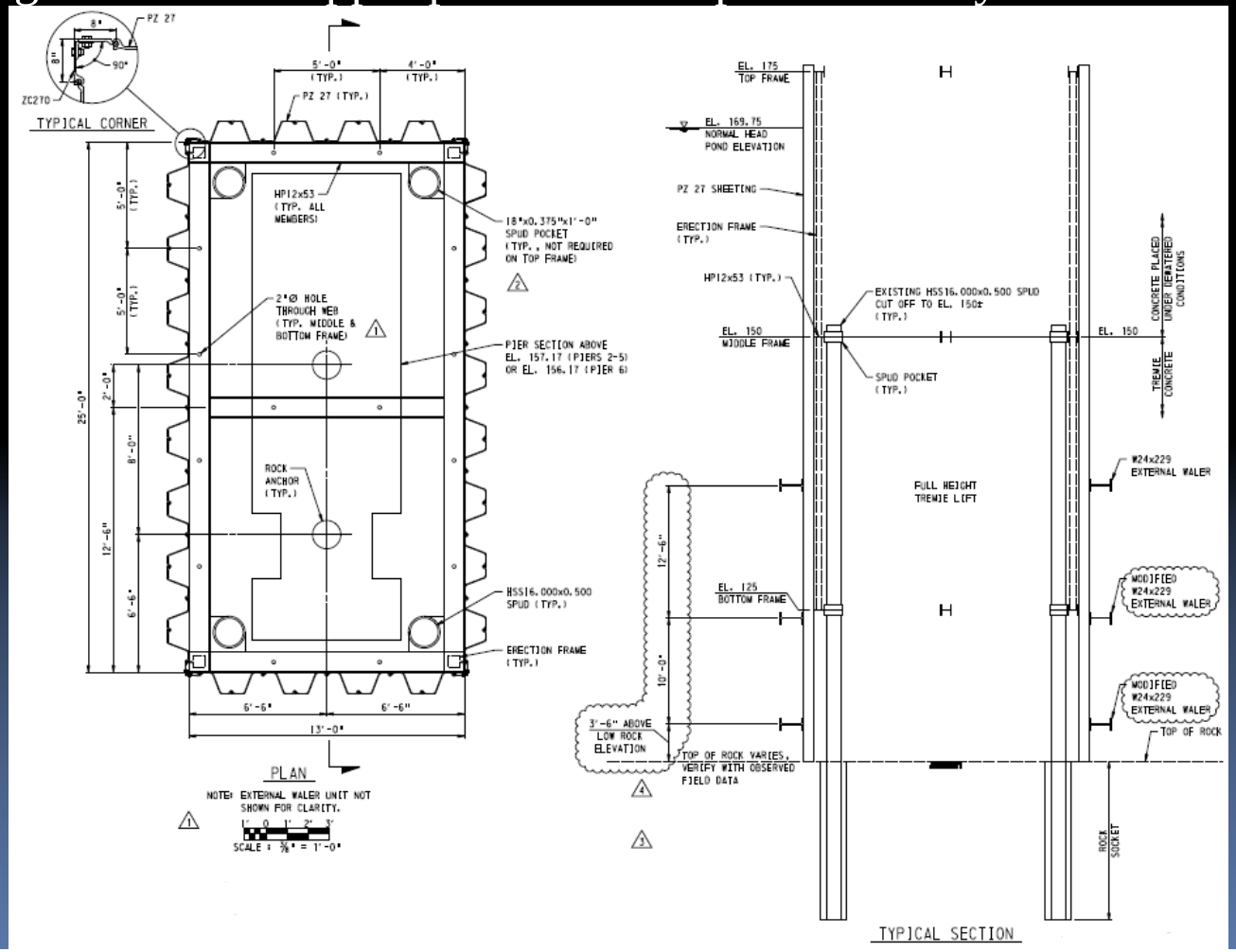
- Used to construct the river piers for a new skimmer wall and bridge
- Skimmer wall blocks floating debris from entering the forebay area



SKIMMER WALL CENTERLINE PROFILE

Cofferdam 3 Design

- HSS spuds grouted into rock sockets to support internal cofferdam frames
  - Designed to resist horizontal flow forces applied to the cofferdam by flood events and normal flows due to existing hydroelectric plant power generation
- Designed for 40ô tremie concrete lift (external walers) and 25ô of internal dewatering to construct upper portion of the pier in the dry

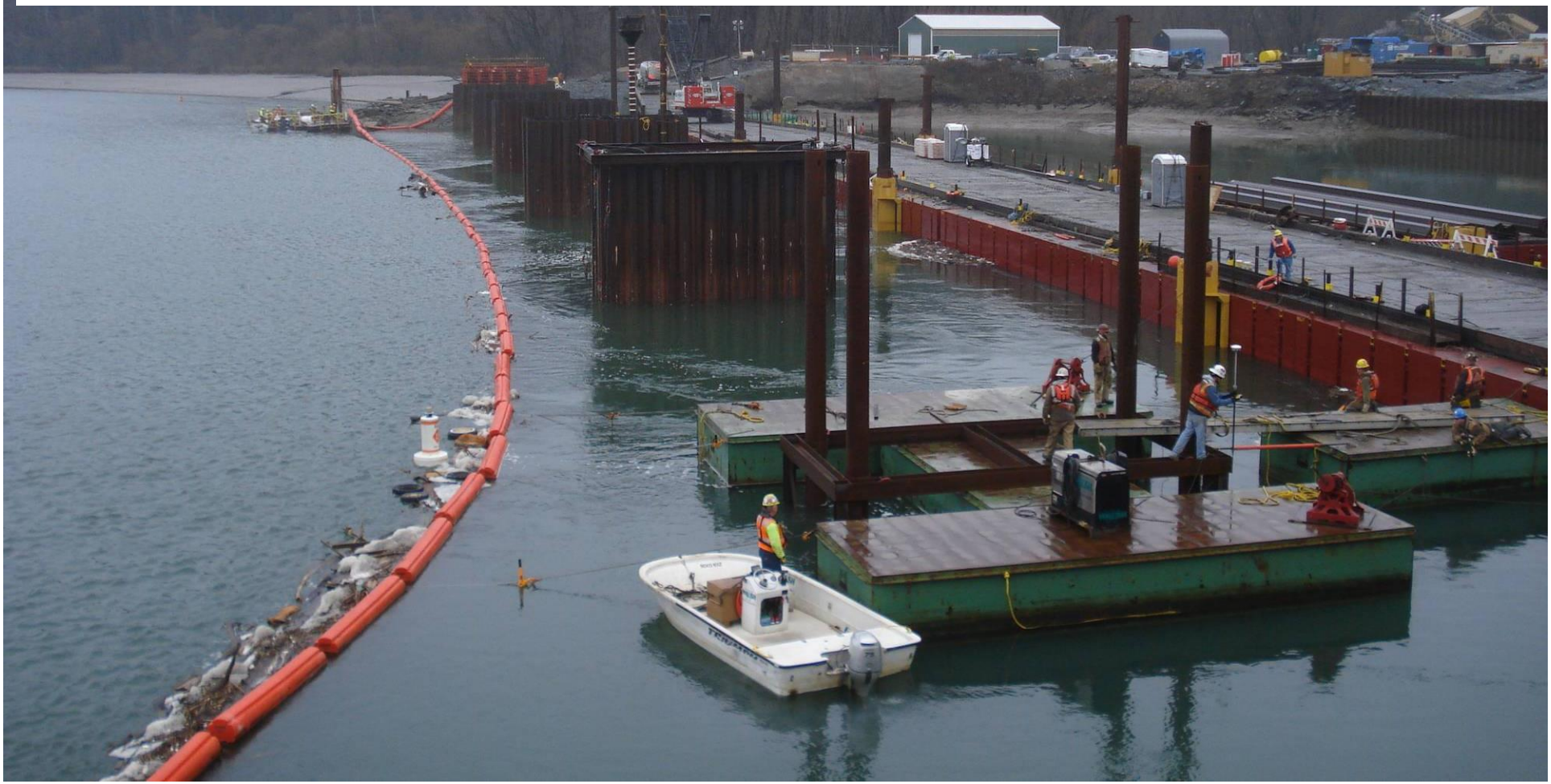


Cofferdam 3 Construction

- Internal frames stood 50ô tall when full assembled

Cofferdam 3 Construction (cont.)

- Assembly line of construction
- Piers in background have been tremie poured
- Nearest completed cofferdam has external waler system clamped around cofferdam
- Positioning of internal frame assembly onto HSS corner spuds at nearest cofferdam

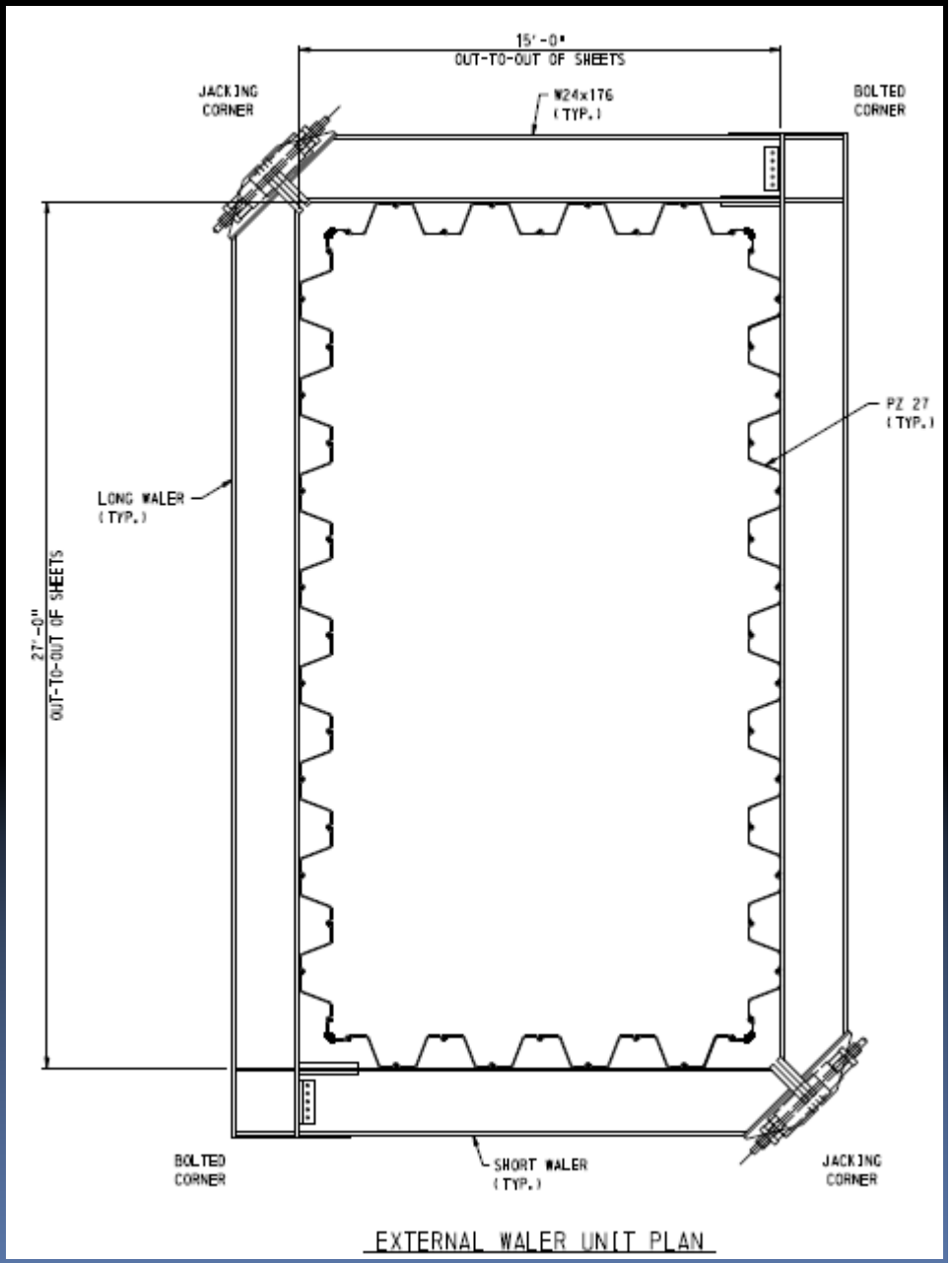


Cofferdam 3 Construction (cont.)

- Completed cofferdam
- Itôs a beautiful thingé for now.

Cofferdam 3 External Waler Design

- 3 levels designed to resist 40ô tremie concrete pour
- 2 L shaped units connected at a pinned corner with center hole jacks, opposite corners designed as a full moment connection
- Jacks ólampedô the external waler system around the cofferdam to hold the sheets in place during the tremie pour

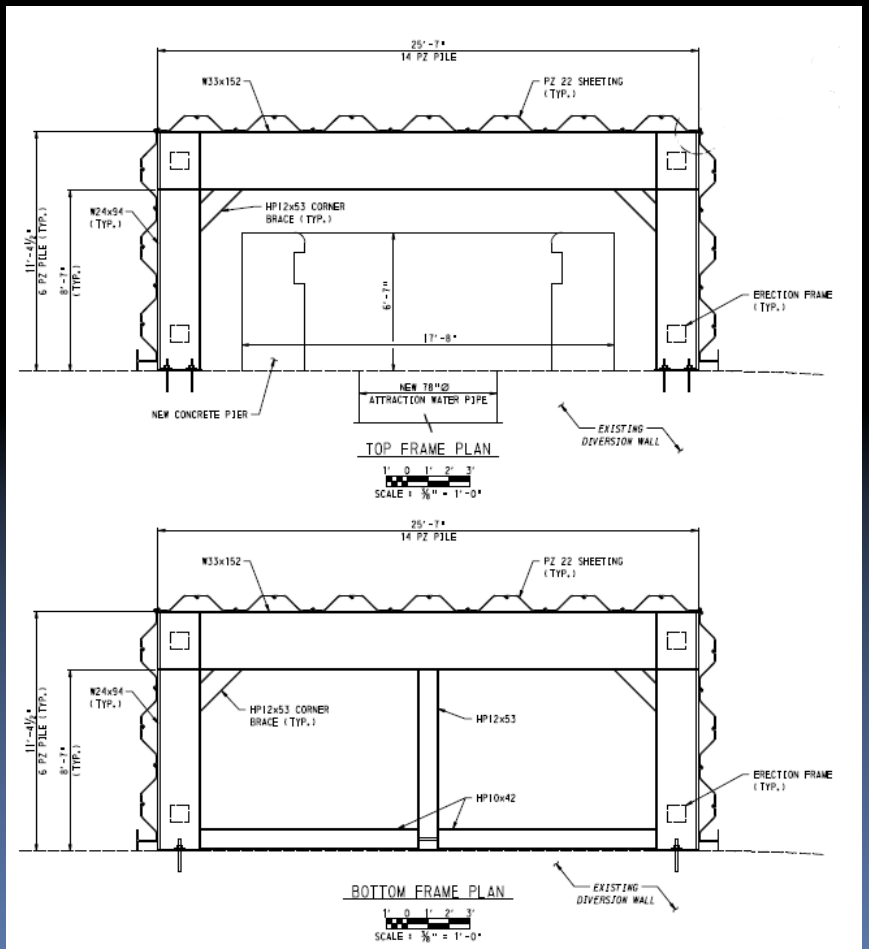


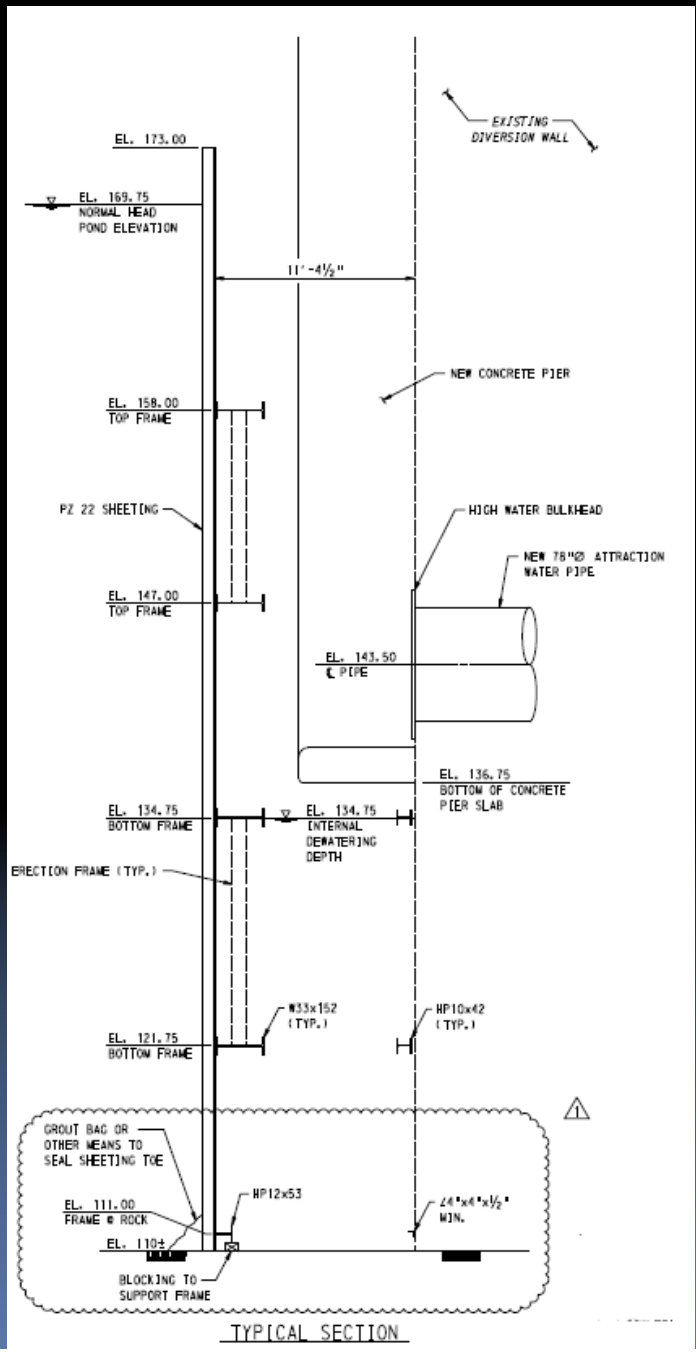
Cofferdam 3
Internal Destruction

Cofferdam 3 Internal Destruction

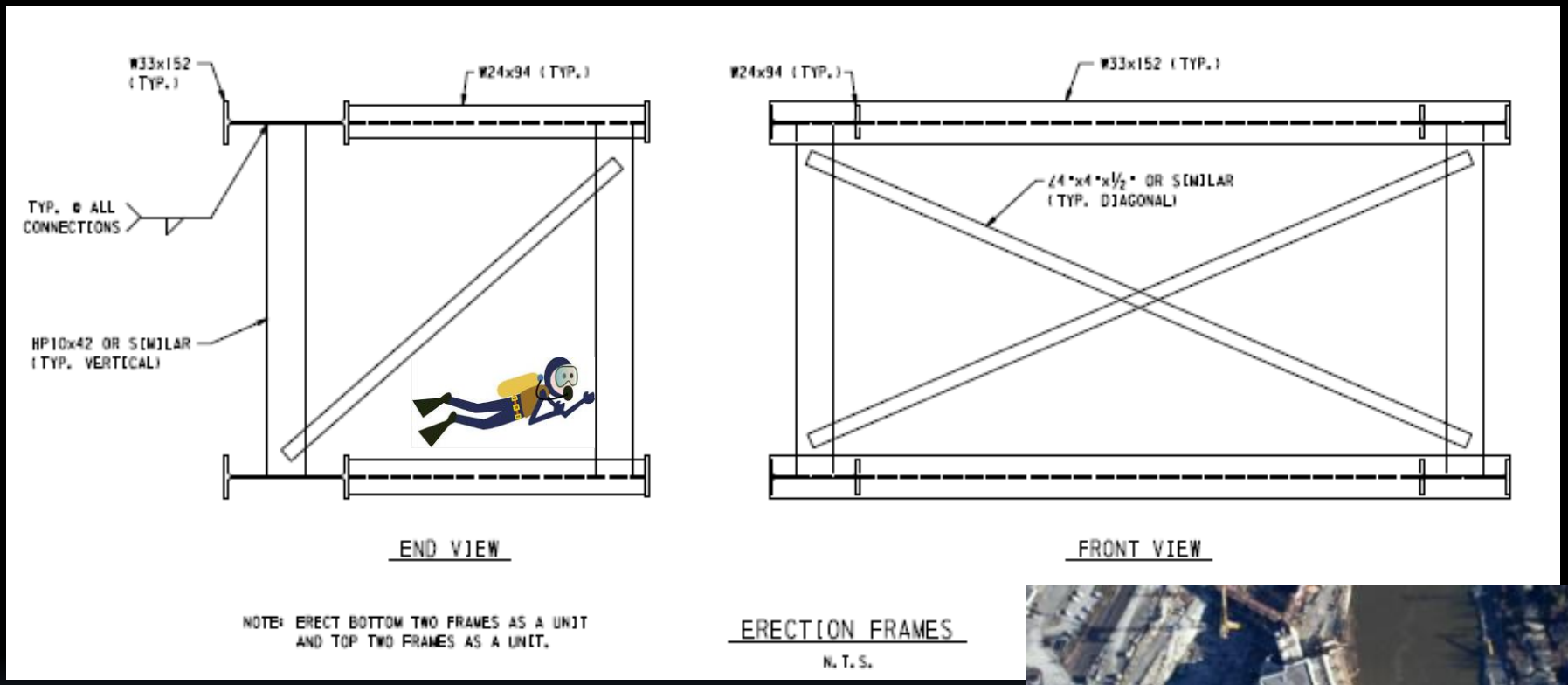
Cofferdam 5 Design

- 3 sided cofferdam constructed against dam face
- Designed for 38.25ô of internal dewatering
- Allowed the construction of a new 78ò dia. attraction water pipe to feed additional water into the existing fish lift





Cofferdam 5 Construction (cont.)



- Internal frames assembled on land into two units then lowered into position
- Divers made connections to the existing dam face

Cofferdam 5 Construction
(cont.)

ñself, if this thing fails while Iôm in here, Iđll probably see a very similar lightò

Cofferdam 5 Construction (cont.)

If there was an emergency, would this make you feel all warm and fuzzy?

Cofferdam 5 Near Destruction

Cofferdam 5 Near Destruction

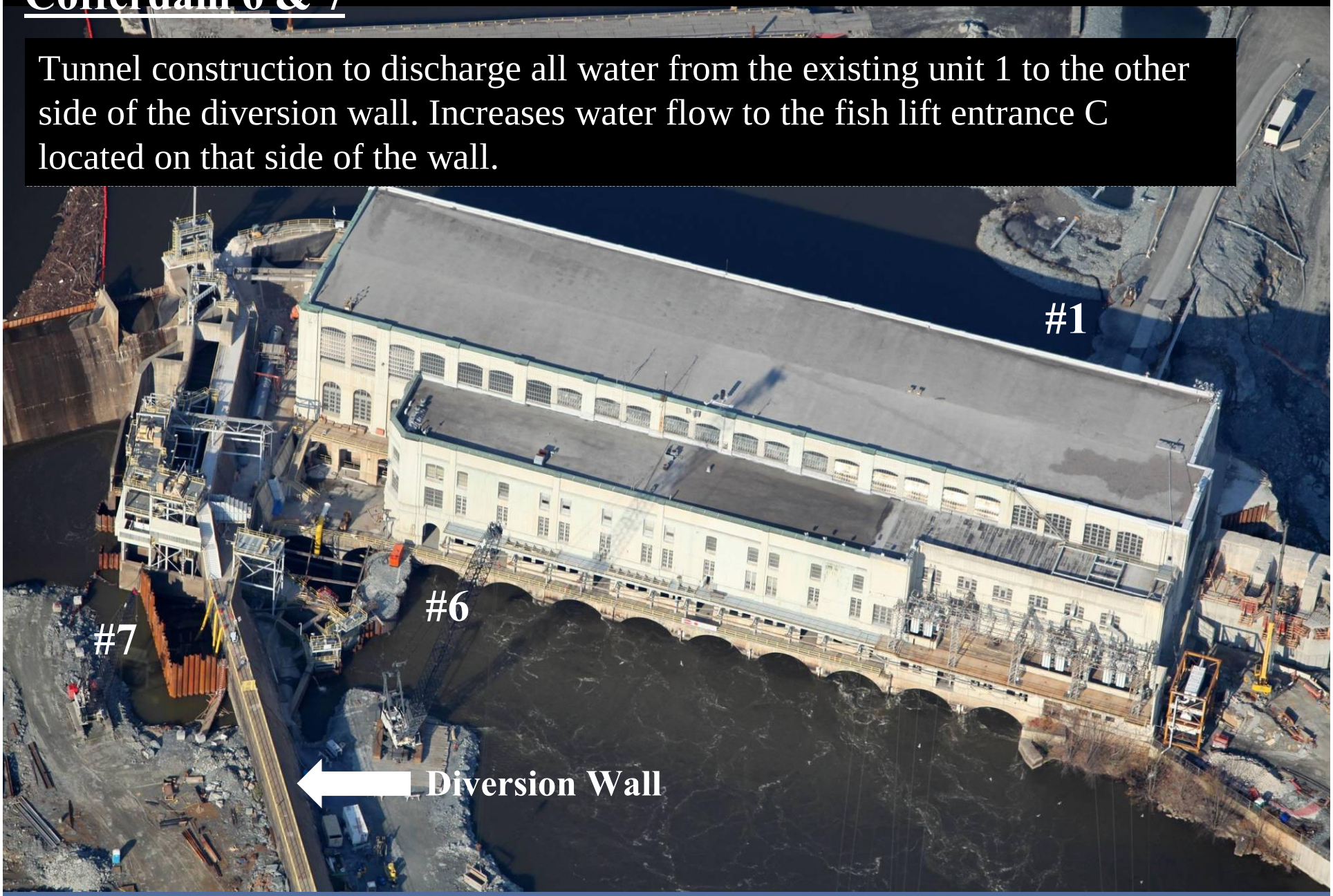
Commonsense 101

Listen to the engineer when he says that you canôt trim the strut.

Donôt start hacking away at a major load carrying member.

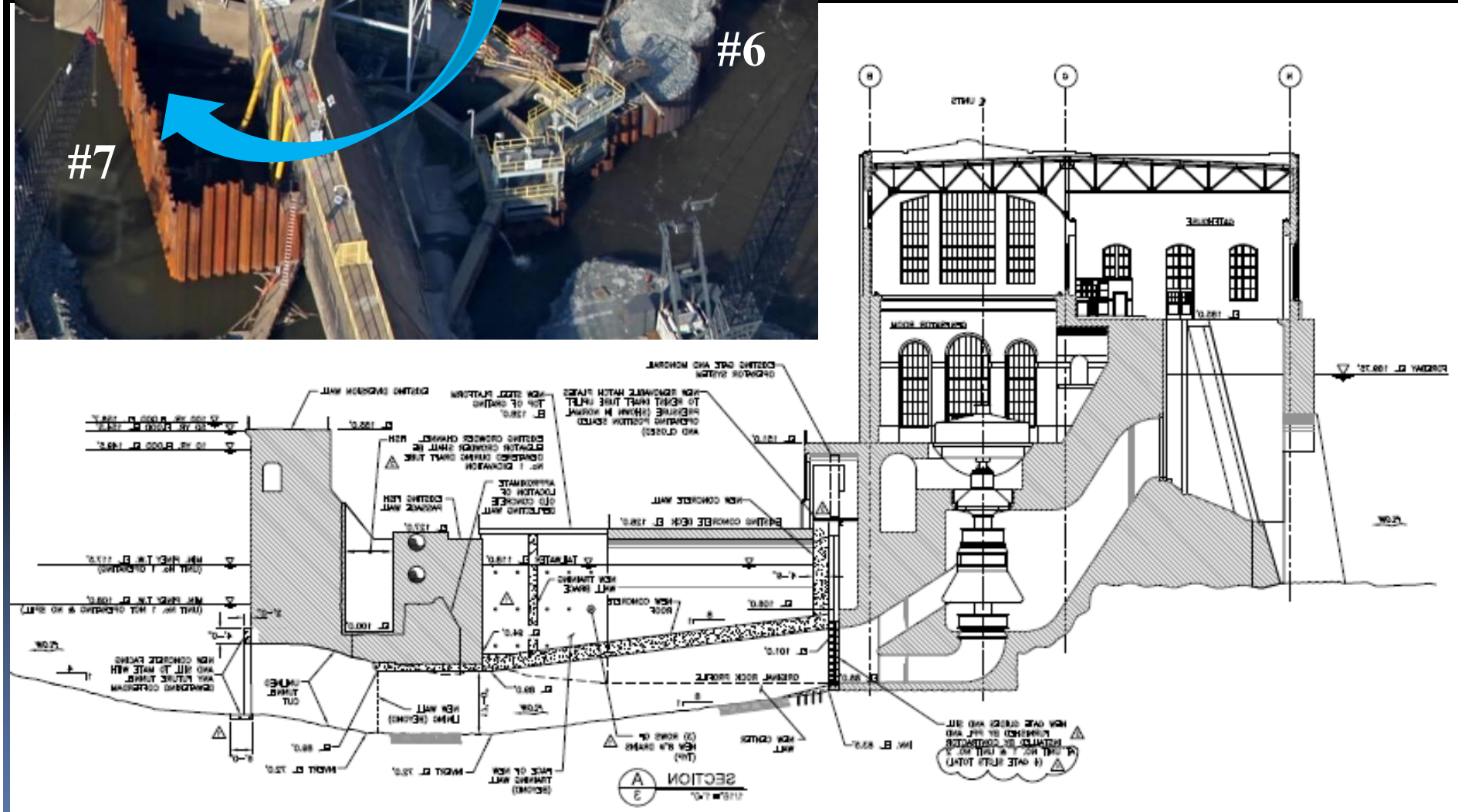
Cofferdam 6 & 7

Tunnel construction to discharge all water from the existing unit 1 to the other side of the diversion wall. Increases water flow to the fish lift entrance C located on that side of the wall.



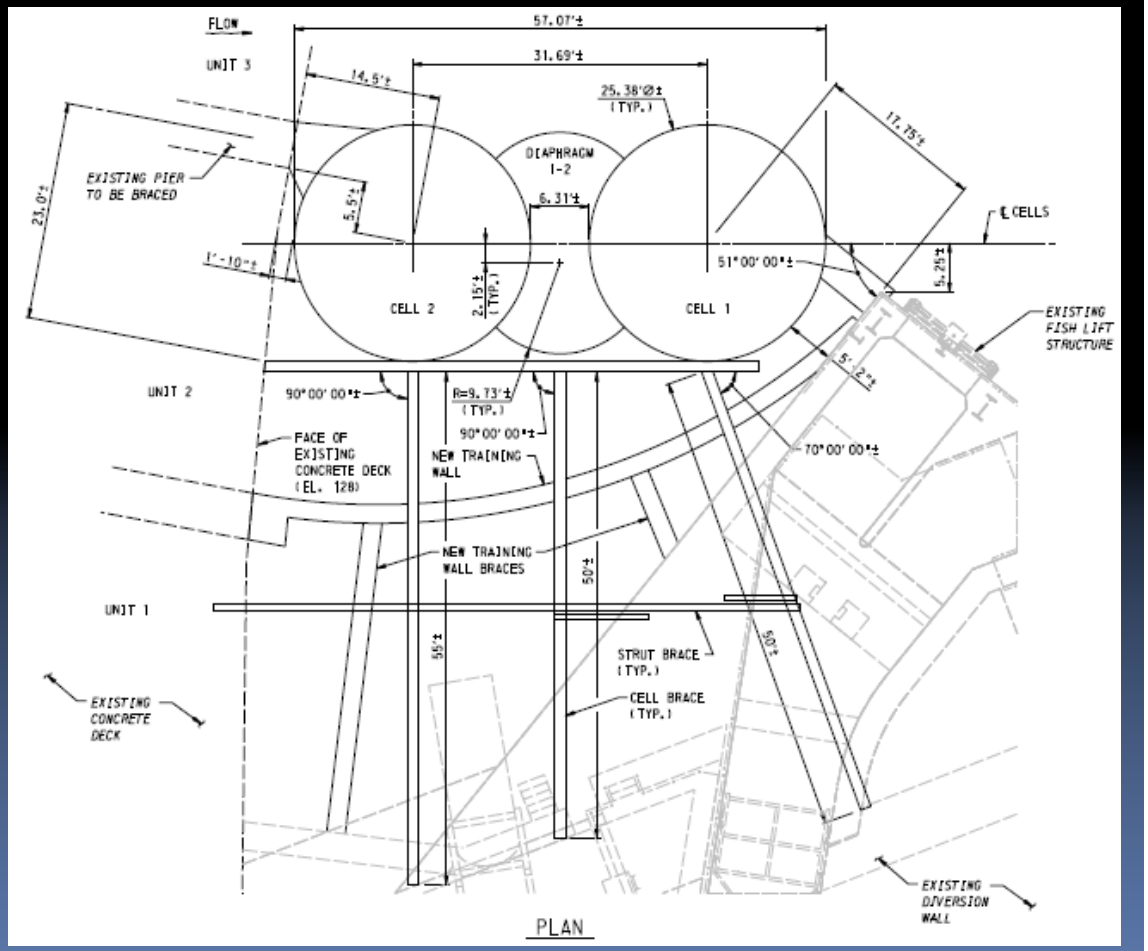
Cofferdam 6 & 7 (cont.)

- Tunnel constructed under existing diversion wall



Cofferdam 6 Design

- Cellular cofferdam consisting of two 25ô diameter cells founded on rock
- Designed for 35ô of water pressure
- 25ô diameter cell versus 35ô of water = NO GOOD!
  - Provided cell bracing at the top of the cells to carry loads into the existing diversion wall
  - Horizontal reaction forces at bottom of cells resisted by sliding resistance

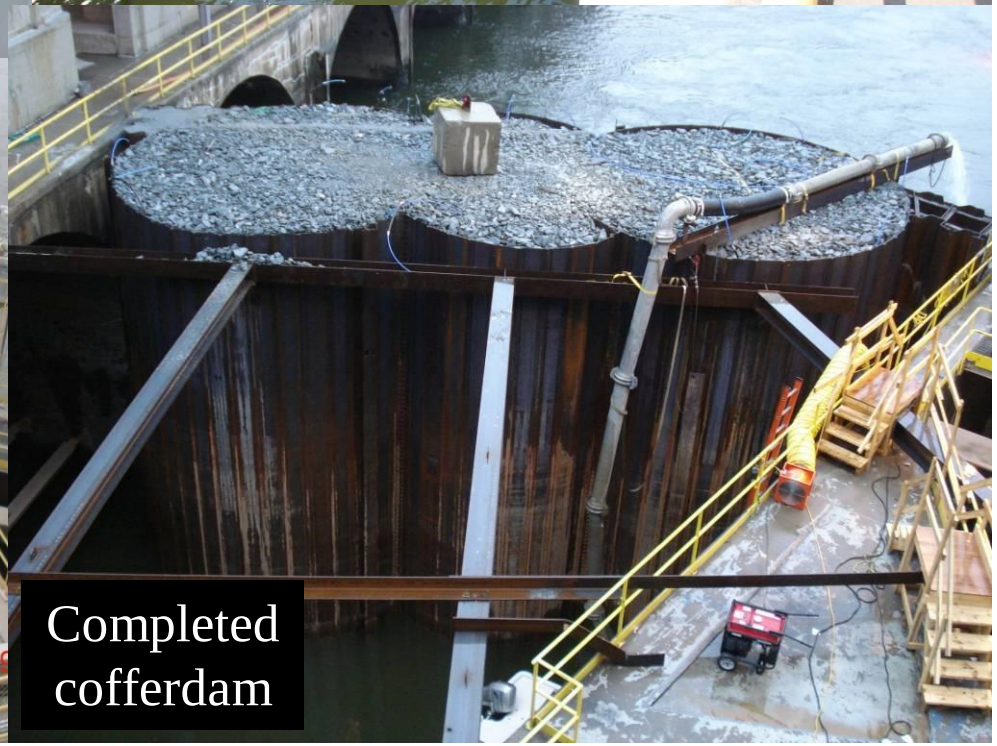


Cofferdam 6 Construction

Cell 1 fill being placed

Cell 2 being constructed

Seating of cell 2 sheets



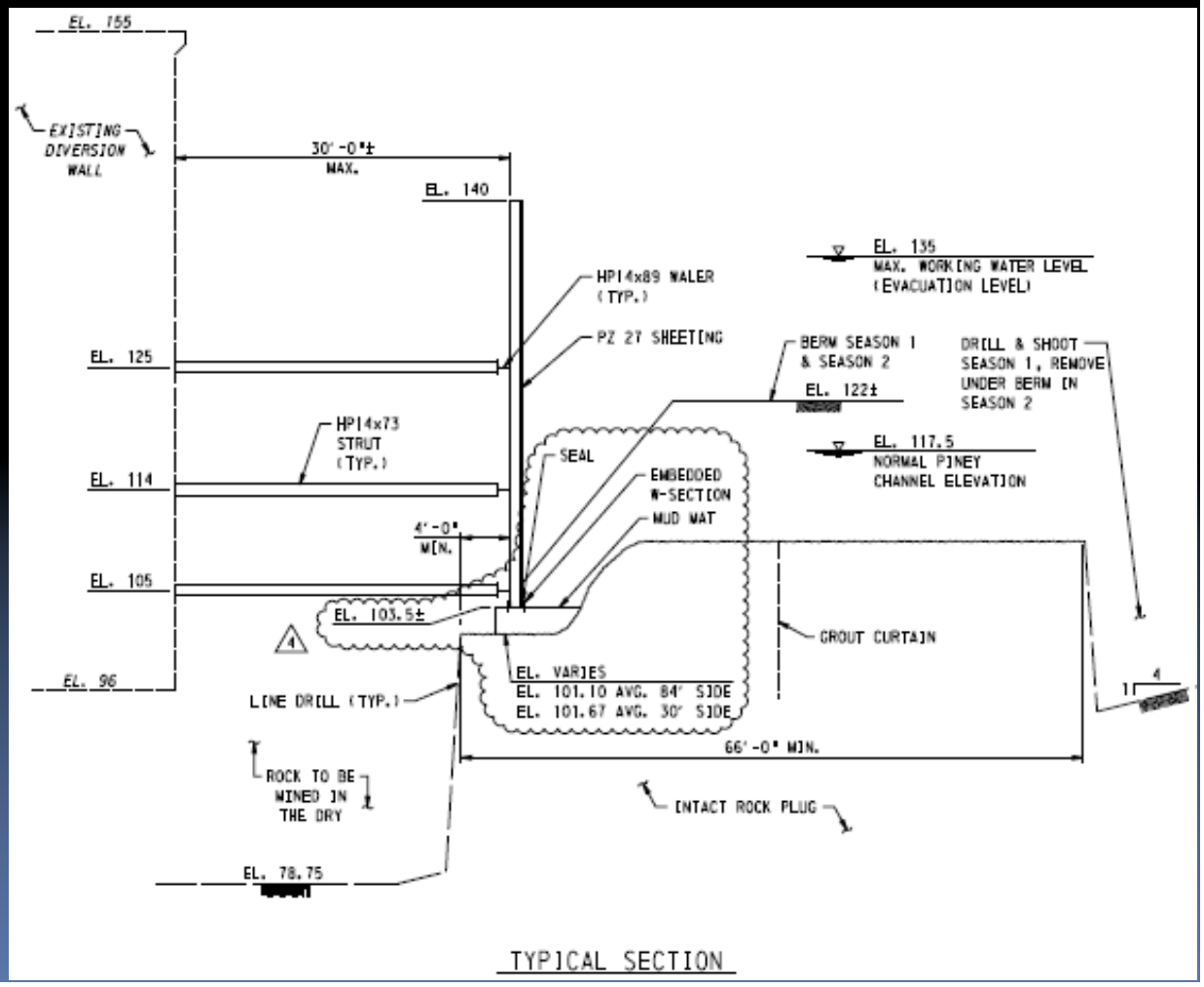
Completed cofferdam

Cofferdam 6 Construction (cont.)

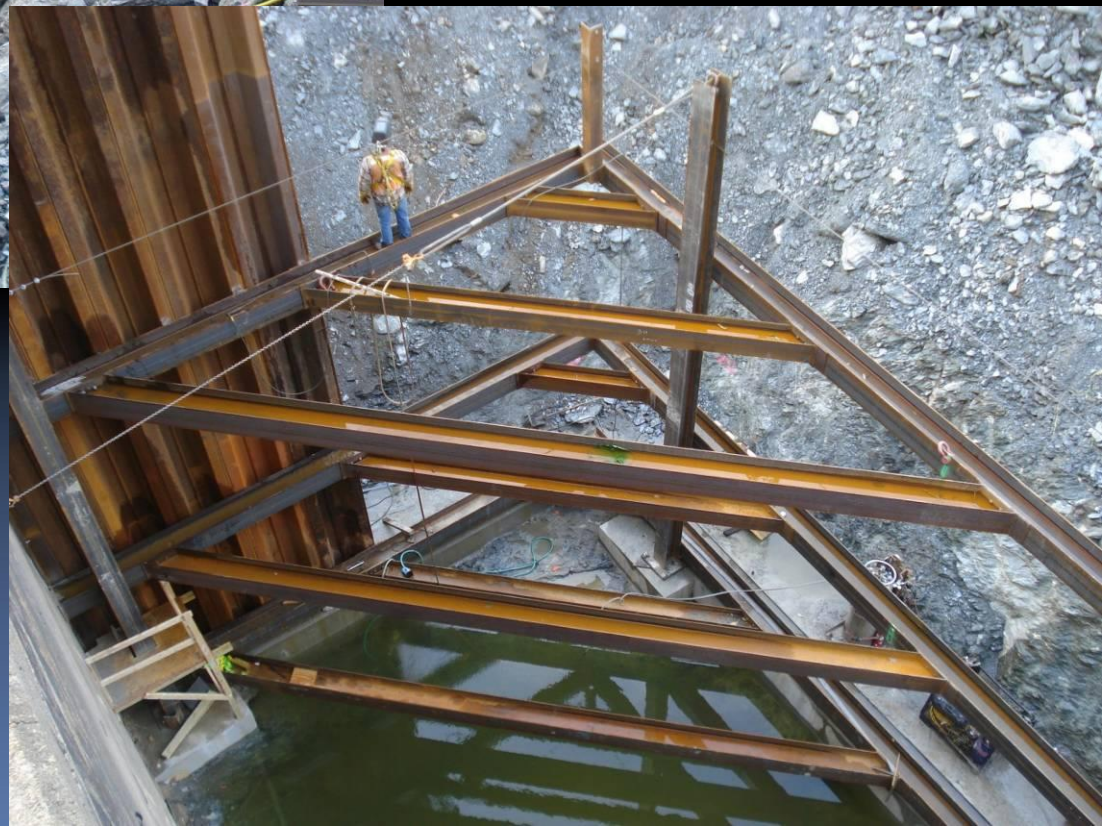
- View from behind cofferdam 6
- 56ô from lowest rock invert to top of cofferdam

Cofferdam 7 Design

- 2 sided cofferdam constructed against diversion wall and fish lift
- Ultimately designed for 36.5ô of internal dewatering (to bottom of sheets)
- Cofferdam sitting on top of 23ô vertical rock face (61.25ô from top of sheets to bottom of hole)
  - Provided rock anchors and dowels for stability of rock face
- PZ sheeting set into the web area of a W-section that was horizontally placed into a mud mat
  - Region between sheets and W-section flanges grouted to create seal



Cofferdam 7 Construction



- Frames erected onto support piles
- Setting PZ sheets

Cofferdam 7 Construction (cont.)

- View inside completed cofferdam

Cofferdam 7 Construction (cont.)

- View inside completed cofferdam

Cofferdam 6 & 7 Near Destruction

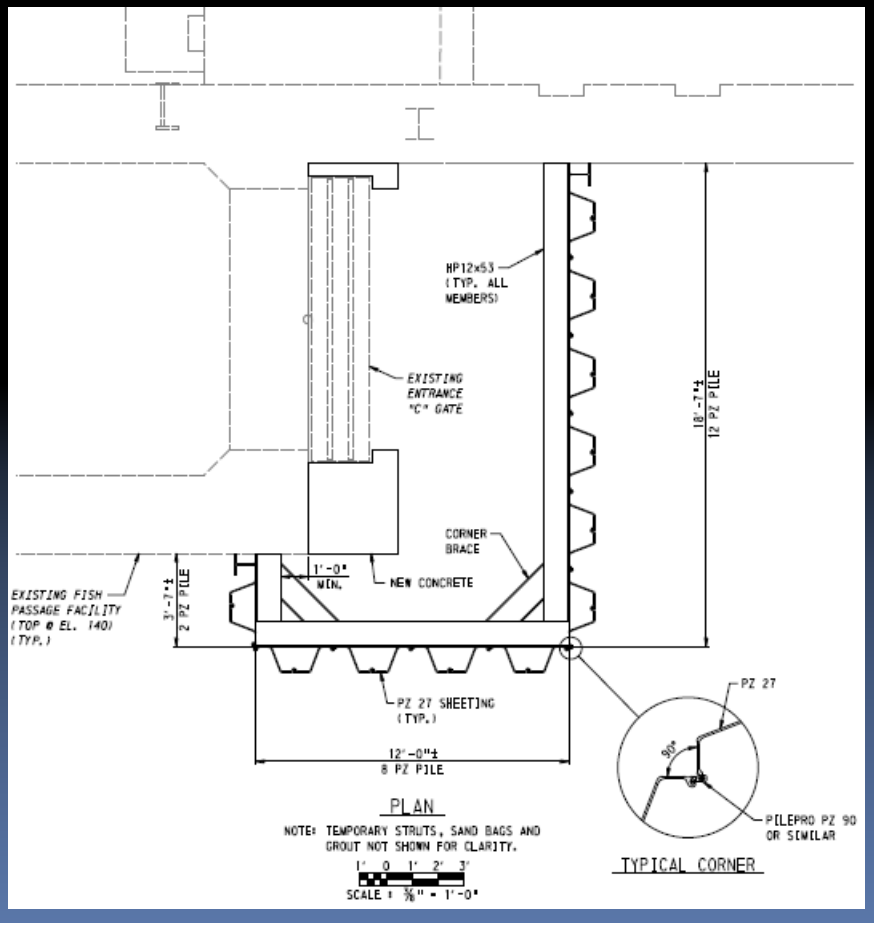
Cofferdam 6 & 7 Near Destruction 1

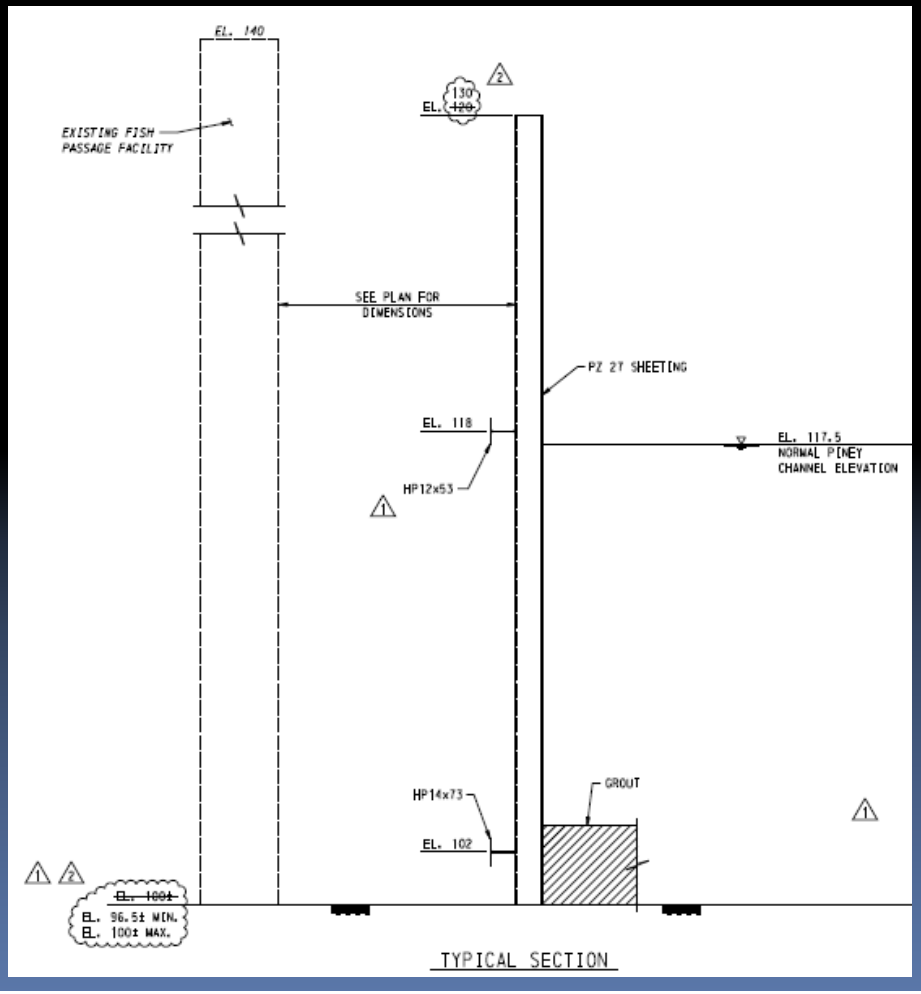
Cofferdam 6 & 7 Near Destruction, Take 2
3-12-11

Also survived higher flood on 9-9-11, water was splashing over this wall

Cofferdam 7, Entrance C Design

- Small, 3 sided cofferdam constructed against existing fish lift
- Ultimately designed for 30ô of internal dewatering
  - Originally design was for 20ô of internal dewatering
- Allowed the existing fish lift entrance gate C gates and hardware to be modified
- No big dealé or so we thought





Cofferdam 7, Entrance C Construction

View from above

#6

#7

Entrance C


Enough with the
near destruction.
Get to the good stuff!

Cofferdam 7
Entrance C
Destruction

Cofferdam 7, Entrance C Destroyed 10-3-10

Cofferdam is in here somewhere

Cofferdam 7, Entrance C Destroyed 10-3-10 (cont.)

Cofferdam 7, Entrance C Destroyed 10-3-10 (cont.)

Å The aftermath

Historical Crests for Susquehanna River at Marietta

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(2) 60.73 ft on 03/19/1936
(3) 58.30 ft on 06/02/1889
(4) 58.16 ft on 09/09/2011
(5) 56.80 ft on 01/21/1996
(6) 56.27 ft on 09/19/2004
(7) 55.73 ft on 09/27/1975
(8) 54.90 ft on 05/29/1946
(9) 54.03 ft on 03/12/1964
(10) 53.49 ft on 02/16/1984
(11) 53.33 ft on 04/02/1940
(12) 53.22 ft on 04/03/1993
(13) 53.21 ft on 03/07/1979
(14) 53.20 ft on 01/01/1943
(15) 52.96 ft on 11/27/1950
(16) 52.86 ft on 03/12/2011
(17) 52.53 ft on 06/29/2006
(18) 51.82 ft on 02/27/1961
(19) 51.71 ft on 04/04/2005
(20) 51.52 ft on 03/16/1986
(21) 51.31 ft on 04/02/1960
(22) 51.15 ft on 04/29/2011
(23) 51.01 ft on 03/26/1994
(24) 50.47 ft on 04/04/1970
(25) 50.33 ft on 03/13/1952

Cofferdam 7, Entrance C Destroyed…Again, 3-12-11

Historical Crests for Susquehanna River at Marietta

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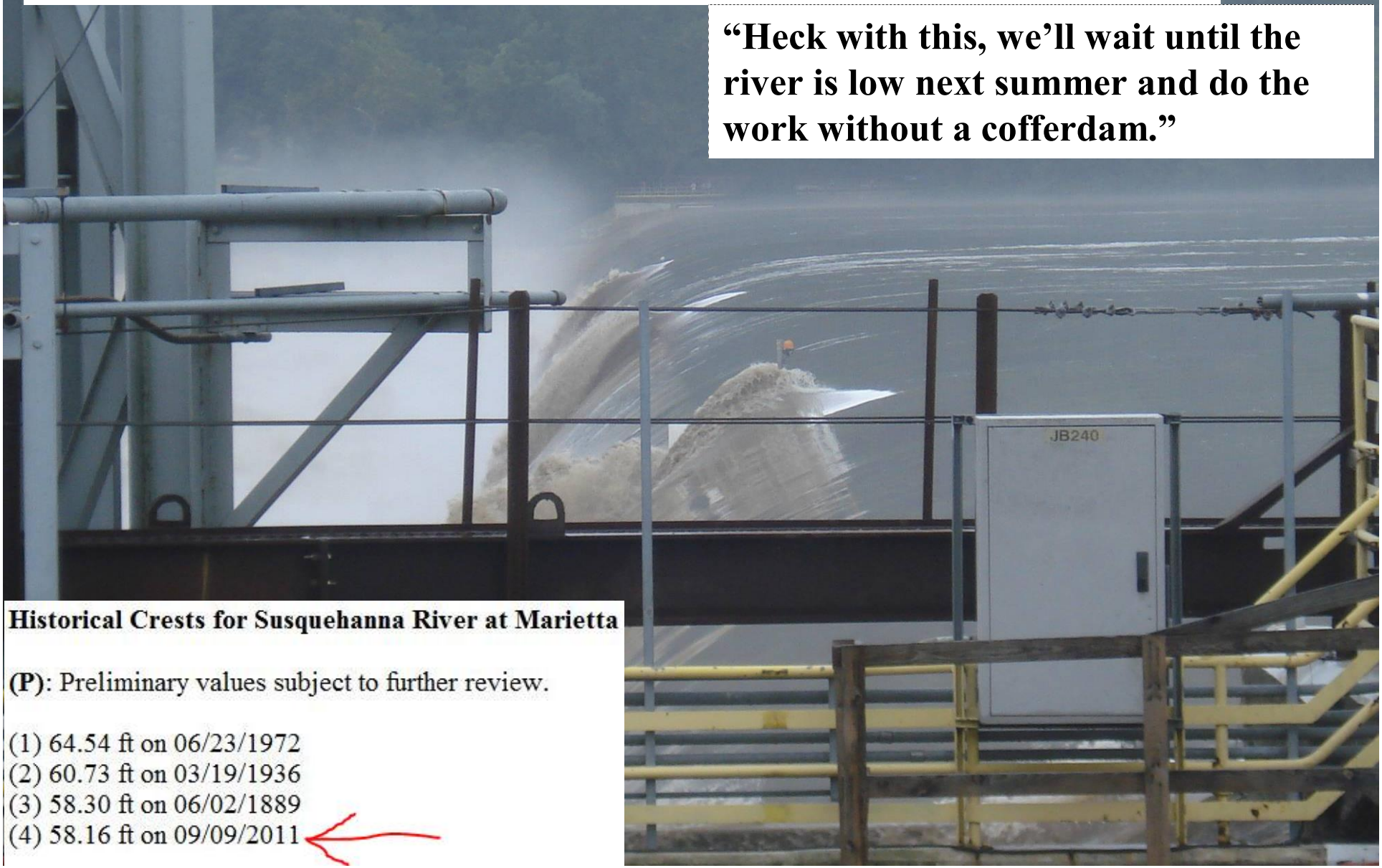
Cofferdam 7, Entrance C Destroyed…Yet Again

9-9-11

"Heck with this, we'll wait until the river is low next summer and do the work without a cofferdam."



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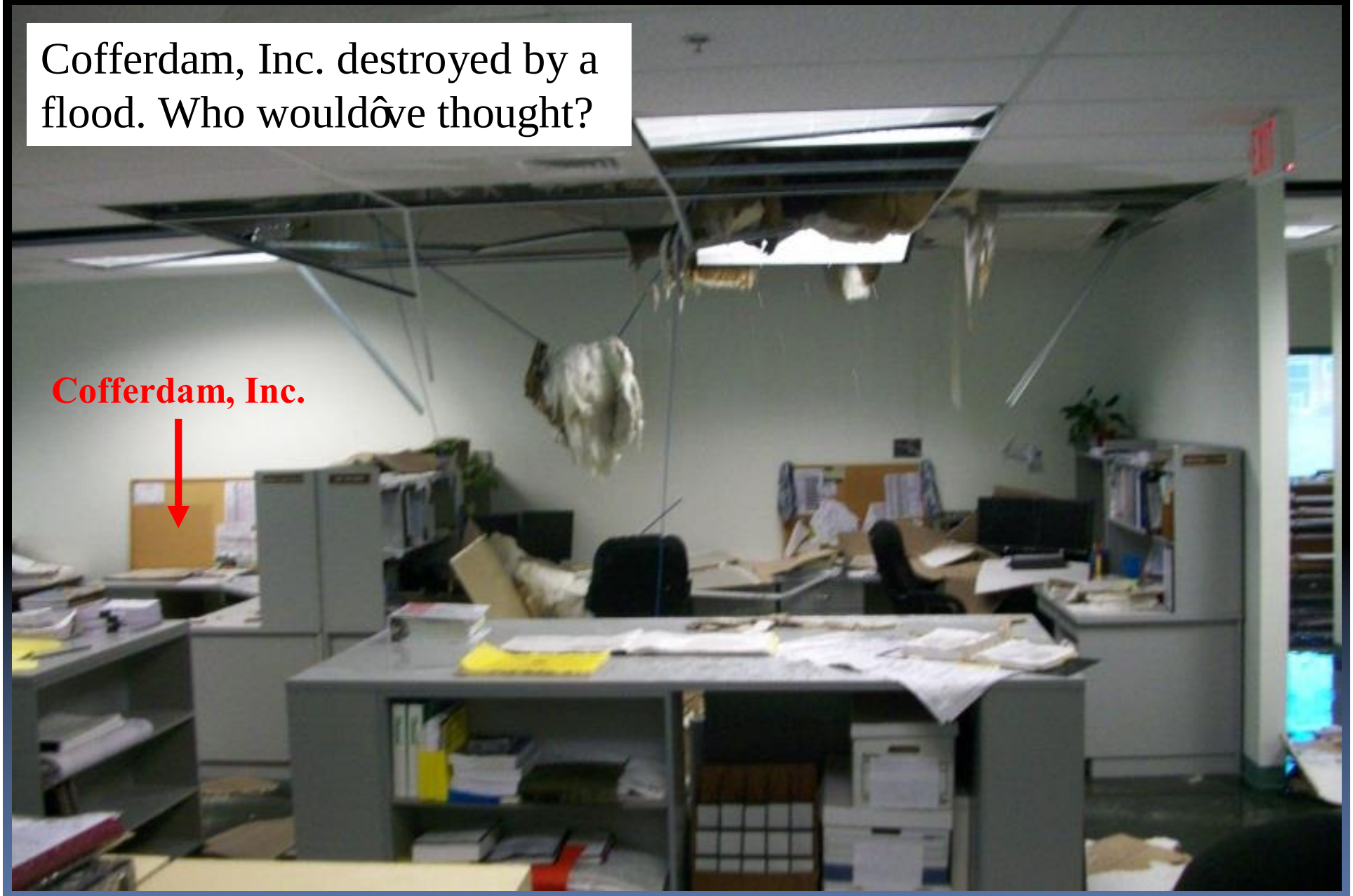
JMT York Office Destruction

Office Flood, 12-9-10



Office Flood, 12-9-10 (cont.)

Questions?

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